ICCE

2019.12.2-12.6, Kenting, Taiwan

27th International Conference on Computers in Education

Conference Proceedings Volume 2

27th International Conference on Computers in Education
Conference Proceedings Volume 2

- TABLE OF CONTENTS -

EDITORS

Maiga CHANG, Athabasca University, Canada
Hyo-Jeong SO, Eawha Womans University, South Korea
Lung-Hsiang WONG, Nanyang Technological University, Singapore
Ju-Ling SHIH, National Central University, Taiwan
Fu-Yun YU, National Cheng Kung University, Taiwan

ASSOCIATE EDITORS

(in alphabetical order)

ORGANIZATION

Workshop & Interactive Events
- *Chair:*
  Niwat SRISAWASDI, Khon Kaen University, Thailand
- *Co-Chairs:*
  Patcharin PANJABUREE, Mahidol University, Thailand
  Michelle P. BANAWAN, Ateneo de Davao University, Philippines

Workshop 1 - The 3rd Workshop on Digital Game-based Learning and Gamification Instructional Strategies for K-12 Schools
- *Organizers:*
  Huei-Tse Hou, National Taiwan University of Science and Technology, Taiwan
  Shu-Ming Wang, Chinese Culture University, Taiwan
  Feng-Kuang Chiang, Shanghai Normal University, China

Workshop 2 - New Computer Simulations in STEM Education
- *Organizer:*
  Chen-Chung Liu, National Central University, Taiwan

Workshop 3 - Emerging Technologies for Teachers' Professional Development at Scale
- *Organizers:*
  Michelle P. Banawan, Ateneo de Davao University, Philippines
  Ma. Mercedes T. Rodrigo, Ateneo de Manila, Philippines
  Cher Ping Lim, University of Hong Kong, Hong Kong

Workshop 4 - The 7th Workshop on Technology-enhanced STEM Education (TESTEM Workshop)
- *Organizers:*
  Chia-Ching Lin, National Kaohsiung Normal University, Taiwan
  Niwat Srisawasdi, Khon Kaen University, Thailand
  Ying-Tien Wu, National Central University, Taiwan
  Patcharin Panjaburee, Assistant Professor, Mahidol University, Thailand

Workshop 5 - The 4th International Workshop on the Theory and Practice of Interest-driven Creators (IDC)
- *Organizers:*
  Zhi-Hong Chen, National Taiwan Normal University, Taiwan
  Hercy N. H. Cheng, Central China Normal University, Taiwan
  Calvin C. Y. Liao, National Taipei University of Nursing and Health Sciences, Taiwan

Workshop 6 - The 10th International Workshop on Innovative Designs for Mobile and Ubiquitous Learning: 1:1 and Beyond

- *Organizers:*
  Noriko UOSAKI, Osaka University, Japan
  Ivica Boticki, University of Zagreb, Croatia
  Lung-Hsiang Wong, Nanyang Technological University, Singapore
  Yanjie Song, Education University of Hong Kong, Hong Kong
  Kousuke Mouri, Tokyo University of Agriculture and Technology, Japan

Workshop 7 - The 3rd International Workshop on Information and Communication Technology for Disaster and Safety Education (ICTDSE2019)

- *Organizer:*
  Hiroyuki MITSUHARA, Tokushima University, Japan

Workshop 8 - The 8th International Workshop on ICT Trends in Emerging Economies (WICTTEE 2019)

- *Organizers:*
  Niwat Srisawasdi, Khon Kaen University, Thailand
  Patcharin Panjaburee, Mahidol University, Thailand
  Bo Jiang, Zhejiang University of Technology, China
  Jessica O Sugay, Ateneo de Manila University, Philippines
  Jayakrishnan M., Indian Institute of Technology Bombay, India (Co-chair)

Workshop 9 - Teaching Logical Thinking and Programming Language at Different Levels of Instruction

- *Organizers:*
  Tzu-Keng Fu, Yuan Ze University, Taiwan
  Jean-Yves, Béziau, Federal University of Rio de Janeiro, Brazil

Workshop 10 - The 6th ICCE Workshop on Learning Analytics (LA) - Scaling up Evidence-based Institutional La Practices

- *Organizers:*
  Brendan Flanaga, Kyoto University, Japan
  Rwitajit Majumdar, Kyoto University, Japan
  Weiqin CHEN, Oslo Metropolitan University, Norway
  Hiroaki Ogata, Kyoto University, Japan

Workshop 11 - New Endeavours of Implementing Computational Thinking in K-12 Education

- *Organizers:*
  Longkai Wu, Nanyang Technological University, Singapore
  Ting-Chia Hsu, National Taiwan Normal University, Taiwan
  Ivica Botički, University of Zagreb, Croatia

Workshop 12 - The 12th Workshop on Technology-enhanced Learning by Posing/Solving Problems/Questions - Analysis and Design of Problems/Questions

- *Organizers:*
  Yusuke Hayashi, Hiroshima University, Japan
  Tsukasa Hirashima, Hiroshima University, Japan
  Kazuaki Kojima, Teikyo University, Japan
  Tomoko Kojiri, Kansai University, Japan
  Jon Mason, Charles Darwin University, Australia
  Tanja Mitrovic, University of Canterbury, New Zealand
  Fu-Yun Yu, National Cheng Kung University, Taiwan

Workshop 13 - Design for Choreographies/Ambiance for Global Agile Learning to Foster Future Skills

- *Organizers:*
  Tosh YAMAMOTO, Kansai University, Japan
  Juling SHIH, National Central University, Taiwan
  Benson ONG, Nanyang Polytechnic, Singapore
  Chris PANG, Nanyang Polytechnic, Singapore
  Hui-Chun CHU, Soochow University, Taiwan
  Takuro OZAKI, Osaka Educational University, Japan
  Yasuhiro HAYASHI, Musashino University, Japan

Workshop 14 - The Applications of Information and Communication Technologies in Adult and Continuing Education

- *Organizers:*
  Xibei Xiong, Guangxi Normal University, China
  Jyh-Chong Liang, National Taiwan Normal University, Taiwan
  Min-Hsien Lee, National Taiwan Normal University, Taiwan

Workshop 15 - The 4th Computer-supported Personalized and Collaborative Learning

- *Organizers:*
  Robin Chiu-Pin Lin, National Tsing Hua University, Taiwan
  Sherry Y. Chen, National Central University, Taiwan
  Gwo-Haur Hwang, National Yunlin University of Science and Technology, Taiwan
  Fu-Yun Yu, National Cheng Kung University, Taiwan
  Wenli Chen, Nanyang Technological University, Singapore
  Shu-Yuan Tao, Takming University of Science and Technology, Taiwan
  Hsiu-Ling Chen, National Taiwan University of Science and Technology, Taiwan

Workshop 16 - The 2nd Workshop on Innovative Technologies for Enhancing Interactions and Learning Motivation

- *Organizers:*
  Jerry Chih-Yuan Sun, National Chiao Tung University, Taiwan
  Sherry Yu-Hua Chen, National Central University, Taiwan

Hui-Chun Chu, Soochow University, Taiwan
Shih-Jou Yu, National Chiao Tung University, Taiwan

Extended Summaries (ES)
- *Chair:*
  Yanjie SONG, The Education University of Hong Kong, Hong Kong
- *Co-Chair:*
  Chengjiu YIN, Kobe University, Japan

Work-in-Progress Posters (WIPP)
- *Chair:*
  Andrei D. CORONEL, Ateneo de Manila University, Philippines
- *Co-Chairs:*
  Swapna GOTTIPATI, Singapore Management University, Singapore
  Fan OUYANG, Zhejiang University, China
  Michelle P. BANAWAN, Ateneo de Davao University, Philippines

Tutorials
- *Chair:*
  Ben CHANG, National Central University, Taiwan
- *Co-Chairs:*
  Ahmed TLILI, Smart Learning Institute of Beijing Normal University, China
  Calvin LIAO, National Taipei University of Nursing and Health Sciences, Taiwan

Early Career Workshop (ECW)
- *Chair:*
  Morris S.Y. JONG, The Chinese University of Hong Kong, Hong Kong
- *Co-Chairs:*
  Jon MASON, Charles Darwin University, Australia
  Ma. Mercedes T. RODRIGO, Ateneo de Manila University, Philippines

Doctoral Student Consortium (DSC)
- *Chair:*
  Weiqin CHEN, Oslo Metropolitan University, Norway
- *Co-Chair:*
  H. Ulrich HOPPE, University of Duisburg-Essen, Germany

WORKSHOP 1 - The 3rd Workshop on Digital Game-based Learning and Gamification Instructional Strategies for K-12 Schools

A Study on Flow Experience and Learning Effectiveness of RFID Educational Board Game System

Hsuan-Yu LIN and Chih-Ming CHU*
Hsuan-Yu LIN, National Ilan University, Taiwan
Chih-Ming CHU, National Ilan University, Taiwan
a25530787870@gmail.com
cmchu@niu.edu.tw

Abstract: This study used the Arduino Mega board to develop related peripheral modules such as RFID cards, combined with SD card to record the data, analyze the data and feedback, and used this board game system to teach the computer hardware and software. This study's course took the "Information Literacy and Application" which is the compulsory general education in a university in northern Taiwan. The study participated in the experiment for a total of 40 people in the first year of the university department of foreign language, and divided into the experimental group of 23 people, control group 17 people, the experimental group used the "Hello, Computer !" learning board game which is self-development and design, and the control group used the discussion method to teach, implement the learning outcome test and flow questionnaire after class. The results show that if used this study's learning board game, the experimental groups' learning outcomes were improved clearly, and in their opinion that this board game had a significant effect on learning, furthermore, when experimental group was engaged in the learning board game of this study, all had high level of flow.

Keywords: Game-based learning, flow experience, learning effectiveness

1. Introduction

Game is one of the memories that accompanies most people's growth. In the present digital generation, the game appeared in our lives in a variety of ways, such as digital games, online games or unplugged board games. Each game was formed with its background and the purpose it wanted to achieve, it could be entertainment, puzzle or even learning, however, regardless of its purpose, the only changeless was that the development which was born for innovation (Wang, 2015). From the learning perspective, gamification is not the same as game, game is an organized play, combined learning with games, and after repeated practice (Forst, Wortham, & Reifel, 2001), through the rules and competition for entertainment or the purposes of education, and gamification used game design and mechanics, stimulate students' motivation in learning and solve the problem(Matsumoto, 2016). In recent years, pedagogy has changed greatly with the development of the times, instructors had new ideas about the way of teaching, they were no longer just using traditional teaching modes such as blackboards and didactic (Matsumoto, 2016). More and more instructors used the entertainment of the game itself to attract students' attention, because of the learning board games had the advantages of unplugged and can promote learner interaction, therefore more instructors were trying to apply it to teaching activities(Wang, Chen, Hou & Li, 2017; Li, Wang, Chen, Kuo, & Hou, 2017). Gamification has been considered a new generation of trends (Yu-Ping Kang, Jung-Chin Liang, Yu-Chin Chai, 2014), this trend has changed the teaching habits of the past, try to integrate the emerging game-based learning into more formal courses, it can help the instructors to establish communication with students more effectively (Barzilai, & Blau, 2014). In addition, game-based learning can enhance learners' learning experience, there were also have significant outcomes (Connolly, Stansfield, & Hainey, 2011), the reason was that the nature of game-based learning can appeal students' interest in learning, and interest will bring students' motivation in learning. In the process of experiencing games, discover more interesting ways to learn (Embi, & Hussain, 2005), achieved the goal of strengthening learning (Chen,

2014). However, although game-based learning can improve learning motivation and learning effectiveness, but there were not have systematic record and analysis of the learning process (Adams, & Clark, 2014). In this study, we took the learning computer hardware and software interface for an example, developed and designed the RFID pairing games, and exploring learning process, flow and learning outcomes of students in the game-based learning, let the instructors understand students' learning problem, and then improve the teaching methods or give appropriate remedial teaching.

2. Literature Review

In recent years, pedagogy has changed greatly with the development of the times (Matsumoto, 2016), instructors had new ideas about the way of teaching, they were no longer just using traditional teaching modes such as blackboards and didactic, instead used the game way to teaching, and used the entertainment of the game itself to attract students' attention. This study hopes to increase the interest of students who are non-department of computer science backgrounds in learning computer hardware by the ways of game-based learning. Gamification has been considered a new generation of trends (Yu-Ping Kang, Jung-Chin Liang & Yu-Chin Chai,2014), this trend has changed the teaching habits of the past. Integrating games into education is what this study hopes to achieve, if can apply the trend of game-based learning to each type of teaching, then can bring the great assist to learning motivation. This study is mainly aimed at students who are non-department of computer science backgrounds, used the game-based learning and traditional learning two ways, and discussing whether the game-based learning is really better than the traditional learning, so that in the future can be applied to more teaching.

2.1 Game-based Learning

Prensky(2007) pointed out that there were twelve characteristics of digital game learning, each is entertaining, gameplay, regularity, target, human-machine interaction, results and feedback, adaptability, sense of victory, conflict competitive and challenging, problem solving, social interaction, image and plot. Integrate these features into teaching, thereby assisting students in learning, and through the challenge and sense of victory of the game, motivate students' motivation, and make happiness in an entertaining environment (Bawa, Watson, & Watson, 2018). Game-based learning is characterized by the integration of educational content into the game, and can also achieve the equal learning effect as traditional teaching (Wouters, van Nimwegen, van Oostendorp, & van der Spek, 2013), therefore, the game-based learning can also achieve the same teaching purpose. Hogle (1996) pointed out that the game has four advantages for learning, each is to cause the motivation and raise the interest, retention of memory, provide practice and feedbacks and can provide a high level of thinking, but for the effectiveness of game-based learning, usually depends on the student's goal set for the challenge of this game (Liao, Chen, & Shih, 2019), instructors must also pay attention to the game progress all the time, when students encountered problems during the game, instructors must provide appropriate assistance, ensure that students participate in the game fully.

2.2 Flow Experience

The flow is described the feeling of individual express their internal motivation(Csikszentmihalyi, 1975), flow experience is that a person is fully engaged in the activity, enjoy the process, and only respond to the goals of the activity (Csikszentmihalyi, 1985), and mentally accompanied by distortion of time and space, let individual self-awareness reduce. When the individual is in the flow experience, the spiritual will be concentrated, almost not be influenced by any feeling, and almost not find anything. As long as there is a passionate and positive response to the activity, it will make individuals unable to aware of the information that is not related to the activity, and the ongoing activity has become the purpose, that is flow experience (Csikszentmihalyi, 1997). This study was teaching by the way of game and combined with teaching elements, stimulated students' interest in learning by the appeal of the game itself, and let students in the flow experience, achieve the teaching purpose. Csikszentmihalyi (1990) points out that flow have nine traits: clear objectives, challenge and skill balance, concentrated on the

task, sense of control, combination of action and consciousness, ignore external, time distortion and self-achievement experience. As long as there are nine traits, naturally, it will enter the flow. Csikszentmihalyi (1997) consider that there are three main characteristics of generating the flow:1. Clear objectives: Individuals have a clear goal for what they want to do, then easy to enter the flow state. 2. Immediate Feedback: Individuals have immediate feedback on what they want to do, can also make yourself in the flow. 3. Challenge and Skill balance: Challenges and skills must be match, if the challenges is higher than the skills, then will feel anxious about the game, if the challenges is lower than the skills, then will make individuals feel board, if your ability is low and the challenge is too low, then will generate a fairly shallow flow, therefore, it's necessary to challenge the appropriate challenge with sufficient ability, can make individuals wholeheartedly enter the game, and then generate the flow.

3. Methods

3.1 System Framework

This study is based on the self-developed and designed RFID educational board game system "Hello, Computer !" as the main experimental tool, and system architectures as shown in figure 1, used Arduino microprocessor as the system core, and combined with RFID, buzzer, button, color LCD and other Arduino peripheral modules, used the SD card to store the game process. This system used the RFID-RC522 module as the game card and sensing interface for the game, because each RFID card has a unique UID code feature, therefore, set all the card functions in the game to RFID cards, through sensing and identifying each RFID card, verify whether the cognitive design is meet by pairing and combining. At the end of game, using the data conversion program of our system, convert the game data into a series of visual charts, and provided it to instructors, so that instructors can quickly and effectively understand students' learning situation after using this system. In this study, using the Arduino as our main board, and set the full of game mechanisms in the system, so that it became the different game cards. During the game, in response to the game mechanism set by the system, through the sensing and use LCD as a game screen, as shown in figure 2, show the news and images in the game, and connect the buzzer to emit correctly or not sounds. Students use RFID game cards to play for the whole game, and this system hereby collects all the data from game processes, conduct subsequent analysis and feedback to instructors.
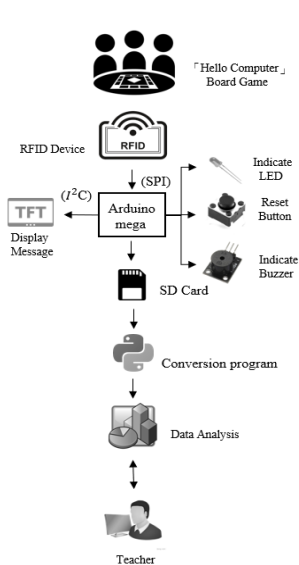
Fig1. System Framework
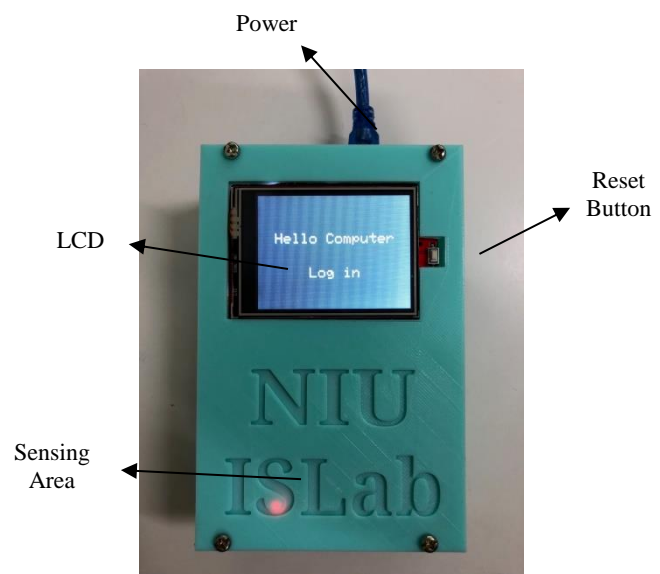
Fig2. System Interface

3.2 Research Participants

This study's course took the "Information Literacy and Application" which is the compulsory general education in a university in northern Taiwan, the course is a single semester and two credits. Implementing "Programming" course for ten weeks of eighteen-week course planning, and implementing computer software and hardware interface peripheral teaching for three weeks, two hours a week, participants in the experiment for a total of forty people in the first year of the university department of foreign language, and divided into two groups, the experimental group of twenty-three people and control group seventeen people, and all the participants are students who non-department of computer science backgrounds. This study used the pretest and posttest experimental design, in the seventeen members of control group, divided into 5 groups, two groups have 4 people, and three groups have 3 people, control group adopted the "Group Discussion", as shown in figure 3, this study established 5 LINE groups and joined each group member, the tester issues a question, and students discusses and answers the discussion question within the group. In the twenty-three members of experimental group, divided into 6 groups, one groups have three people, and five groups have four people, the experimental group used the game-based learning by the self-developed "Hello, Computer !" learning board game, as shown in figure 4, beside to the pretest and posttest, also implement a flow questionnaire, the content of the test is based on the flow experience questionnaire compiled by Pearce (2005) et al., the questionnaire contains 8 questions including "entertainment", "concentration" and "control"(Cronbach α = 0.907), and the answer is scored using a Likert scale 5-point scale.

Fig3. Control Group do the Group Discussion   Fig4. Experimental Group do the Learning Board Game

3.3 Group Discussion

In the way of the teaching, the control group used the traditional group discussions, we randomly divided the members of the control group into 5 groups, and organized the relevant knowledge of the computer peripheral into 7 questions. At the beginning of the course, we sent a discussion question to the group, and the discussion time is 10 minutes, during this time, students of the control group discussed each other and answered the question, and after the time is up, the next discussion question will be sent. If students have any questions or need to help during the discussion, we also have member answering questions within the group. Through these discussion questions are selected by this study, and able to get help immediately when confusing, so as to improve students learning outcomes.

3.4 "Hello, Computer！"Learning Board Game

This study took the computer peripheral as an example, we divided computers into software and hardware two categories, included the components within the motherboard. Used the form of sensing RFID game card pairing to play the game, the cards are divided into five types, and illustrate as follows: First type: User Card, as shown in figure 5, this is the most important card for this system. It represents the identity ID of each player in the system, and it will automatically record all the data of the player

during the game. When player starts, must be used the player's own User Card first, and waiting for the system to confirm identity to enter game screen, then can start the pairing. Second type: Green Card, as shown in figure 6, this type contains the hardware interface and system program of the computer. After the system successfully identifies the ID, this card can be sensed on the game screen, and entering the "Green Card Mode". Third type: Blue Card, as shown in figure 7, this type contains the hardware peripheral and program language of the computer. When system entering the "Green Card Mode", then can sense this card, and the buzzer and LCD will show the result of the pairing after sensing. Fourth type: Reward and Penalty Card, as shown in figure 8, after system show the result of pairing, if successful, then you can draw a reward card, otherwise, draw a penalty card. This card is used in the game screen, then can add or deduct points. Fifth type: Red Card, as shown in figure 9, this type contains the necessary components in the host computer. When the player pair successfully draws the reward card, have probability will get it, and used in the game screen, then can add double points, and collect a certain number can win earlier. The detailed game rules are as follows:1. Divide green and blue into 2 card piles, Red Card pile, Green Card recycle pile, and Blue Card discard pile. 2. At the beginning, randomly give 1 Green Card and 3 Blue Cards for each player. 3. Before starting the round, player must first log in to the player's User Card. 4. Players can only login to the "Green Card Mode" once per round. 5. Before you login the Blue Card for pairing, players must login the Green Card. 6. Before logging in the Green Card, you can choose to draw out one Blue Card or randomly change the Green Card once. 7. Matching in your own round. 8. The same Green Card can be paired with Blue Card infinitely, if successful, you can continue to pair, if fail, you must recycle the Green Card, discard the Blue Card, and end of round. 9. If you pairing fail and result in you have no Green Card can use, in the next round, the player only can draw out the Green Card. 10. If your Blue Card and Green Card paired successfully, then you can get the Blue Card's score. 11. The Red Card doesn't need to be paired, you can use after logging in the User Card. 12. The Green Card recycle pile cannot be drawn out. If there is no Green Card in the Green Card pile, then can put back the Green Card from the Green Card recycling pile. If there is no Blue Card in the Blue Card pile, then the game is finish. 13. If you collect the CPU, Motherboard, Power Supply, HDD and any Operation System in advance, then you can win directly
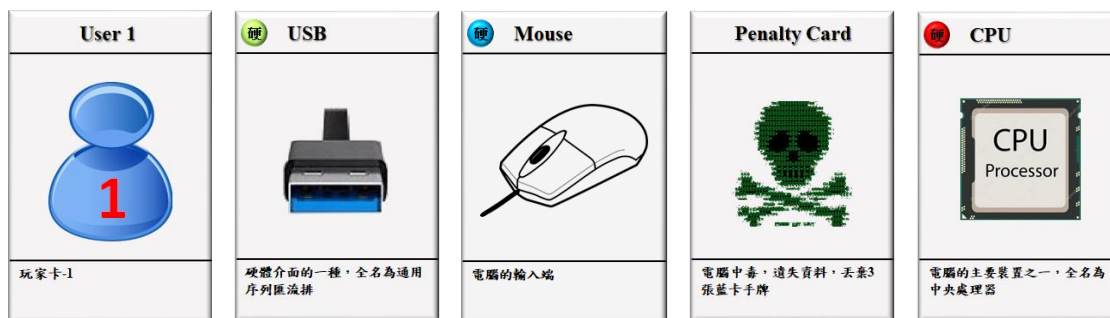
| Fig5.User Card | Fig6.Green Card | Fig7.Blue Card | Fig8.Penalty Card | Fig9.Red Card |

4. Results

4.1 Learning Outcomes

In this study, the experimental group used the "Hello, Computer !" learning board game, and control group used the traditional group discussion teaching, improve students' cognition and application of computer peripherals. This study adopted the Wilcoxon signed rank test, analysis of the pretest and posttest scores of the experimental group and the control group respectively, and practicality of teaching methods, observe whether the flow and the learning outcomes of the experimental group are different from the control group. As shown in table 1, both of the experimental group and control group have significant progress(experimental group $z = -3.96$, $p = .000 < .05$, control group $z = -3.02$, $p = .003 < .05$), indicate that after the students in the experimental group and the control group separately perform the "Hello, Computer !" learning board game and the group discussion activities, they are all have significant progress of learning outcomes for the computer peripherals, about the comparison of

progress extent, posttest average score of the experimental group improved by 19.83 points, although the control group also has a significant improvement, but compared to the experimental group, control group only increased by 8.3 points. Therefore, it was found that the learning outcomes of game-based learning was better than traditional group discussion teaching in this study.

Table 1

Pretest and Posttest Wilcoxon signed rank test of Experimental Group and Control Group

Group	Number of Participants	Stage	Average	SD	z	p
Experimental	23	Pretest	22.91	14.95	-3.96	.000
	23	Posttest	42.74	16.65		
Control	17	Pretest	32.00	12.65	-3.02	.003
	17	Posttest	40.30	13.58		

P <.05

4.2 Teaching Practicality

On the other hand, as shown in table 2, teaching practicality analysis of the teaching methods in the experimental group and the control group (EP4: Before playing this board game, how much do you know about the computer hardware interface and programming language?, EP5: After playing this board game, how much do you know about the computer hardware interface and programming language?, CP4: Before the group discussion, how much do you know about the computer hardware interface and programming language?, CP5: After the group discussion, how much do you know about the computer hardware interface and programming language?), the results show that, the experimental group consider the "Hello, Computer !" learning board game has significant differences in the cognition of the computer peripherals (z = -3.27, p= .001< .05), but the control group consider there is no significant difference in group discussion for teaching (z = -1.00, p = .317> .05). As a result, this study found that using the "Hello, Computer !" learning board game, it can more effectively enhance students' cognition of the computer peripherals.

Table 2

Teaching Practicality Wilcoxon signed rank test of Experimental Group and Control Group

Group	Number of participants	Questionnaire	Average	SD	z	p
Experimental	23	EP4	2.26	.92	-3.27	.001
	23	EP5	2.91	.60		
Control	17	CP4	2.47	.62	-1.00	.317
	17	CP5	2.59	.71		

P <.05

4.3 Flow Experience

In respect of the flow experience, compare the difference between the "Hello, Computer !" learning board game and the traditional group discussion for the experimental group and the control group respectively, as shown in table 3, the average of the experimental group in the flow experience dimension is 3.81, it is higher than the median 3-point which in the 5-point scales, and the average of the control group in the flow experience dimension is 2.90, it is lower than the median 3-point which in the 5-point scales. This result indicates that when the experimental group is conducting the "Hello, Computer !" learning board game teaching activity, all have a phenomenon of entering the flow, representing the experimental group with a high degree of concentration in game-based learning activities, compared to the control group, there is no obvious phenomenon of entering the flow. Therefore, this study indicated that when the experimental group is during game-based learning, all can focus on the game activities, this can help students' improve learning motivation.

Table 3

Average and Standard Deviation of Flow Experience Questionnaire in the Experimental Group and Control Group

Dimension	Experimental Group (N=23)		Control Group(N=17)	
	Average	SD	Average	SD
Entertainment	3.88	0.60	2.84	1.21
Concentration	3.86	0.57	2.88	1.14
Control	3.63	0.63	3.00	1.22
Flow experience	3.81	0.53	2.90	1.15

4.4 "Hello, Computer！"Data Feedback

During the game, this system will automatically record all the game processes of students. After the game, integrate all the system's game data, and convert to a visual chart, feedback to instructions as a reference for teaching. The feedback content is divided into interface and user mode two categories, and illustrate as follows: 1. The game way is pairing, represent the computer interface and peripherals are matched each other (e.g: SATA and HDD). This game divides the pairing interface into SATA, USB, PCIe, PS/2, TRS, Wired Network, Wireless Network, VGA, DVI, HDMI and divides the system program into Compiler, Assembler, Interpreter, a total of thirteen kinds. This system can calculate the success rate of each interface being paired to make a pie chart, and instructions based on the success rate of various interfaces, understand students' cognitive level of different computer peripherals. Figure 10 is the PCIe interface with the lowest pairing success rate among the 13 interfaces in the experiment, PCIe is mainly applied to the use of components in the motherboard, for the non-Department of Computer Science backgrounds students, they may have less chance to know. Figure 11 is the USB interface with the highest pairing success rate among the 13 interfaces in the experiment, USB is very familiar for most students, the reason is that USB is currently the most common to use. This system can also analyze individual game data for each student, make a bar chart and give feedback to instructions, as shown in figure 12, so as to understand students' cognitive level and learning situation.
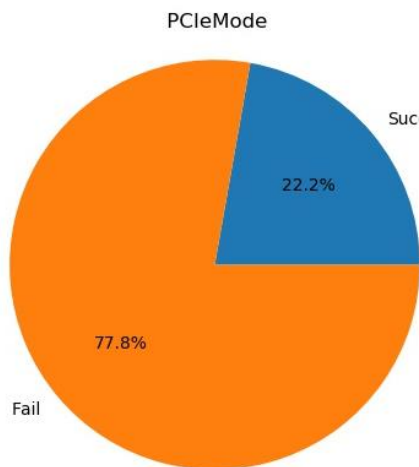
Fig10. Low Success Rate   Fig11. High Success Rate
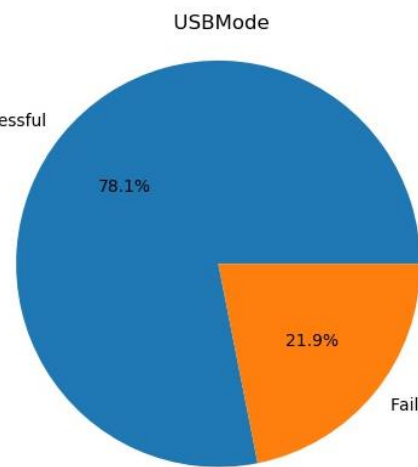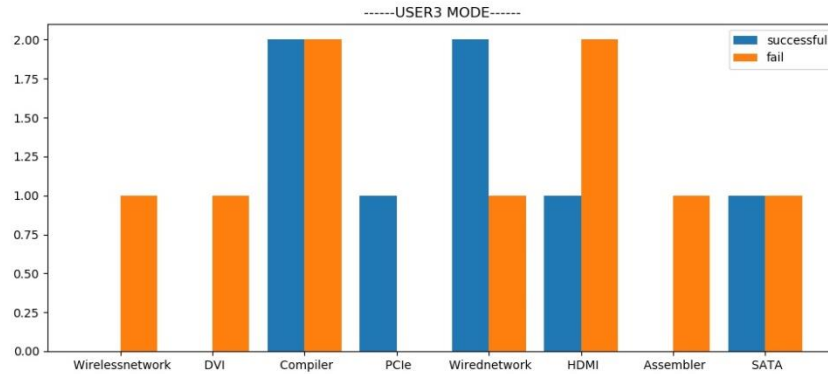
Fig12. Student's Game Data

5. Conclusions

This study used the "Hello, Computer !" learning board game and traditional group discussion two teaching methods, exploring whether the difference between the both on cognitive of teaching for the computer peripherals, and their flow experience. The study found that, whether it's the experimental group or the control group, both of all have significant effect in learning outcomes for the computer peripherals, but compare the progress extent of two groups from pretest and posttest, the experimental group progress score is higher than the control group score of 12. This study also pointed out that experimental group think that using "Hello, Computer !" learning board game can help them improve their cognition of computers. However, the control group think that group discussion has no great effect on cognitive teaching of computers, representing to use game-based learning by this board game has a significant effect on cognitive teaching of computers, but the group discussion did not. Furthermore, about the degree of flow experience, the average of flow experience by the experimental group is 3.81, is higher than median 3, show that using the this learning board game to teach, students all in the high degree of flow, but the average of flow experience by the control group is 2.90, is lower than median 3, representing the flow is not very well. In terms of system mechanism, in addition to the basic one-to-one pairing mechanism, this system also set the multi pairing mechanism of the cards, so that students can also learn higher levels of cognitive content in the game.

6. Future Work

At present this system is only used for the computer peripherals, depend on set each RFID card as a game card for the computer peripheral, so this study hopes to apply the board game system to different teaching. According to the needs of instructions, set different teaching elements in the RFID cards. In this way, any teaching that can be done in a matched manner, all can be applied to this system.

References

Adams, D. M. & Clark, D. B. (2014). Integrating selfexplanation functionality into a complex game environment: Keeping gaming in motion, Computers & Education 73(1), 149-159.

Barzilai, S. & Blau I. (2014). Scaffolding game-based learning: Impact on learning achievements, perceived learning, and game experiences, Computers & Education 70(2), 65-79.

Bawa, P., Watson, S. L., & Watson, W. (2018). Motivation is a game: Massively multiplayer online games as agents of motivation in higher education. Computers & Education, 123(2), 174-194.

Byron R. & Leighton R. (2009). Total Engagement: Using Games and Virtual Worlds to Change the Way People Work and Businesses Compete. Harvard Business Press, 177.

Chen, Z. H. (2014). Exploring students' behaviors in a competition-driven educational game, Computers in Human Behavior 35(1), 68-74.

Connolly, T. M., Stansfield, M., & Hainey, T. (2011). An alternate reality game for language learning: ARGuing for multilingual motivation. Computers & Education, 57(1), 1389-1415.

Csikszentmihalyi, M. (1975). Beyond Boredom and Anxiety. San Francisco: Jossey-Bass.

Csikszentmihalyi, M. (1985). Emergent Motivation and the Evolution of the Self. In D. A. Kleiber & M. Maehr (Eds.), Advances in Motivation and Achievement (Vol. 4, pp. 93-119). Greenwich, CT: JAI Press.

Csikszentmihalyi, M. (1997). Finding flow: The psychology of engagement with everyday life. New York: Harper Collins.

Csikszentmihalyi, M. (1990). Flow: The psychology of optimal experience. New York: Harper & Row.

Embi Z. C. & Hussain H. (2005), Analysis of local and foreign edutainment products - An effort to implement the design framework for an edutainment environment in Malaysia. Journal of Computers in Mathematics and Science Teaching, 24(1), 27-42,.

Forst, J. L., Wortham, S. C., & Reifel, S. (2001). Play and Child Development. New Jersey: Prentice Hall

HogleJ. G., (1996). Considering Games as Cognitive Tools: In Search of Effective "Edutainment" University of Georgia Department of Instructional Technology.

Liao, C.-W., Chen, C.-H., & Shih, S.-J. (2019). The interactivity of video and collaboration for learning achievement, intrinsic motivation, cognitive load, and behavior patterns in a digital game-based learning environment. Computers & Education, 133(2), 43-55.

Lieberoth, A. (2015). Shallow Gamification, Testing Psychological Effects of Framing an Activity as a Game, Games and Culture 10(3), 229-248

Matsumoto, T. (2016). Motivation Strategy Using Gamification. Creative Education, 7(10), 1480-1485.

Matsumoto, T. (2016). The Flipped Classroom Experience of Gamified. Creative Education, 7(10), 1475-1479.

Pearce, J. M., Ainley, M., & Howard, S. (2005). The ebb and flow of online learning. Computers in Human Behavior, 21(5), 745-771.

Prensky, M. (2007). Digital Game-Based Learning. New York: McGraw-Hill.

Wang, S. M., Chen, K. T., Hou, H. T., & Li, C. T. (2017). A science history educational board game with augmented reality integrating collaborative problem solving and scaffolding strategies. The 25th International Conference on Computers in Education, Christchurch, New Zealand.

Wang, L., et al. (2015). Mining Experiential Patterns from Game-Logs of Board Game, International Journal of Computer Games Technology, 1-20.

Wouters, P., van Nimwegen, C., van Oostendorp, H., & van der Spek, E. D. (2013). A meta-analysis of the cognitive and motivational effects of serious games. Journal of Educational Psychology, 105(2), 249–265.

Kang, Y. P., Liang J. C., Chai Y.C. (2014). An Innovative Design of Board Game Device, *International Journal of Kansei Information*, 125-130.

Designing and evaluating a mobile educational game "Void Broken 2.0" for history instruction

Yi-Shiuan CHOU[a], Huei-Tse HOU[b*], Chien-Lun SU[b] & Kuo-En CHANG[a]
[a]*Graduate Institute of Information and Computer Education, National Taiwan Normal University, Taiwan*
[b]*Graduate Institute of Applied Science and Technology, National Taiwan University of Science and Technology, Taiwan*
*hthou@mail.ntust.edu.tw

Abstract: This study adopted Theory of Cognitive Development in the design of an educational game for Chinese history learning, Void Broken 2.0©. An empirical study was conducted to explore whether this game can help students improve their history learning performance and have good evaluation results. Sixty-six high school students (24 boys and 42 girls) participated in this study with an average of 16.26 years old. The results showed that the student's history learning performance improved significantly after playing the game and the mean scores of game evaluation in all dimensions were above the median. Although male students perceived the game as more useful and easier to use compared to female students, the history learning performance and the evaluation of the game elements showed no significant of gender differences.

Keywords: game-based learning, theory of cognitive development, history instructions

1. Introduction

Traditional history instructions usually focus on memorizing names and date. Therefore, many students consider history a boring subject unrelated to their lives, resulting in their low learning motivation (Schul, 2015). For example, there are a large number of events and figures during the turbulent period of modern Chinese history (A.D. 1644-1911). Their names and relations are difficult to memorize for students, but they are necessary for Chinese history learning. Without enough background knowledge, students may have difficulties in history learning (Monem, Bennett, & Barbetta, 2018; Okolo, 2005). Moreover, students should develop their inquiry skills to analyze complicated ancient documents (Shanahan, Bolz, Cribb, Goldman, Heppeler, & Manderino, 2016).

On the other hand, one of the advantages of traditional history instructions is the efficient reorganization of historical contents and materials (Schul, 2015). Some researchers believe that students interacting with teaching materials actively have better learning performance (Monem, Bennett, & Barbetta, 2018). Therefore, if we add game elements (Prensky, & Thiagarajan, 2001; Alessi, & Trollip, 2000) to help students easily interact with the learning materials, they may be more interested in the analyzing process of historical data. The process of human knowledge development is explained by Piaget (Piaget & Cook, 1952), which can be the foundation for the learning material design. According to Piaget, a cognitive schema is the basic unit of human memory, which changes or reforms through the adaptation process. The adaptation process includes assimilation, accommodation, and equilibrium components.

This study intends to integrate cognitive schema, assimilation, accommodation, and equilibrium components into an educational game for Qing dynasty history learning, Void Broken 2.0. In the game design, the cognitive schema includes the main elements of the game, the relations among characters, and the historical events during that period; the adaptation process includes the mechanism for information match and acquisition. The students are expected to acquire history knowledge efficiently by analyzing and inquiring plenty of historical data in this game.

1.1 Research Questions

This study has three research questions investigating whether Void Broken 2.0 helps students improve their history learning performance and whether the students enjoy their learning process. The educational game-based learning design also should consider gender differences (Lukosch, Kurapati, Groen, & Verbraeck, 2017). Therefore, we also explore whether this game is suitable for students of different genders.

Do students have a better history learning performance after playing Void Broken 2.0?

Do students show high evaluations for the game after playing Void Broken 2.0?

Is there any effect of gender differences on students' history learning performance or game evaluation after the students play Void Broken 2.0?

2. Methodology

2.1 Participants

The sampling method of this study was convenience sampling. From the researcher's lecture classes, the participants were freshmen of high school in northern Taiwan. The average age of the participants was 16.26, including 24 boys (36%) and 42 girls (64%). The total number of the participants was 66 and they never took the formal courses about the content in this experiment. Before the day of the experiment, students were divided into a group of two or three students, and there were 32 groups in total.

2.2 Research Design and Procedure

In this study, a single group pretest design (pre-experimental design) was used, and the same experiment was performed in two classes. Each experiment began with a 10-minute pretest, and then the researcher explained the game for 10 minutes. Each group also received a book with game instructions. After the students understood the game mechanism, they played the game for 50 minutes without the novice guide. Subsequently, the students were given a 10-minute posttest and a 10-minute game evaluation questionnaire (Figure 1). The experiment took about 90 minutes in total. The game was played by the same group student members, while the pretest, posttest, and the game evaluation questionnaire were completed by each individual student.

The game system was preloaded into 8-inch mobile devices, which could be applied to the general traditional teaching environment without network. During the experiment, each group of the students received a mobile device with the opening scene of the game on the screen. The researchers only helped the students with technical problems that were not related to game contents, e.g., the game quit unexpectedly. The students could only discuss with other members from the same group rather than with the members from different groups during the gameplay. Except for the gameplay stage, each individual student completed all the tests and the questionnaire by himself or herself and could not look for any data or discuss with others.

Pretest	**Demonstration**	**Gameplay**	**Posttest**	**Evaluation**
10 mins	10 mins	50 mins	10 mins	10 mins
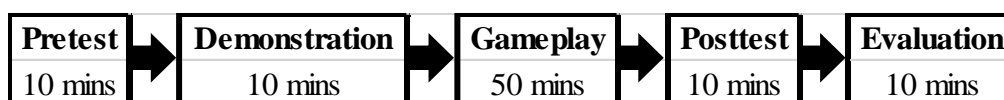
Figure 1. Procedure of the experiment.

2.3 Educational Game for History Learning: Void Broken 2.0

This study used HTML5 as the development tool and modified the Void Broken, which had been created in 2016. The new version was called Void Broken 2.0, with its game mechanism and core gameplay adjusted based on the learning theory. We also added more historical information and pictures to connect the learning theory with the game mechanism and learning materials. The game was completed in 2017. The game story was about a time-space traveler, who accidentally returned to the ancient Chinese Qing Dynasty. The student played the traveler to match the correct figures and events. By using a special device, students could conquer all the battles and go back to reality.

According to the curriculum guidelines of domestic high school, the historical data was designed by the researcher, a high school history teacher. Because of the limited experimental time, the experimental version of the game only included five historical events and three difficulties, but the original number of 50 historical figures remained unchanged.

2.3.1 Cognitive Development Theory and Game Mechanisms

The figures and events in this game were designed as the fundamental units for players to memorize and acquire. Realizing the relations among them was necessary for history learning, and the players needed to match the correct relations in the game.

The students were expected to experience the adaptation process during this relation matching. For instance, when the students played the game at the beginning, they may already notice certain incorrect relations among characters and events, leading to the difficulties in battles. The student players could not get to the next challenge if the match was few correct. The students' cognitive schema that the incorrect relations did not work in battles and needed to be fixed for the next challenge led to the students' accommodation. After some trials and errors, the students may find out that they needed more descriptions of the relations and they could acquire the information from the historical data in the game. The students' cognitive schema changed and reformed when they were acquiring new knowledge, which was called assimilation. After the students went through all the challenges without difficulties, they were skilled in matching and their cognitive schema worked without errors. This was called equilibrium, which was the result of our expectation.

Table 1

Components of Cognitive Development Theory

Components	Players' Behaviors
Cognitive Schema	Realizing characters, events, and their relations The researchers used characters, events, and their relations as the pretest and posttest.
Adaptation Processes	Matching characters to events based on their relations It is a process for players to connect characters and events.
Accommodation	Feeling difficult to match the relations between characters and events The students' cognitive schema needed to be fixed for the next challenge.
Assimilation	Acquiring information about events, characters, and their relations The students' cognitive schema changed when they were acquiring new knowledge.
Equilibrium	Feeling easy to match the relations between characters and events The students were skilled in matching and their cognitive schema worked without errors.

2.3.2 Characters, Events and Relations

In this study, fifty important figures of the Qing Dynasty (A.D. 1644-1911) were designed as in-game decks. The important five historical events were designed as game battles (Figure 2), which were Taiping Kingdom of Heaven, Self-Strengthening Movement, First Sino-Japanese War, Nien Rebellion, and Siege of the International Legations. Each battle had three difficulty levels, depending on the number of cards, the accuracy of pairing requirements, the level of guardian monsters, and the number of rounds, etc.

There were two kinds of relations in the game. One was the characters' identities and the other was the relations among characters and events. The characters' identities referred to the statuses of historical figures in the Qing Dynasty. There were four statuses, including Royal Family, Political Minister, General Military, Foreign Forces or Anti-Government Elements. For instance, Empress Dowager Cixi was classified as a royal family because of the pedigree of the ruling nation and the highest predominant class. Hong Xiuquan was classified as an anti-government element because he led The God Worship armed group to carry out military activities against the Qing government.

The relations among figures and events included whether the figure's lifetime span was across the event period (called contemporary) or not (called irrelevance), or the person had an important influence on the event directly (called participant). For example, Hong Xiuquan was born in 1814 and died in 1864. The event of the Taiping Kingdom of Heaven occurred between 1851 and 1864. Hong Xiuquan was the leader of the God Worship armed group and led the troops to take over Nanjing (an important city at that time in southern China). Consequently, the relation between Hong Xiuquan and the Taiping Kingdom of Heaven was seen as a participant.

The event of the Nien Rebellion occurred between 1853 and 1868, which overlapped part of Hong Xiuquan's lifetime span, but he did not make a significant impact on this event in history. The relation between Hong Xiuquan and the Nien Rebellion was considered contemporary. Other people whose life span did not overlap the event were named as an irrelevance.

Figure 2. The main interface of Void Broken 2.0.

2.3.3 Matching Mechanisms

Matching is a process for players to connect characters and events. Players placed the cards in hand on the 3X3 grid battle board (Figure 3), and the system calculated the score according to the correct relations between the characters and the events. The final score in the round equaled the power against the guardian monster.

The vertical line on the battle board was the position to check the relations among the cards and the battle, which was called the timeline condition. The horizontal row was the position to test the identity of the cards, which was called the status condition. Any position would test both conditions at the same time. If a player placed a card on the battle board, but no condition was activated, the card was going to break.

To encourage the players to challenge the accuracy of more conditions, we designed a bonus frame, which was only activated by dual conditions and appeared on the battle board randomly. The number of bonus frame was one or two, depending on the difficulty level of the battle. It is a necessary skill for the students to get into the next level because of the high health point of guardian monsters and the limited rounds. When the players were getting familiar with the characters and events, they were able to activate more conditions and had more opportunities to overcome the challenges.

In addition, we also hoped that students can learn more from matching, so the cards on the battle were different without repetition every round. The cards on the battle were based on the deck built by the players before the battle. The deck needed eight or sixteen cards, depending on the difficulty level. At the easiest level, the players had to build eight cards into their deck with three cards in hand every

round. At the other difficulty levels, the players had to build sixteen cards into the deck with five cards in hand every round.

This design helped the players to understand a certain number of characters; otherwise, they may lose the battle because of some unfamiliar cards. This design also encouraged the players to master the relations and to use more cards, so that the students could learn more things as their prior knowledge in history.
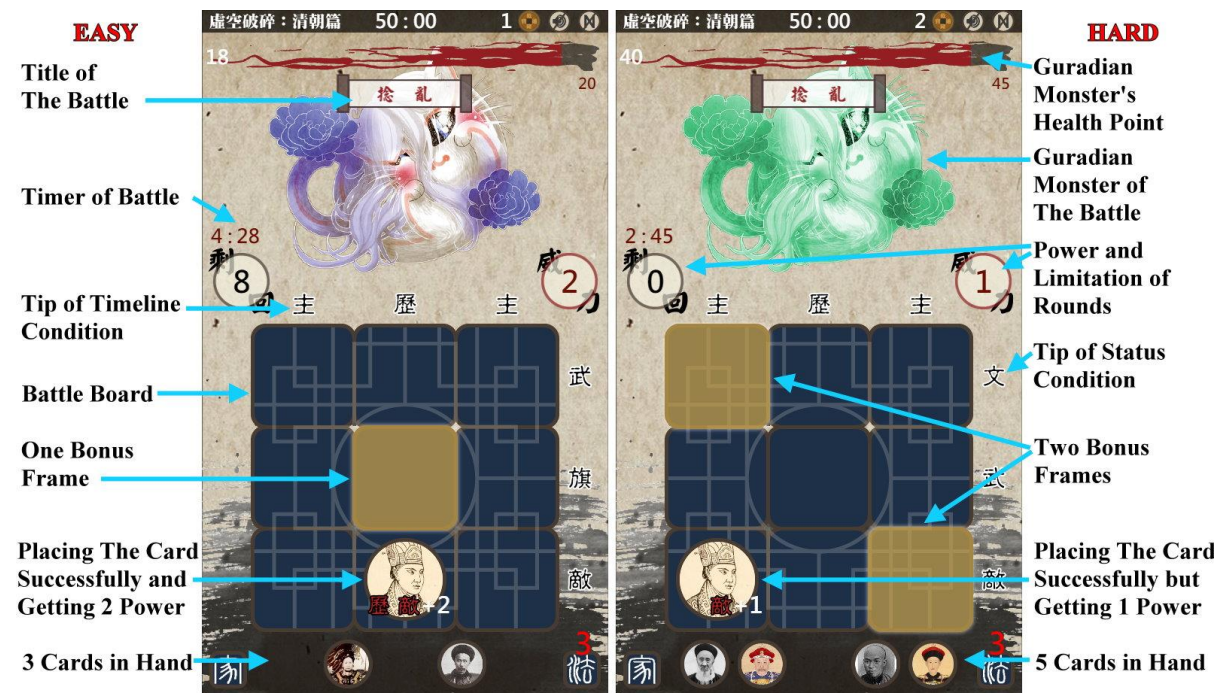
Figure 3. The battle interface of Void Broken 2.0.

2.3.4 Acquired Information Mechanisms

The battles designed in this study was based on the location of historical events in the ancient Chinese map of the Qing Dynasty (Figure 2). Players started a battle by clicking the title of events on the map. The students could read the biography of characters and the description of events in the game (Figure 4).

Figure 4. The information of events and characters.

15

The biography of characters contained the name, picture, lifetime and a brief introduction. Players could decide the suitable cards for certain battles based on the clues in the biography. The description of the events included the title, picture, and descriptive information. Players could decide the event for their deck based on the clues in the descriptions. The players were expected to have high learning motivation and reform their cognitive schema by analyzing those historical data in the game.

2.4 History Learning Performance Evaluation

The history learning performance evaluation was developed by the researchers to test students' history learning performance after they played the game. The researchers used participants' relation matching items as the pretest and posttest. There were five events and 50 figures in the game. The students should answer the number of figures in each event in the limited answer slots. The total score of the evaluation was 48 points and each correct answer received one point. The topics of the pretest and posttest were exactly the same. In order to reduce the memory effect of students, the order of events in the pretest and posttest was different, but the number of figures remained the same.

2.5 Game Evaluation Questionnaire

This study used the game evaluation questionnaire of Hou and Chou, (2011) and made a slight modification according to the need of this study to evaluate the game system. The questionnaire was a 5-point Likert scale (1=strongly disagree, 2=disagree, 3=agree and disagree are equal, 4=agree, and 5=strongly agree). It investigated the perceived usefulness, perceived ease of use (Davis, 1989), and game elements evaluation (Prensky, & Thiagarajan, 2001; Alessi, & Trollip, 2000) by the students. The internal consistency was .90 (Cronbach's α = .899). In 2012, Chou et al. (Chou, Hou, Yu, Lee, Wu, Yang, & Liao, 2012) used the same evaluation questionnaire with the reliability of .783, which was considered acceptable by DeVillis (1991).

3. Data Analysis and Results

3.1 History Learning Performance

The first research question in this study investigates whether the students have better history learning performance after playing Void Broken 2.0. We conducted a dependent sample t-test on the history learning performance with the students' pretest and posttest scores. As shown in Table 2, the student's history learning performance improved significantly after the game (p<.001, t=9.58). This finding may suggest that the students acquired more knowledge about the relations among characters and events after the gameplay. The results showed that the average score of the students' progress was 5.74 points (the maximum progress score in the sample was 18 points). This indicated that the students could answer correctly more than 5 items after the 50-minute gameplay.

Table 2

The Paired-Samples t Test of History Learning Performance

	Posttest (N=66)		Pretest (N=66)			
	M	SD	M	SD	*t*	*p*
History Learning Performance	13.62	5.66	7.88	4.38	9.58***	.000

*** p < .001

3.2 Game Evaluation Questionnaire

The second research question investigates the students' evaluations of the game. According to the game evaluation questionnaire, the results showed that the means in all dimensions were above the median (median=3), as shown in Table 3. This finding suggests that the game was perceived useful in history learning and not difficult to play. In addition, the students were satisfied with the game elements

designed in the game. Generally speaking, this result indicates that the game designed in this study is an enjoyable history educational game.

Table 3

The Mean and Standard Deviation of Game Evaluation Questionnaire

Dimensions	M	SD
Overall Game Evaluation	4.29	0.53
Perceived Usefulness	4.29	0.58
Perceived Ease of Use	4.14	0.70
Game Elements	4.41	0.63

3.3 *Gender Differences*

The third research question investigates whether the gender factor affects the students' history learning performance and game evaluation. According to the results shown in Table 4, gender differences were not found in students' history learning performance but found in the overall game evaluation. In more depth, the effect of gender was found in the two dimensions of the students' game evaluation (perceived usefulness, and perceived ease of use). Compared to female students, male students believed that the educational game was more helpful in their learning, and it was easier to use.

Table 4

The Independent-Samples t Test of History Learning Performance and Game Evaluation between Gender Groups

	Male (N=24)		Female (N=42)			
	M	SD	M	SD	*t*	*p*
History Learning Performance	4.21	4.10	6.62	5.10	-1.98	.052
Overall Game Evaluation	4.49	0.49	4.18	0.53	2.35*	.022
Perceived Usefulness	4.54	0.51	4.14	0.57	2.83**	.006
Perceived Ease of Use	4.38	0.68	4.01	0.69	2.09*	.041
Game Elements	4.52	0.65	4.35	0.61	1.10	.276

* $p < .05$, ** $p < .01$

4. Discussion, Conclusion and Future Works

Based on the findings in this study, we believe that the Void Broken 2.0 can help students learn more about modern Chinese history of Qian Dynasty. From the results of history learning performance, the students can understand more important figures in history. When playing the game, the students can discuss, explore, and analyze historical materials with their team members. This group work may help improve their knowledge acquisition process and could be practiced in the history classroom.

According to the results of high scores in the game evaluation, it seems that the students enjoy the game. This information also indicates that we can bring students back to the classroom and focus on learning. The teacher doesn't have to talk much and the students can focus on the game. From the experience of the researchers in the experimental field, the students are very active and don't feel that they are taking part in a boring history class. Many students want to play the full version of the game in the future.

However, we are also worried about whether such a design is biased to certain game groups. In terms of gender differences, it seems that the game was viewed as more useful and easier to use by male students. It is probably because male students are more familiar with game designs and operations. However, the students' history learning performance and the game elements evaluation are not

significantly different between male and female students. This suggests the game can be useful and enjoyable for students' learning regardless of their genders.

Based on the findings in this study, it seems that the game may improve the students' history learning performance and enhance their learning motivation. However, whether the students' high-level cognitive process can be facilitated by the game remains unknown in this study. We are also curious about the collaboration and problem-solving process of students in the game. For future studies, it may be necessary to integrate other methods for data triangulation. For example, researchers can analyze the students' high-level cognitive behaviors with the system operation records and the discussion data of the students. This may help explain the students' high-order cognitive thinking process (Hou, Yu, Chiang, Lin, Chang, & Kuo, 2019) and related issues.

Acknowledgements

References

Alessi, S. M., & Trollip, S. R. (2000). *Multimedia for learning: Methods and development.* Allyn & Bacon, Inc..

Chou, Y. S., Hou, H. T., Yu, M. C., Lee, H. J., Wu, H. S., Yang, Y. T., & Liao, Y. J. (2012, March). Running Tommy©: Developing a Digital Adventure Game Based on Situated Learning to Promote Learners' Concepts of Earthquake Escape. In *2012 IEEE Fourth International Conference On Digital Game And Intelligent Toy Enhanced Learning* (pp. 156-158). IEEE.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly*, 319-340.

DeVillis, R. F. (1991). *Scale development: Theory and applications.*

Hou, H. T., & Chou, Y. S. (2011). Designing a Digital Adventure Game Integrating Instant Feedbacks with Simulation Manipulation to Promote Learners' Knowledge of Computer Hardware. In *Work-in-Progress Poster of the International Conference on Computers in Education: ICCE 2011* (p. 41).

Hou, H. T., Yu, T. F., Chiang, F. D., Lin, Y. H., Chang, K. E., & Kuo, C. C. (2019). Development and Evaluation of a Mind tool-based Blog Learning Environment for promoting learners higher order Cognitive thinking in online Discussion activities: Analysis of Learning Effects and Cognitive Process, *Journal of Educational Computing Research.*

Lukosch, H., Kurapati, S., Groen, D., & Verbraeck, A. (2017). Gender and Cultural Differences in Game-Based Learning Experiences. *Electronic Journal of e-Learning, 15*(4), 310-319.

Monem, R., Bennett, K. D., & Barbetta, P. M. (2018). The Effects of Low-Tech and High-Tech Active Student Responding Strategies during History Instruction for Students with SLD. *Learning Disabilities: A Contemporary Journal, 16*(1), 87-106.

Okolo, C. M. (2005). Technology and social studies instruction for students with mild disabilities. *Handbook of special education technology research and practice*, 623-641.

Piaget, J., & Cook, M. (1952). *The origins of intelligence in children* (Vol. 8, No. 5, p. 18). New York: International Universities Press.

Prensky, M., & Thiagarajan, S. (2001). Digital Game-Based Learning, Paragon House, St. *Paul, Minnesota, USA.*

Schul, J. E. (2015). Pedagogical triangulation: The mergence of three traditions in history instruction. *The Social Studies, 106*(1), 24-31.

Shanahan, C., Bolz, M. J., Cribb, G., Goldman, S. R., Heppeler, J., & Manderino, M. (2016). Deepening what it means to read (and write) like a historian: Progressions of instruction across a school year in an eleventh grade US history class. *The History Teacher, 49*(2), 241-270.

A Flipped Classroom Model with Gamified Inquiry-based Process-Concept Relationship

Tanakorn PANOMRERNGSAKa, Niwat SRISAWASDIb*

aScience and Technology Education Program, Faculty of Education, Khon Kaen University, Thailand
bDivision of Science, Mathematics, and Technology Education, Faculty of Education,
Khon Kaen University, Thailand
*niwsri@kku.ac.th

Abstract: In recent years, flipped learning has received increasing emphasis because of its impact on learning enhancement. Nowadays, gamification plays an important role in promoting students' motivation and attitude toward learning. A gamified flipped inquiry-oriented laboratory learning is proposed for promoting students' science learning performance in this study. To examine the effectiveness of the proposed approach, an experiment was conducted in physics learning activity of a secondary school. The participants were two classes of 62 tenth graders, and they were assigned into one experimental group and one control group. Those learning in the experimental group used the proposed learning mode, while those in the control group learned with the conventional learning mode. The results indicated that the integration of gamification into flipped inquiry-oriented laboratory learning produced a better progression of students' understanding of scientific concepts and process than without gamification. However, there was no significant difference on science motivation between students who learned through the proposed learning mode and who learned through the conventional learning mode. This finding suggests that the gamified flipped inquiry-oriented laboratory learning can be used to effectively support construction of comprehensive understanding of both science concepts and processes in the natural setting of school science learning.

Keywords: Gamification, flipped learning, inquiry-based learning, scientific understanding, science motivation

1. Introduction

Concept of applying game elements to increase the attracting non-game context process called gamification (Deterding et al., 2011). Gamification can be motivated the audiences to manipulate the challenge missions with game elements. Furthermore, an interesting application of gamification is it can be modified and applied in several knowledge areas include Education, Entertainment, Health, Business, and Marketing (Muangsrinoon & Boonbrahm, 2019). Moreover, many researchers studied the impact of gamification in numerous areas. Johnson et al. (2016) studied the impact of gamification on health, the results indicated that gamification had the positive impact on health behavior. In addition, Dicheva et al. (2015) suggested that research should be more seriously study the affectation of gamification on motivation to the audiences.

In education, one highlight of the emerging technologies is flipped classroom, it can be a standard of teaching and learning to promote student's learning (Hamdan et al., 2013), flipped classroom was created and introduced in 2007 by two chemistry teachers Bergmann and Sams (Tucker, 2012). For this learning pedagogical method, it will be available possibilities choice for contemporary instruction method, and flipped classroom is a trend that is currently popular in education (O'Flaherty & Phillips, 2015). The main idea of this instruction is based on students leaning by themselves (Sams & Bergmann, 2013). Flipped classroom was separated in to two sessions of classroom; Out-class and In-class parts. Out-class, students need to study the contents that will learn in class by themselves through lecture video watching before attending class (Zainuddin, 2018). In-class part, students will learn with new things as an interactive activity which regarding with the contents in an out-class video (Keengwe et al., 2014). Since, flipped classroom has received several researches attention, Berrett

(2012) resulted that conceptual understanding, thinking process, and self-directed learning were increased by the flipped classroom.

From previous study, we found that most of students were classified in incomplete conception and misconception in concept of energy consisting of six concepts of energy; kinetic energy, spring potential energy, gravitational potential energy, energy principle, transformation of energy, and conservation of energy (Panomrerngsak & Srisawasdi, 2018). Therefore, this research mixed gamification with flipped classroom we defined as Gamified Flipped-classroom to eliminate incomplete conception and misconception in these above energy concepts except energy principle, and to improve student's Pro-Cept of energy. In this study, two terminologies "gamified flipped learning and gamified flipped inquiry-based classroom" are not strictly distinguished. The research questions were addressed: Do the students who learn with gamified flipped inquiry-based classroom improve Pro-Cept of energy than those who learn with traditional flipped classroom? Do the students who learn with gamified flipped inquiry-based classroom approach have science motivation and perception better than those who learn with traditional flipped classroom?

2. Literature review

2.1 Foundation of Pro-Cept and Relevant Study

Pro-Cept is a conceptual framework to combine concept and process. To make we are on the same page, we will clearly discuss more about concept and process definitions in this work. Concept is important conclusions, ideas or fact that illustrates the important common characteristics of various factors from the concept group (Termtachatipongsa, 2007). Furthermore, we discussed to distinguish two terms of process and procedure to realize what actually process is. Process is using in the common sense of addition, deletion, multiplication, and division (Gray & Tall, 1994). Vice versa, procedure refers to implementation of process or procedure carry out the process to solve an equation (Davis, 1983). Thus, in this study process is not same as procedure. For a relevant study, Gray & Tall (1994) claimed that successful mathematicians use mental structure that merge together between concept and process which is called Pro-Cept.

2.2 Flipped Classroom and Gamification

The design of instruction is extremely significant to students or learners. Flipped-classroom is a choice of teaching activity or pedagogy which is rapidly spread around the world and becomes trend in current (Mzoughi, 2014). In addition, four reasons that support flipped classroom were proposed by Hwang et al. (2015). First of all, limitations of learning from time and space were eliminated by technology, for example students can learn anywhere and anytime from multimedia which teacher provides before come to class. Secondly, this pedagogy gave students prepare themselves to have prior knowledge. Third, from the second reason if students have prior knowledge, they could achieve higher level learning. The last one is gap between teachers and students will closer due to interactive activities in classroom, these activities will make pleasant atmosphere to classroom, it is probably increase students' learning motivation. There are numerous positive educational researches about Flipped classroom, Chaipidech & Srisawasdi (2016) found that students who have learned with the mobile flipped inquiry learning have better perceptions and engagements than students who have not learned with the same method. Chaipidech & Srisawasdi (2017) showed that learning performance of students who have learned with flipped-inquiry based was better than students who have learned with traditional method and hand-on open inquiry. Vice versa, there are researches also reported negative results from flipped classroom, Boevé et al. (2017) reported there are no learning behavior difference between students from flipped classroom and a non-flipped-classroom. Tse et al. (2017) published that students in the flipped class have lower motivation than students in the traditional class for reading subject. From abovementioned researches, Zainuddin (2018) increased performance of this pedagogical method by merging flipped classroom with gamification concept that is called gamified flipped-class. His results reveal that the gamified flipped-class made students have better motivation and engagement. Gamification is the process that uses game elements to motivate audiences (Zichermann & Cunningham, 2011).

3. Methods

3.1 Participants

The participants of this work were separated into two groups. There were 32 students for experimental group, who learn with gamified flipped classroom, and the other group was control group include 30 students, who learn with traditional flipped classroom; both of two groups were tenth-grade students who had age about 15 to 16 years old. The participants were selected from students who had attended an additional physics in an extra-large public school in Kalasin province, Thailand.

3.2 Research Instrument

There were two types of instruments in this work. The first one was the Pro-Cept test of energy concept, Energy Concept Assessment (ECA) that is developed by Lin Ding (Ding, 2007) and Energy Concept Inventory (Swackhamer, 2003) were modified that from one tier multiple choices to two-tier and translated them to Thai version. We used only 10 items that regarding five main concepts of energy: kinetic energy, gravitational potential energy, spring potential energy, energy transformation, and conservation of energy. We had got the reliability of our test that is 0.708. The second one was the science motivation and perception questionnaires toward learning approaches that are likert scale, Science motivation validated by Glynn et al. (2011) consisting of 25 items, included the following scales, each with 5 items: intrinsic motivation, self-determination, self-efficacy, career motivation, and grade motivation. Science motivation developed by Peng et al. (2009) comprises 21 items, includes two parts, learning experience (12 items) and overall impression (9 items), respectively. Both of them were transforming to Thai language. We recruited one expert to verify communication validity of the test.

3.3 Data Collection and Analysis

The activity implementation had procedure as follow; all participants had to complete the entire test before starting learning activities. Then, students learning toward four activities, kinetic energy, gravitational potential energy, spring potential energy, and energy transformation and conservation of energy were merged into one activity, each with 100 minutes. After that, students had to complete the entire test as the post-test. Thus, the total duration of the research process is about three weeks included pre-test and pro-test (teach twice a week). In order to answer the research questions, One-way Multivariate Analysis of Variance (MANOVA) was conducted to compare two groups of students in term of perception. In addition, multivariate analysis of covariance (MANCOVA) was used to determine the science motivation between experimental group and traditional control group. We used Mann-Whitney U test to investigate students' Pro-Cept.

3.4 Learning Materials and Activity

3.4.1 Traditional Flipped-classroom for Control Group

For traditional flipped-classroom, the conventional lecture is frequently changed to be in the form of a video (Sams & Bergmann, 2013). Students are obliged to watch video-recorded for understanding contents before attending class and learning through activity in classroom (Zainuddin, 2018). Therefore, we designed traditional flipped-class learning process for control group as followed these steps; first of all, students interacted with lecture video that teacher provided before attending class, which video we retrieved and modified from OPTCHELP.com, these videos were created from the cooperation of a regular teacher and Ministry of Education of Thailand. Next, this is a practical session or in-class students handed on traditional laboratory regarding with content in video. For in-class, teachers had prepared all major laboratory equipment for students. After students finished laboratory, the teacher explained, discussed, and concluded about content and consistency between laboratory and content, as shown in Figure 1.
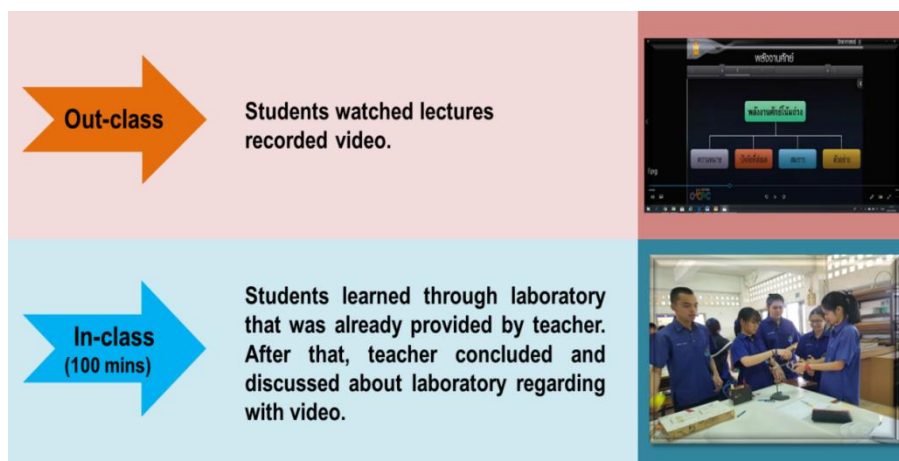
Figure 1. Implementation of traditional flipped classroom.

3.4.2 Gamified Flipped-class Inquiry Learning for Experimental Group

Inquiry teaching is a crucial pedagogy for science (Chaipidech & Srisawasdi, 2016), thus in this work we followed inquiry process according to Buck et al. (2008), there were six characteristics for undergraduate laboratory; (1) Problem/Question, (2) Background/Theory, (3) Procedure/Design, (4) Results Analysis, (5) Results communication, and (6) Conclusions. We used opened-inquiry to design our gamified flipped-class inquiry classroom; question and theory were provided but the others one was not provided to students. We inserted game mechanic into the learning activities. Game mechanic or game elements in this work consisted of badges, leaderboards, points, and team components from a total of fifteen game element terms (Werbach & Hunter, 2012). For abovementioned, in out-class session, we constructed interactive video including inquiry question and theory about energy, the video was filled with elements of game. Figure 2 illustrated an example of an interactive video screen, in the screen had two choices and timer to motivate player for responsiveness and concentrate with the video. Moreover, each responsiveness will affect the score and the next scene, each scene is related to the physical phenomena resulting from the relevant variables. In addition, in-class session, first students bought the equipment for laboratory that they thought that are necessary buy using points from the video instead of money. Then, students in each group helped each other to design experiment or laboratory for answering inquiry question in the video. To made the classroom more fun in the game activity, we made classroom life by input agitated cards into class, such as adding scored cards, deleting scored cards, stop working cards, and listen to music cards. In the procedure, a group volunteer randomly selected a card then followed the commands on the card. In every process teacher gave students group score for group progression, these scores had shown real time on board in front of classroom. If any group of students received the most points, they will obtain special privileges to arrange of the experimental presentation of each group. Then, the inquiry question was answered by students with a teacher who was an assistant. After class, students assessed their own learning and understanding by using student response system called poll everywhere.

Figure 2. An interactive video screen example.

4. Results and Discussion

4.1 Students' Pro-Cept of Energy Concepts

To investigate the influence of two instructions on students' Pro-Cept, Mann-Whitney U test was used as statistical data analysis technique to compared progressive score (different score between pre-test and post-test) of two groups. Results of Mann-Whitney U test indicated that there were significantly differences between experimental and control groups in two concepts; spring potential energy and conservation of energy, Z (n = 62) = -3.357; p = 0.001 and Z (n = 62) = -3.577; p < 0.001, respectively. Although, there were no significant difference between both groups in three concepts include kinetic energy, Z (n = 62) = -1.642; p = 0.113, gravitational potential energy, Z (n = 62) = -1.537; p = 0.113, and transformation of energy, Z (n = 62) = -1.026; p = 0.355. The Mann-Whitney U test results are summarized in Table 1.

Table 1

Mann-Whitney U test results for the progressive score of experimental and control groups

Subscale	Groups	N	Mean	Mean Rank	U	Z	Sig
kinetic energy	Control	30	1.00	27.77	368.00	-1.642	0.113
	Experimental	32	1.59	35.00			
spring potential energy	Control	30	0.70	23.68	245.50	-3.357	**0.001****
	Experimental	32	2.06	38.83			
gravitational potential energy	Control	30	1.43	27.97	374.00	-1.537	0.113
	Experimental	32	1.97	34.81			
conservation of energy	Control	30	0.67	23.23	232.00	-3.577	**0.000****
	Experimental	32	1.97	39.25			
transformation of energy	Control	30	1.47	33.87	409.00	-1.026	0.355
	Experimental	32	1.19	29.28			

Note. **p <.01

Moreover, we fabricated a rubric scoring for interpreting students' Pro-Cept of energy concepts, at two presentation levels; concept and process levels. For each concept and process, (+) symbol was present the status of scientific concept or process, in the other hand, alternative concept or process was represented by (-) symbol. A (0) symbol (zero point) was used for either no responsible or no reasonable to indicate no conception. Thus, maximum scores of each level was equal to ten, likewise, minimum scores of each level was equal to ten. After that, we plotted mean center and standard deviational ellipse of students' score to clearly illustrate the increase of students' Pro-Cept in Figure 3. We assign x axis as concept and y axis as process of energy concepts. Moreover, we invited five first year master degree students of Khon Kaen university in department of physics to participant this study as expert. Visually, Figure 3 showed that both of two groups have different prior Pro-Cept, control group was in scientific process but alternative concept, experimental group was in both alternative concept and process. However, control group and experimental group were in scientific concept and process after their action with instructions. This means both instructions of gamified flipped classroom and traditional flipped classroom effectively encouraged to eliminated alternative concept and process of students and increased students' scientific concept and process. In addition, results presented all students in experimental group cannot reach to expert levels, while a few students in control group can reach to expert levels. However, Zainuddin (2018), he founded the students' post-test indicated that students' learning performance scores in the gamified flipped class were higher than that of students in the non-gamified flipped class. In addition, Chaipidech & Srisawasdi (2017) showed that students'

learning performance on liquid pressure was superior in the flipped inquiry-based learning with mobility as compared to hands-on inquiry-based learning and traditional learning.
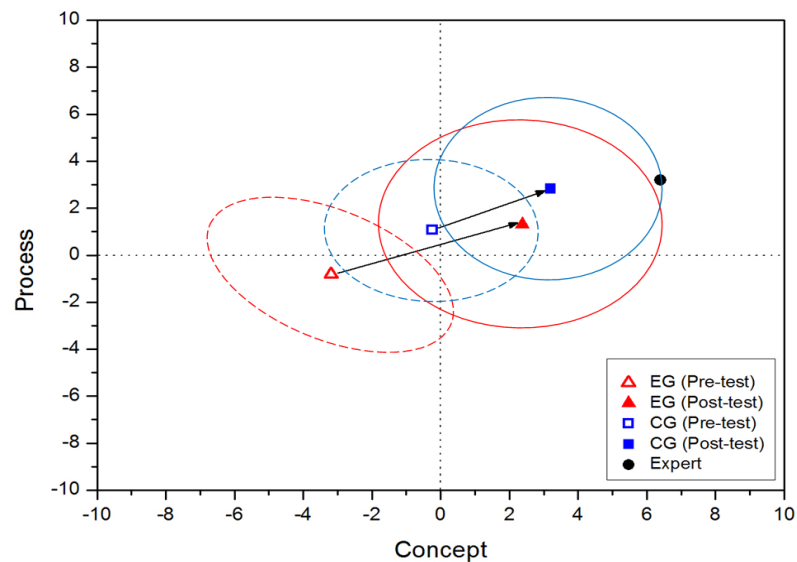

Figure 3. Mean center (MC) and Standard deviational ellipse (SDE) of Experimental group and Control group in Students' Pro-Cept compared with expert).

4.2 *Students' Science Motivation and Perception toward learning strategies*

In this subsection separated into two parts; science motivation and perception. First, one-way multivariate analysis of covariance (MANCOVA) was conducted to explore students' science motivation for experimental group and control group. The results indicated that there was no significantly difference in science motivation between experimental group and control group (Wilks' Lambda = 0.903, F(5,52) = 1.114, p = 0.364, partial η^2 = 0.097) after intervention. The results in each component of science motivation are summarized in Table 2. The MANCOVA results displayed a no significant effect on IM, CM, SDT, SEC, and GM. This implied that both flipped classrooms have the same effect on science motivation. These results make this study noteworthy because of small among of teachers actually use gamification in their classes, although gamification is interested by numerous academic reports. This research demonstrated that using gamification in courses does not decrease students' science motivation, nonetheless students' science motivation who learn with gamification instruction is approximately equal to students' science motivation who learn with regular instruction. Second part, perception was investigated by one-way multivariate analysis of variance (MANOVA) the results for one-way MANOVA showed that there was no significantly difference in perception for both groups (Wilks' Lambda = 0.959, F(2,59) = 1.267, p = 0.289, partial η^2 = 0.041) after intervention. MANOVA results for students' perception in two groups are illustrated in Table 3. Consider to subscales of students' perception; learning experiences and overall impressions both of them were no significantly difference in each subscale. In this subsection, according to these results, students' science motivation and perception of experimental group and control group were no significantly difference. From MANCOVA and MANOVA results notice that the mean of science motivation and perception in both groups were in favorable criteria (average mean was four out of five of Likert scale) Therefore, gamified flipped classroom and traditional flipped classroom effectively encouraged to enhance science motivation and perception. Accordingly, González-Gómez et al. (2016) showed that most students had a favorable perception about the flipped classroom as well as increased individualized learning. Jeong et al. (2016) displayed that the students have the overall positive perceptions to a flipped classroom pedagogy. There were no significantly difference in both science motivation and perception due to all participants were classified into high achiever students from school criteria, they were classified in the group of Gifted students. Likupe & Mwale (2016) proposed that students attribute success and failure to many components such as ability, effort, task difficulty and luck, and they found that high achievers attributed their success and failure mostly to effort and ability. This means high achievers can learn well

in all pedagogies of teaching and learning because they have effort and ability for learning to their success. Thus, this is a hypothesis which suggest that why there were no significantly difference in both science motivation and perception in control group and experimental group.

Table 2

MANCOVA results of students' science motivation

Subscale	Groups		F	df	Sig.	η^2
	Control	Experimental				
Covariate	19.01		0.950	5, 52	0.457	0.084
Intrinsic Motivation (IM)	19.14 (0.47)	19.62 (0.44)	0.489	1, 56	0.487	0.009
Self-Determination (SDT)	17.74 (0.37)	18.15 (0.35)	0.781	1, 56	0.381	0.014
Self-Efficacy (SEC)	16.27 (0.58)	14.94 (0.55)	0.649	1, 56	0.424	0.011
Career Motivation (CM)	20.69 (0.64)	19.61 (0.61)	1.434	1, 56	0.236	0.025
Grade Motivation (GM)	19.92 (0.40)	20.12 (0.38)	0.098	1, 56	0.755	0.002

Note. Pre-test of Career Motivation was entered as a Covariate,

Table 3

MANOVA results for students' perception in two groups

Subscale	Groups		F	Sig.	η^2
	Control	Experimental			
Learning Experiences	43.78 (5.59)	45.66 (5.88)	1.659	0.203	0.27
Overall Impressions	32.92 (4.15)	34.61 (4.38)	2.457	0.122	0.39

5. Results and Discussion

This research, gamified flipped classroom was constructed by combining together of gamification, technology, and flipped classroom. The research aimed to investigate students' learning performance and attitude in the gamified flipped classroom, comparing the results with traditional flipped classroom. The finding of this study demonstrated two noteworthy key points for integrating of gamification, technology, and flipped classroom. First, there were three concepts of energy have no significant difference between progressive score of experimental group and control group. In contrast, the other two concepts were significant difference in term of progressive score. This significantly means the students who learn with gamified flipped inquiry-based classroom do not improve Pro-Cept of energy than those who learn with traditional flipped classroom. Second, students in both groups had no significant difference on science motivation and perception. This means the students who learn with

gamified flipped inquiry-based classroom approach do not have science motivation and perception better than those who learn with traditional flipped classroom. From this study, perhaps the significant implication was: based on research results, the researcher believed that the use of gamification and technology to integrate with learning strategy does not negatively affect the students' learning performance and attitude. Conversely, this integration of these had similar impact as traditional flipped classroom. Therefore, this research suggested the challenge to develop this instruction for making students have progressive learning performance and attitude than traditional flipped classroom.

Acknowledgements

References

Berrett, D. (2012). How 'Flipping' the Classroom Can Improve the Traditional lacture. *The chronicle of higher Education, 1*(1), 1-14.

Boevé, A. J., Meijer, R. R., Bosker, R. J., Vugteveen, J., Hoekstra, R., & Albers, C. J. (2017). Implementing the flipped classroom: an exploration of study behaviour and student performance. *Higher Education, 74*(6), 1015-1032.

Buck, L. B., Bretz, S. L., & Towns, M. H. (2008). Characterizing the Level of Inquiry in the Undergraduate Laboratory. *Journal of College Science Teaching, 38*(1), 52–58.

Chaipidech, P. & Srisawasdi, N. (2016). Mobile Technology-enhanced Flipped Learning for Scientific Inquiry Laboratory: A Comparison of Students' Perceptions and Engagement. *Proceedings of the 24th International Conference on Computers in Education*. (pp.268-275). India: Asia-Pacific Society for Computers in Education.

Chaipidech, P. & Srisawasdi, N. (2017). A Flipped Inquiry-based Learning with Mobility to Improving Students' Learning Performance in Science: A Comparative Study. *Proceedings of the 25th International Conference on Computers in Education*. (pp.587-594). New Zealand: Asia-Pacific Society for Computers in Education.

Davis, R. B. (1983). Complex Mathematical Cognition. In H. Ginsburg (Ed.). *The Development of Mathematical Thinking*. (pp.254-290). New York: Academic Press.

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: Defining gamification. *Proceedings of the 15th international Academic MindTrek Conference: Envisioning Future Media Environments*. (pp. 9-15). New York: Association for Computing Machinery.

Dicheva, D., Dichev, C., Agre, G., & Angelova, G. (2015). Gamification in Education: A Systematic Mapping Study. *Educational Technology & Society, 18*(3), 75-88.

Ding, L. (2007, May 14). *Designing an Energy Assessment to Evaluate Student Understanding of Energy Topics*. Retrieved April 27, 2018, from https:// www.compadre.org/Repository/document/ServeFile.cfm?ID=5345 &DocID=2844

Glynn, S.M., Brickman, P., Armstrong, N., & Taasoobshirazi, G. (2011). Science motivation questionnaire II: Validation with Science Majors and Nonscience Majors. *Journal of Research in Science Teaching, 48*(10), 1159-1176.

González-Gómez, D., Jeong, J. S., Airado Rodríguez, D., & Cañada-Cañada, F. (2016). Performance and perception in the flipped learning model: An initial approach to evaluate the effectiveness of a new teaching methodology in a general science classroom. *Journal of Science Education and Technology, 25*(3), 450-459.

Gray, E. M. & Tall, D. O. (1994). Duality, Ambiguity and Flexibility: A Proceptual View of Simple Arithmetic. *The Journal for Research in Mathematics Education, 26*(2), 115–141.

Hamdan, N., McKnight, P., McKnight, K., & Arfstrom, K. M. (2013). *The Flipped Learning Model: A White Paper Based on the Literature Review Titled A Review of Flipped Learning*. Arlington, VA: Flipped Learning Network.

Hwang, G.J., Lai, C. L., & Wang, S.Y. (2015). Seamless flipped learning: A mobile technology-enhanced flipped classroom with effective learning strategies. *Journal of Computers in Education, 2*(4), 449-473.

Jeong, J. S., González-Gómez, D., & Cañada-Cañada, F. (2016). Students' perceptions and emotions toward learning in a flipped general science classroom. *Journal of Science Education and Technology, 25*(5), 747-758.

Johnson, D., Deterding, S., Kuhn, K.A., Staneva, A., Stoyanov, S., & Hides, L. (2016). Gamification for health and wellbeing: A systematic review of the literature. *Internet Interventions, 6*, 89-106.

Keengwe, J., Onchwari, G., & Oigara, J. N. (2014). *Promoting Active Learning through the Flipped Classroom Model*. Hershey, PA: IGI Global.

Likupe, G., & Mwale, M. (2016). The Study of Attributions of Low Achievers and High Achievers about the Perceived Causes of their Success and Failure: the Case of Adolescent Students in Secondary Schools – Malawi. *Journal of Child and Adolescent Behavior, 4*(5).

Muangsrinoon, S., & Boonbrahm, P. (2019). Game elements from literature review of gamification in healthcare context. *Journal of Technology and Science Education, 9*(1), 20-31.

Mzoughi, T. (2014). An Investigation Of Student Web Activity In A "Flipped" Introductory Physics Class. *Procedia - Social and Behavioral Sciences, 191*, 235 – 240.

O'Flaherty, J., & Phillips, C. (2015). The use of flipped classrooms in higher education: A scoping review. *The Internet and Higher Education, 27*, 85-90.

Panomrerngsak, T. & Srisawasdi, N. (2018). Development of Gamified Flipped-class Inquiry Learning in Physics Concept of Energy for School Science: An Early Stage. *Proceedings of the 26th International Conference on Computers in Education*. (pp.390-398). Philippines: Asia-Pacific Society for Computers in Education.

Peng, H., Chuang, P.Y., Hwang, G.J., Chu, H.C., Wu, T.T., & Huang, S.X. (2009). Ubiquitous Performance-support System as Mindtool: A Case Study of Instructional Decision Making and Learning Assistant. *Educational Technology & Society, 12*(1), 107–120.

Sams, A., & Bergmann, J. (2013, March). Flip Your Students' Learning. *Educational Leadership, 70*, 16-20

Swackhamer, G., & Dukerich, L. (2003). An Energy Concept Inventory. *Proceedings from 127th American Association of Physics Teachers National Meeting*. Madison: [n.p.].

Termtachatipongsa, P. (2007). *A study upper secondary students' conceptual change in gene function using a multidimensional interpretive framework*. Ph.D. Dissertation, Department of Science Education, Faculty of Education, Khon Kaen University, Thailand. [in Thai].

Tse, W. S., Choi, L. Y., & Tang, W. S. (2017). Effects of video-based flipped class instruction on subject reading motivation. *British Journal of Educational Technology, 50*(1), 385-398

Tucker, B. (2012). *Online instruction at home frees class time for learning*. Retrieved March 25, 2018, from http://educationnext.org/the-flipped-classroom/

Werbach, K., & Hunter, D. (2012). *For the Win: How Game Thinking Can Revolutionize Your Business*. Philadelphia, USA: Wharton DigitalPress.

Zainuddin, Z. (2018). Students' learning performance and perceived motivation in gamified flipped-class instruction. *Computers & Education, 126*, 75-88.

Zichermann, G., & Cunningham, C. (2011). *Gamification by Design: Implementing Game Mechanics in Web and Mobile Apps*. Sebastopol, CA: O'Reilly Media.

The design and evaluation of junior high school physical mechanics game

Juan Du[a], Feng-Kuang Chiang[b*]
Department of Educational Technology, College of Education, Shanghai Normal University, China
*fkchiang@shnu.edu.cn

Abstract: In order to learn the physics learning interest from junior high school students and improved the boring physics teaching environment. The author has designed a physics game which combines with the physical knowledge and practices in the course. Under the mixed research methods, the students able to learn the basic knowledge of mechanics in playing game and know the physics comprehensively from the perspective of physics. In this research, in the first step, it has held a physics expert and two physics teachers were invited to evaluate the game and leave with the commands, Secondly, about 40 students from the science course of the sixth grade in junior high school were selected to play game. After that, they have completed the questionnaire of satisfaction of the game and interviewed by our staff, Finally, the author has organized some staff to collect the commands from experts, teachers, questionnaire data and interview. The results show that the students have been significant influence in physical mechanics game. Above all, with the above proves, the summary shows that the physical mechanics game of this study has high availability, and students have a positive learning attitude in using this game. This study provides a reference for subsequent researchers to develop physical education game, and helps teachers to make a better solution on physical knowledge teaching.

Keywords: Digital game-based learning, physical mechanics, formal education

1. Introduction

In the 21st century, the integration of ICT (information and communication technology) and formal education courses is a major development trend in formal education (Chiang & Qin, 2018), the educational game applied to formal subject teaching have become a new approach and model for the integration of technology and curriculum (Yang & Xie, 2018). In the beginning, the junior middle school students couldn't understand the contact of physical knowledge, and the explanation from teachers has reduced the learning enthusiasm from students, which impact the enthusiasm from students, and they think that physical content is dull and boring. What's more, it has ultimately disturbed the teaching effect (Wu, 2019; Huang, 2018). Therefore, the extra educational game in physics knowledge classroom able to help teachers inspire classroom learning atmosphere, improve the concerns from students, and improved the teaching quality in the classroom (Wu, 2019). Besides, it has the effect to inquiry students' psychology for physical knowledge and self-confidence in learning physics, enrich teachers' teaching methods, and thus improve the quality of teaching (Zhang, 2018). Although some studies have shown that the concept of integration in educational game and formal teaching has been implemented, the depth of integration is still short, and the researchers and teachers need to work together and explore it (Fan, 2018). This study developed a physical mechanics educational game based on the junior high school sixth grade science course. In this test, the students have participated in this study, which has improved the experience in entertainment and challenges to the game. Besides, it can be increasing the skills in the relevant knowledge of physical mechanics in the game and analyze the physical problems from the perspective of physics comprehensively. The research questions have included the exploring the learning outcomes of students and their attitudes toward physical learning after playing educational game.

2. Literature Review

In the recent years, the development of educational game application has been attracted more and more attention in public (Hou & Chou, 2012), and the research on educational game has attracted widespread attention. The results show that game able to improve the knowledge base, and improve the players' advanced knowledge skill, attracted students' attention and improved hand-eye interaction. Besides, they will help students to improve their motivation by setting goals to make them feel challenged and stimulated (Brad & Jim, 2005; Chiang, Chang, Hu, Zhang, & Liu, 2019; Denis & Jouvelot, 2005; Dondlinger, 2007; Zhao &Zhu, 2006). In summary, the educational game will make better assist in education and show great business potential in the classroom. However, there are a few of researches focus on the application of game in formal education, and some researches even ignore the overall research of teaching objectives in game. Therefore, this study aims to apply physical mechanics games to formal education.

3. The Design and Development of Game

The ambition of the game is designed an educational game models which developed by Ibrahim and Jaafar (2009). The model contains three factors: game design, pedagogy and learning content modelling, with emphasis on usability, multimodality, fun, problem solving and syllabus matching(Ibrahim & Jaafar, 2009), the design of this game is shown as Table 1.

Table 1

Game Design Theory and Function Introduction

Element	Design Scheme	Function Design
Satisfaction	More than 90% of the game are interactive and animated; Attractive color arrangement; New and interesting levels.	Level; Interactive Feedback
Efficiency	The requirements in the syllabus and the teaching knowledge points is repeatedly applied to the game session and marked out so that students can understand and think about them.	Hinting Function
Effectiveness	The continuity and increasing difficulty of the level and the gradual progress of the learning objectives, coupled with the application of the theory, make the game applicable to anyone that has not been exposed to physical mechanics.	Level; Interlope Barrier
Multimedia And Interaction	Multimodal object, such as attractive cartoon characters; Meaning hint; Dynamic music and sound effects; Animation effects, such as zooming in and out of the object.	Scene Introducing
Challenge	All levels have a clear goal and a clear challenge.	Game Rule
Clear goals	Players can be inspired curiosity and imagination during the game exploration process. Only those who understand the knowledge of physical mechanics can be successful.	Game Rule
Uncertain Outcome	The thinking process is different at each level of the game, so whether the players can pass the game is uncertain.	Game Rule
Self Esteem	Players need to understand the theory of the level to pass the game.	Game Rule

In the pedagogy, the outcome of student's knowledge is mainly to understand the relevant knowledge of gravity, and apply equilibrium knowledge to solve the game level. This game can

immerse students in gamification learning by breaking for the barrier mode, stimulate students ' learning motivation, let students study independently, and apply what they learn to solve the problems of the game.

In learning content modeling, the content of the game comes from the concepts and contents of physics mechanics in junior high school science textbooks. The main knowledge points are the concept of gravity, the direction of gravity, interactive force, resultant force, multi-force balance and other basic mechanics knowledge. Physical knowledge points appear in the form of text scaffolding in the game. Based on the above design of the game, Game Maker Studio 2 programming software is used for the development of the game, and GML language is used for software programming. This game only needs to be installed on the computer, and it can be played by clicking on the mouse. No special skills are required.

4. Research Design

The purpose of this research is to design a physics game software for junior high school students. It focus on testing the feasibility of the game in teaching and the learning attitude of students after using the software. Researchers has improved the design of physical mechanics game according to the use of software by physics expert (1), physics teachers (2) and students (40). When they completed the questionnaires and interviews, it will help students grasped more physical knowledge. Specific assessment and analysis tools are shown in Table 2.

Table 2

Evaluation and Analysis Tools

Evaluation Tools	Collecting Information	Detailed Description	Analysis Tools
Game Software	Game Frequency	50 points per level of the game, a total of 10 levels, a total of 500 points.	SPSS Statistics 20 (independent t-test)
	Game score		
Questionnaire	Game Satisfaction Questionnaire (43 portions)	Game satisfaction questionnaire designed by the researchers and two physics teachers was (18) questions. Likert scale was adopted, and students were asked to fill in the open questions.	Excel2017 (chart analysis)
	Knowledge Test Questionnaire (80 portions)	A total of 15 questions, 10 judgment questions (5 points per question), 5 drawing questions (10 points per question); Total 100 points, answer time 15min;	SPSS Statistics 20 (paired sample t test)
	Interview Audio (8 portions)	Random students' interviews were conducted according to the collected data.	Excel2017 (Text Analysis)

The specific evaluation process as follows：

In the first stage of game evaluation, researchers invited a physics expert in the university to play the game. After the game, the experts were joined in the interview. The main interview content is the setting of the knowledge points in the game, and then the experts filled in the game satisfaction questionnaire.

In the Second stage of game evaluation, Researchers invited two physics teachers to play the game. After the game, the two teachers were joined in the interview. The main interview content is the existence of the knowledge points in the game and problem pattern design of the knowledge test questionnaire, and then two physics teachers filled in the game satisfaction questionnaire.

In the third stage of game evaluation, Researchers selected 40 students from the sixth grade of a junior middle school. The students conducted a pre-test of the knowledge test questionnaire, then they

joined in the game to play demo, after all the test, they refilled the knowledge test questionnaire and the game satisfaction questionnaire. Finally, the researchers interviewed five students, tried to let them understand the psychological activities in the process of playing game. The picture of student trying to play the game is shown in figure 1:

Note: The game picture (left) is the first level of the game developed in this study. Mainly let students use the direction of gravity to play games. Click on the wooden block in the picture, then the piece disappears. Pipixiu can fall to the position of the apple according to its own gravity.

Figure 1. Game picture(left) and the picture of student trying to play the game(right).

5. Results

5.1 Usability assessment of physical mechanics educational game

After evaluating a physics expert and interviewing two physics teachers, the practicality of the physics education game software was affirmed. At the same time, two physics teachers combined with personal teaching gave a very pertinent evaluation of the software in the test.

"This physics education game is designed very good, it will help students to improve their interest in physics learning. Otherwise, students' impression in physics class are always less of intercommunication, which is difficult for learning and seems boring."

"If there is an online software with the actual physics course content, teachers can apply this application in the classroom to make further help in teaching."

According to the game satisfaction questionnaire (40 portions) filled out by the students, the researchers has used excel 2017 to analyze the functional utility, the appearance practicability and the story background of the game. The mainly analysis results are shown in Figure 2, Figure 3, and Figure 4:
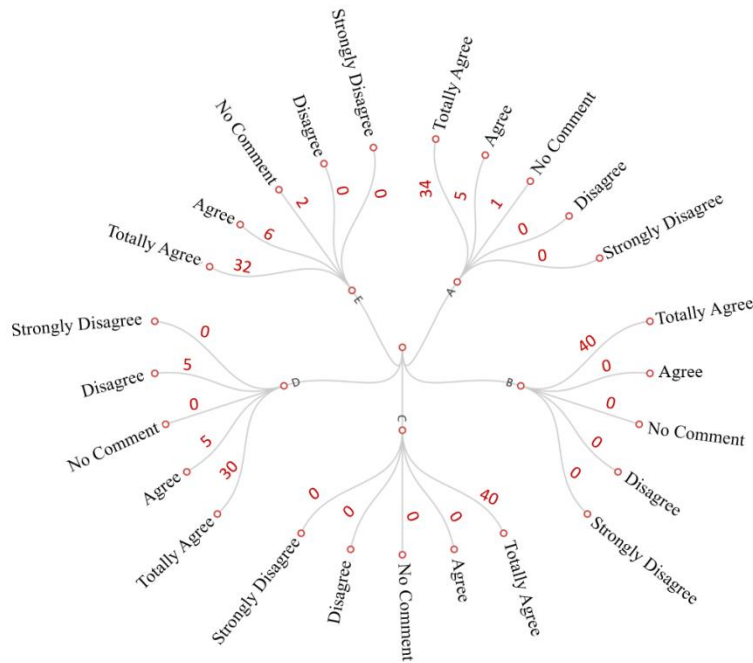
Note: The question represented by A is that it is easy to find the function you need in the game; The question represented by B is that the gameplay is very simple; The question represented by C is that no carton phenomenon in the game; The question represented by Dis that text prompts are easy to understand; The question represented by E is that the animation of the game levels are very smooth.

Figure 2. Game interface analysis diagram.

According to the data analysis in Figure 2, about 80% of the students think that the software has make positive influence in practicability. so, the initial operation feedback function of the software is qualified. At the same time, according to the text prompts in the questionnaire, there are 5 students did not think that the text prompts are easy to understand. When the researchers have randomly selected a student from 5 students for an interview, the student replied:

"If there has animation tips, it will be better, and it is more convenient for the grasp of knowledge. The text always feels a little unclear on how to use it."
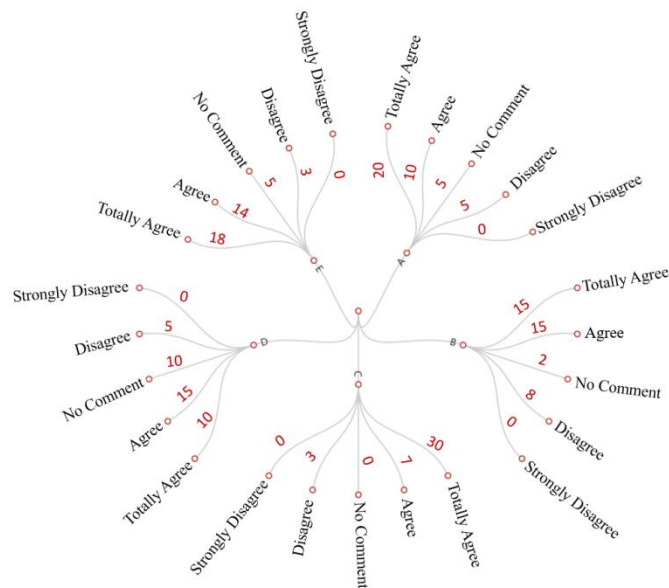
Note: The question represented by A is that the interface of the game is very good; The question represented by B is that the color matching of the game is very suitable; The question represented by C is that the game level animation is very beautiful. The question represented by D is that I like the background of the game; The question represented by E is that I like the main characters of the game

Figure 3. Software design interface analysis diagram.

According to the data analysis in figure 3, there are many students keep a neutral attitude towards the design interface of this software. Therefore, there will be more questions about the design direction of the software in the interview, the student A thinks:

"The background setting of the game should be reflected in the game, so that we will may have a better understanding of the game, and the teacher has directly explained the background of the game, we feel bored...."

Student B thinks: "The interface of the software is monotonous, which is purple, can you add more color in there?"

Student C believes, "the game character should be built as three-dimensional, this one looks a bit weird."

In summary, the students do not satisfy with the interface design of the software. Therefore, the researchers have discussed the solution with the students in the interview. Finally, in the step of modifying the software, the researchers have adopted the comprehensive cartoon characters and actively studied color issues.

Note: The question represented by A is that I like the function of timing game; The question represented by B is that I like the function of scoring game; The question represented by C is that I like the function of game with text instructions; The question represented by D is that I like the process of revealing game strategies by myself; The question represented by E is that these game functions are enough for me to use.

Figure 4. Functional interface analysis of game.

The analysis of the data in Figure 4 shows that almost 90% of the students like the game mode of physical breakthrough, and the game evaluation of the function is positive.

5.2 Analysis of the acquisition of mechanics knowledge in educational game

Pretest and posttest results of Mechanical knowledge acquisition are shown in Table 3:

Table 3

Pretest and posttest results of Mechanical knowledge acquisition

	Mean	Std. Error	95%Confidence Interval		t	df	sig
			Lower	Upper			
Pretest—Posttest	-34.86	2.35	-39.63	-30.12	-14.83	39	.000

It can be seen from the table that the value of Sig is less than 0.05, so there is a significant difference between the pre-test of knowledge base and the post-test of knowledge base, which means that students able to acquire physical knowledge during the process of playing physics education game. Besides, it can be stated that the software is suitable for teachers in the class.

5.3 Correlation analysis of game frequency and player gender

The analysis of the frequency of game played and the gender of players in physical mechanics education game is shown in table 4:

Table 4

Data analysis of game frequency and player gender

	F	Sig	t	df	Sig. (2-tailed)	Mean difference	Std. Error difference	95% Confidence Interval	
								Lower	Upper
Equal variances assumed	1.35	.25	5.40	38	.000	8.16	1.51	5.10	11.21
Equal variances not assumed			5.26	31.25	.000	8.166	1.555	5.00	11.33

According to the data in the table, sig>0.05, which means the variance is equal, in the case of the correlation coefficient t=5.40, sig=0.000<0.05, there is a significant difference between male and female students in the game played frequency. According to the analysis shows, the average number of girls playing game will be less of boys. Most girls do not pay close attention to other unrelated factors such as the speed of the game.

Game scores and player gender analysis are shown in Table 5 below.

Table 5

Game score and player gender data analysis

	F	Sig	t	df	Sig. (2-tailed)	Mean difference	Std. Error difference	95% Confidence Interval	
								Lower	Upper
Equal variances assumed	.53	.47	5.42	38	.000	120.35	22.20	75.40	165.30
Equal variances not assumed			5.32	32.95		.000	120.35	22.64		

According to the data in the table, the sig>0.05, so the variance is equal, in the case of the correlation coefficient t=5.42, sig=0.000<0.05, male and female students have significant differences in the performance of playing game. According to the data analysis, boys will get the score better than girls, which means that boys are more likely to play game in real life than girls. Male students have made better performance than female students in game, which indicate that male students are exposed to play game more often than female students does in real life.

5.4 Analysis of students' learning attitude

Data analysis of students' learning attitude is shown in figure 5.

Note: The question represented by A is that after playing game, I am very interested in physics. The question represented by B is that when I play game, I expect to learn more about physics The question represented by C is that I like game-based learning in physics class.

Figure 5. Analysis of students' learning attitude.

According to the data analysis of Figure 5, there are 80% of the students are more interest in physics after playing the game. For those students, who is not interested in physics, the researchers have randomly selected a student to interview, Student A said.

"It's a bit difficult to play game. I don't like physics very much. But if there is a game in physics class, I would like to listen more information, and I 'd lie to study liberal arts. I feel the physics is too difficult."

5.5 The Modification of Game

According to feedback from some of the students' interviews, some students suggested "Teacher, why didn't the apples fall into the hands of Pipixiu? It's strange to let Pipixiu fall." The researchers modified the unreasonable part of the game. Specific modification as shown in Figure 6.

Figure 6. Checkpoint modification.
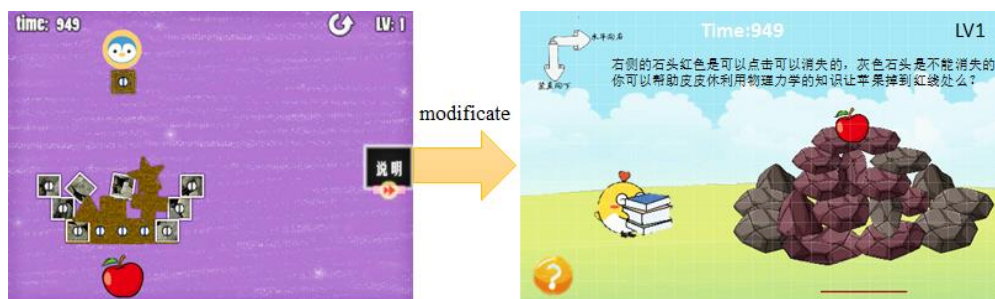
The modifications of the checkpoints are as follows:
● The story of Newton being hit by an apple tree suggests that there is a physical gravity knowledge.
● The question mark contains hints for the game. (Text scaffolding, picture scaffolding or other cognitive scaffolding).
● The coordinate system (Up, down, left, right) in the checkpoint provides students with more accurate knowledge.

35

6. Discussion and Conclusion

The physics education game has make the study more popular among the students, and about 80% of students think that the software runs smoothly and has strong usability, so the software is qualified in the basic operation function. On the other hands, the students do not very satisfy with the interface design of the software. Therefore, in the subsequent modification of the software, the researchers mainly modified the software interface to make up for the deficiencies; Almost 90% of the students like the game mode of breakthrough, and the evaluation of the game's function is positive. When the physical education game is applied in the classroom, the ability of knowledge test in the game has reached a significant high level, which indicates that the game able to make positive influence on students' physical learning. This study suggests that the reason that games assist students in cognition may be that games can help students learn to slow down and concentrate on one thing (Graham, 1985). Therefore, students' ability to understand knowledge has also increased. The results of this study are consistent with the conclusions of the game proposed by the educator Piaget (Wu and Guo, 2003). According to the research, the male students repeat checkpoints more often than female students, and male students' game scores are higher than females, which shows that male students are more adaptable and devoted to solve problems in the physics game. At the same time, research shows that the game is more in line with the taste of the boys, so it will lead to a smaller experience for girls, while the boys have a stronger game experience (Subrahmanyam & Greenfield, 1998). This may also be a reason why boys' score higher in the game. After the game, the students' interest towards physical learning has improved, and 80% of the students has showed interest in physics. This shows that the game has made a positive influence for the students. This is consistent with the results of the Alfiana's study, which has a certain impact on the student's attitude towards future subject learning (Alfiana, 2019), this study interviewed a student who was not interested in physical learning, she believed that physics-related games are interesting, but it is too difficult to learn physics, and her future direction of learning is liberal arts, so she will not take the initiative to learn physics. In addition, the game mechanics in this study can be repeatedly applied to the design and development of games in other disciplines, and the game mechanics are universally adaptable. However, the limitation of this study is a monotonous in pre-test and post-test, there is no comparison between the control group and the experimental group. And, the study has no long-term effect verification, so the author suggested that it is necessary to continue the Verification of the teaching effect in the follow-up study.

References

Alfiana, A. (2019). An Attempt to Develop Students' Interest and Learning Outcomes in Economics through a combination learning models. Classroom Action Research Journal (CARJO), 3(1).

Brad, P., & Jim, B. (2005). Game, Motivation, and Effective Learning: An Integrated Model for Educational Game Design. Proceedings of DiGRA 2005 Conference: Changing Views - Worlds in Play. Retrieved from http://www.digra.org/wp-content/uploads/digital-library/06276.18065.pdf%5Cnhttp://www.digra.org/digital-library/publications/game-motivation-and-effective-learning-an-integrated-model-for-educational-game-design/.

Chiang, F. K., Chang, C. H., Hu, D., Zhang, G., & Liu, Y. (2019). Design and development of a safety educational adventure game. International Journal of Emerging Technologies in Learning, 14(3), 201–219. https://doi.org/10.3991/ijet.v14i03.9268.

Chiang, F. kuang, & Qin, L. (2018). A Pilot study to assess the impacts of game-based construction learning, using scratch, on students' multi-step equation-solving performance. Interactive Learning Environments, 26(6), 803–814. https://doi.org/10.1080/10494820.2017.1412990.

Denis, G., & Jouvelot, P. (2005). Motivation-driven educational game design: Applying best practices to music education. ACM International Conference Proceeding Series, 265(April), 462–465. https://doi.org/10.1145/1178477.1178581..

Dondlinger, M. (2007). Educational Video Game Design: A Review of the Literature. Journal of Applied Educational Technology, 4(1), 21–31.

Fan baorong. On the necessity of deep integration of information technology and education and teaching [J]. Jilin education: synthesis, 2018.

Huang tengfei. On problems and countermeasures in junior middle school physics teaching [J]. New curriculum (middle school),2018(05):117.

Huei-Tse Hou & Yi-Shiuan Chou. (2012). Exploring the Technology Acceptance and Flow State of a Chamber Escape Game - Escape the Lab© for Learning Electromagnet Concept. In The 20th International Conference on Computers in Education (ICCE2012), Singapore, November (pp. 26–30).

Ibrahim, R., & Jaafar, A. (2009). Educational games (EG) design framework: Combination of game design, pedagogy and content modeling. Proceedings of the 2009 International Conference on Electrical Engineering and Informatics, ICEEI 2009, 1(August), 293–298. https://doi.org/10.1109/ICEEI.2009.5254771.

Graham, A. (1985). Chess makes kids smart. Parents, 112-116.

Wu liang. Find the crux of the problem to remedy the case -- junior high school physics teaching problems and countermeasures analysis 2019.

Subrahmanyam, K., & Greenfield, P. M. (1998). Computer games for girls: What makes them play. From Barbie to Mortal Kombat: gender and computer games, 46-71.

Wu, H. L. & Guo, J. H. (2003). Playgroup: the theory and practice of game development. Taipei: ALi.

Yang guifang, & xie qi. (2018). Gamification learning: a new model of curriculum integration. China information technology education (7), 59-63.

Zhang li. Finding the crux and applying the remedy to the case -- problems and countermeasures in junior middle school physics teaching [J]. China external education, 2018(1).

Zhao hailan, zhu zhiting. International research trend and enlightenment of educational games [J]. China audio-visual education, 2006(7):73-76.

The road towards friendly, classroom-centered interactive digital contents authoring

Andrea VALENTE [a]*, Emanuela MARCHETTI [b]
[a]*Maersk Mc Kinney Moller Institute,*
Embodied Systems for Robotics and Learning,
University of Southern Denmark (SDU), Denmark
[b]*Media Studies, Department for the Study of Culture,*
University of Southern Denmark (SDU), Denmark
*anva@mmmi.sdu.dk

Abstract: In this paper, we argue for the need of new kinds of visual, digital game authoring tools. The main goal for this project is to reconceptualization the programming of interactive digital contents, to minimize the coding aspects, and focus instead on the creative and design-like parts, leveraging on a tangible metaphor, so to empower teachers and pupils to create digital interactive content, expanding the creative affordances offered by digital games. The resulting tool is called Stick&Click, it is based on findings from our past research, and it targets the pedagogical practice of editing games that is currently common in Danish primary schools. The study is organized according to the research through design approach, and centers around user needs and experience. We discuss our explorations of the computational model behind Stick&Click, requirements and design principles, and alternative ways to visualize its user interface.

Keywords: game design, game programming, primary school, learning, tangible metaphors.

1. Introduction

In the past 10 years we have been working on recontextualization and reconceptualization of interactive digital contents, to make them more accessible to teachers, pupils and young students, in and outside the classroom. Our goal has been to empower digital creativity and close the gap between tinkering in the physical world and authoring of game-like digital materials, which require a certain degree of programming skills. Our approach centers around user needs (Preece, Rogers & Sharp, 2019), from the perspective of teachers and pupils, which we investigate typically using ethnographic qualitative methods. In this way, we aim at collecting not only changes in performances or self-reported data, which are related to the conscious level of human experience (Löwgren & Stolterman, 2007), but also unarticulated needs, actual practices and concrete adaptations of methods (Dunne, 2018), and reactions derived from personal values, which are related to the unconscious level of human experience and cannot be captured through surveys (Preece, Rogers & Sharp, 2019). This qualitative approach is usually adopted in research through design (Zimmerman & Forlizzi, 2014) where new knowledge is gathered through the creation of prototypes, to explore the design of new technologies as well the nature of human experience.

In this paper, we leverage data from previous user centered design projects, from which we found that Danish primary schools often employ games and design of games as learning resources for their pupils. Games, digital as well as role-play and paper-based games (e.g. card games and board games), are seen as more creative and playful alternatives to traditional written assignments, enabling pupils to engage with the learning content in new ways, hence eliciting new understandings. It emerged through our previous studies that teachers exploit the popularity of digital games as a motivational resource for supporting learning, however, we found that digital games can be experienced as less creative than paper-based games, as these can be redefined based on social agreement among teachers and pupils. Digital games come as a black box, which can be played only in a particular way and cannot be changed nor created from scratch without advanced programming skills (Marchetti, 2016), hence digital games cannot be easily customized according to pedagogical needs. Interestingly, during our studies (Valente

& Marchetti, 2012, Valente & Marchetti, 2015, Valente & Marchetti, 2019) we found that teachers have systematically expressed interest in being able to edit or at least customize existing digital games and also to enable their pupils to customize or design digital games, to better meet their pedagogical needs. Moreover, Danish schools have engaged in different initiatives to enable their pupils to learn how to program, using systems like Scratch, Minecraft or Blockly, and are currently in the process of formalizing Computational Thinking (CT for short) as a subject. Therefore, Danish schools are open in exploring different digital tools that could enable a richer engagement with digital technologies, than what is typically afforded by available digital games or editors.

Starting from these premises, we present in this paper our investigation around a possible system to support creative authoring of digital games, targeting the pedagogical practice of editing games that is currently taking place in the classrooms of Danish schools. Our goal with this project is to empower teachers and pupils, to expand the creative affordances offered by digital games and learning platforms, enabling them to create interactive content.

Section 2 presents related work and our previous studies that provide the basis for the design and implementation of our new web-based prototype tool; the incremental development of tool itself is discussed in section 3. Section 4 concludes the paper, presenting ongoing and future work.

2. Related work – Game design in the classroom

Recently the Danish school systems have been experiencing a digitization process, which is causing a generalized integration of digital technologies inside the school, consequently, teachers are exploring new approaches to motivate their pupils in engaging with their learning content and to foster them new, deeper understandings (Marchetti & Valente, 2016). In our study, we approach primary schools as complex information ecologies (Nardi & O'Day, 1999), in which technological changes take place as an organic transformation, causing a deep reconceptualization of existing practices affecting how teachers and pupils engage in learning processes inside the classroom. During our previous studies, we found that use of games, in digital or analogue form, is a spread practice in Danish schools, aiming at fostering deeper understandings of the subjects at hands and at motivating their pupils at engaging with their learning material on an independent basis (Møller, 2016, Hoffmeyer et al, 2017). A typical workflow that we observed would start with teachers introducing a topic in a lecture; pupils would then be invited to engage with books and other available digital resources that the teachers have gathered for them, such as: articles or videos available on-line, or games. In the end, the children would be invited to play the given games and/or to produce creative artefacts that could exemplify their understanding of the subject, in the form of board or card games, videos, or digital slide presentations.

Several studies have been conducted in Denmark and internationally regarding the use of games in literacy and language (Fenyveri, 2018, Cadierno & Eskildsen, 2018) and also in mathematics (Misfeldt & Zacho, 2016). Commercial digital games were found to contribute to motivation and rich interaction in the class. Moreover, Cadierno and Eskildsen (2018) investigated the use of games in English classes with oral and written English, in comparison to games with only oral or written English input. Results from their study shows that use of games with both oral and written English contributed significantly to children's high scores in vocabulary tests (Cadierno & Eskildsen, 2018). Similarly, Fenyveri (2018) found that engagement in games and videos found on YouTube, worked as motivational resources for primary school pupils to engage in learning of English. However, games and videos, do not only work for motivation, but as a familiar territory for applying knowledge. As a consequence, the pupils are able to better memorize words and use them correctly, as through the game they have reflected on the contextual use of the terms that they have learned.

Despite all of these studies and evidence for the usefulness of existing digital contents and self-created analogue games, we repeatedly observed a lack of tools for authoring digital games (and interactive digital contents more in general), specifically targeted at teachers and pupils. This difficulty in creating games for learning is seen in Danish schools for instance in the explorations conducted with the authoring of different media productions, such as interactive scenarios (Misfeldt & Zacho, 2016) and movies editing with iPad (Møller, 2016), which were found beneficial in terms of fostering creativity, collaboration, and forms of peer learning. In Misfeldt and Zacho (2016) observations in the mathematics classes revealed how teachers and pupils relate to games as something to "design", in order to exploratory engage with the subject and prepare for open-ended projects. Editing short movies on an iPad has the advantage of supporting touch-based forms of multimodal interactions, which would

not be in focus with other media. In this way the children engage in a multimodal form of negotiation, communicating with each other through haptics, visually and verbally to negotiate on the outcome to be created and solve potential conflicts (Møller, 2016).

Moreover, these productions can be used as forms of informal assessment, as the pupils have to engage in depth with the learning content to reelaborate it in the form of movies or games. In this way, the artefacts created by the pupils carry the knowledge that they have acquired, hence these can be used as triggers for assessment, as *boundary objects* (Star & Griesemer, 1989) of conversation between teachers and pupils on the subject at hand. However, it was found that criteria for assessment based on multimedia productions are vague and lack clarity. According to Hoffmeyer et al (2017), students respond better to assessment if supported by feedback based on explicit criteria, which can not only highlight what is wrong, but also where there can be improvement and how. Hence these practices are challenging traditional assessment approaches, demanding for the establishment of new criteria regarding "form, content and typology" (Hoffmeyer et al, 2017, p.27) to become an acknowledged form of assessment.

Issues emerged also when both teachers and pupils have to adapt to using new tools, which require a learning process on their own right. In this respect we found that teachers were adapting in different ways to the integration of digital technologies in the classroom (Marchetti & Valente, 2016), and we identified three main attitudes towards technologies:

1. IT Concerned – teachers who are relying preferably on low-tech solutions, often paper-based such as written scores for role-play and board games,
2. IT Mediators – teachers who are integrating in their teaching different available media which were not specifically designed for learning,
3. IT Designers – teachers who would like to involve technologies in a more creative way, creating their own media content.

The first category is represented by a few individuals, often dealing with classes of pupils with special needs. The second category is the most represented and includes teachers, who are expressing an open and opportunistic attitude towards technology, so that they are ready to embrace and recontextualize for their teaching activities whatever technology is available. These are often open also to input from their pupils to find suitable technologies. The third category includes teachers, who are also open to experiment with technologies, but would like to reedit or even create their own interactive content. Interestingly, we noticed that teachers in this third category end up choosing paper-based solutions when they want to design their own games, similarly to the teachers who are IT concerned, as the level of programming skills required for such a task is too high.

On the other hand, during one of our studies aimed at designing a table top game on the Viking Age (Marchetti, 2016), we observed groups of 10 years old children expressing themselves creating their own game pieces. Moreover, we observed a few of the kids spontaneously engaging in forms of playful play (Sutton-Smith, 1997). These kids spent all their time creating game pieces and rules of play for their mates, who in turn were happy to include the newly created pieces with the ones they made for themselves.

As digital technologies have become increasingly present in the classroom, the teachers have gone through a learning process on their own, to familiarize with the new available resources and with how these were affecting their teaching practice. At the same time, as the teachers have become more competent, they also became more aware of their needs, setting new demands for self-expression, for themselves and their students; our explicitly attempts to address such needs.

3. Stick&Click

The initial idea came from the results of the tests conducted with paper materials and digital games, as in Marchetti and Valente (2017) and Fables (Valente & Marchetti, 2019). In both cases simple rules allowed the pupils to author their own materials into digital, non-linear, and visual novels; hence we wanted to identify a single mechanism, as simple as possible, that we could use as a formal model for such digital, interactive artefacts.

In both studies we used web-based prototype tools to let the pupils enact our scenarios, so it was natural to look at central ideas in web programming; moreover, in previous work one of us used a set of static HTML pages with hyperlinks and images to reason about non-linear narrative in designerly ways, as one of us attempted with a class of young adults, in Marchetti & Valente (2016).

From the point of view of game design, planning a visual non-linear story is often done via *sticky notes* and tangible materials, a set of activities that is very close to the typical tinkering we observed many times in Danish primary schools. However, the final goal of digital game designers is of course to create a digital game, while pupils and teachers usually would stop at table-top or pen-and-paper games. Finally, in our attempts to find a metaphor that could help us explain our experiments to primary school practitioners and their pupils, we looked at *action transfers* and *sticker albums*, which albeit being toys, can be easily associated and reappropriated as props and materials to be used in game design.

Our first experiment was then to define a simple JavaScript library, to make it very easy (for us at that time) to create non-linear visual novels with static HTML. The main interaction mechanism was images with HMLT anchors; we used some simple CSS ricks so that all the pages were fullscreen and responsive, allowing us to deploy on mobile devices from the start. Minimal persistence-like support was added, so that the state of every image in the page could be stored and retrieved from *LocalStorage*, effectively allowing a player stop to and resume playing. Since we were targeting mobile devices, such as tablets which are commonly used in Danish primary schools, we realized that our idea could easily express non-linear digital games in the style of point-and-click games.
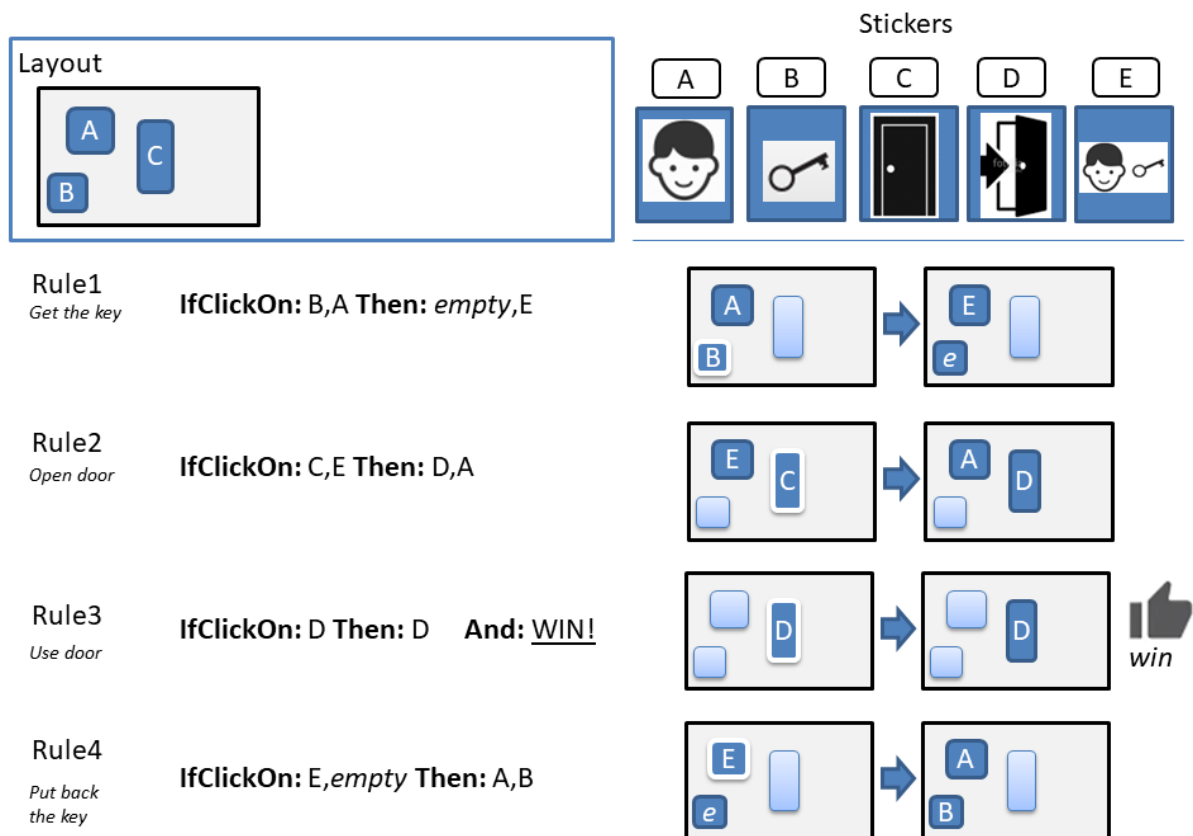
Figure 1. A simple example of a game definition.

In our scenario, the author of the game would define one of such games by doing the following:

- Define a layout for each page, i.e. rectangular regions that we call *markers,*
- Decide which images, from a palette of self-created ones, will initially occupy which markers,
- Then define rules for the game, so that when the player clicks on an image (with its associated hyperlinks) two things could happen:
  - the game could change page,
  - or the image might change to another.

Since this scenario could be summarized as "the game designer places stickers on pages and then the player would click on them", we gave this system the name **Stick&Click**. The most difficult part of the design of Stick&Click was to find a good way to express the rules avoiding the typical difficulties of coding.

We looked at rewriting systems and simple IF-THEN statements, and we decided that visual rules with a match-rewrite structure should work well here, in particularly taking in consideration what we know about the pupils' visual and reasoning skills from Marchetti and Valente (2017).

As visible in Figure 1, the rules have the following structure: if the player clicks on a certain image, then the image rewrites to another image, and perhaps the game ends because the player has won. In general, however, we wanted to have more *contextually aware* rules, so for example rule 1 in Figure 1 states that if the player clicks on image B, which is the key (wherever that might be in the page), **and** somewhere else in the page there is an instance of image A, the face of the boy, then image B is replaced by the label *empty* and A changes to E, the boy holding the key. The label *empty* is interesting, since it does not represent an image in the palette (i.e. one of the "stickers" used in this game), but instead it is an invisible special symbol.

The author of Stick&Click games can freely define new labels, to help her mark interesting locations in the page. The use of special symbols is common in theoretical Computer Science, and we made use of these marker-like symbols in our Paper Turing Machine (Valente & Marchetti, 2011), when complex computations needed to be performed; leaving a special symbol on the tape of the Paper Turing Machine made the rules simpler to express, as we wanted the same for Stick&Click's rewriting rules.

In Figure 2 it is shown the state diagram representing all possible navigations throughout the page. More complex games can be defined by having multiple pages, which in turn means that the rules can also have a JUMP clause, similar to the target URL of an HTML anchor.

The important feature for us is that both the graphics and the logic (i.e. the rules) of the point-and-click game in the making are defined by the user, without explicitly coding. The rules themselves can be expressed more visually, as shown in the right part of Figure 1, and work on a match-rewrite principle. The only interactivity available to the player is to trigger one of the rules, the first declared that matches the current state of the images on the screen, by clicking on one of the "stickers".
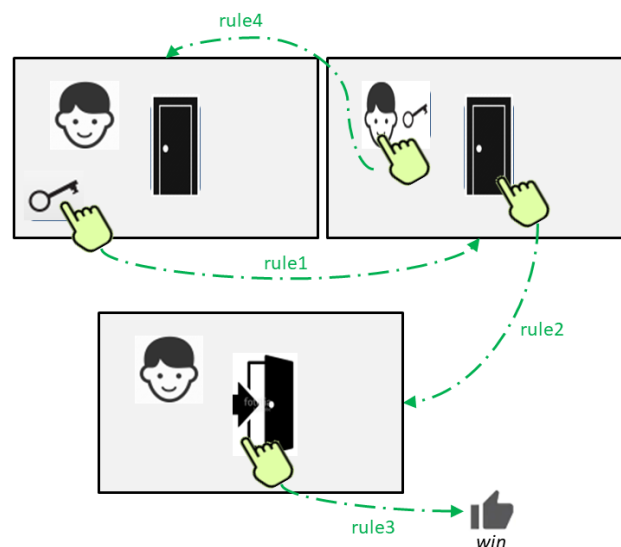
Figure 2. Navigation diagram for the game.

3.1 More experiments

The first set of experiments we performed with Stick&Click consisted in the creation of very short non-linear, interactive visual novels, using HTML and the JavaScript library described above. We mainly performed functional tests and explored expressiveness and scenarios of use. After having worked for a few months with this first implementation, we wrote a transpiler in Node.js, capable to

take a JSON specification file and a folder of images, and create an entire website of static webpages, implementing the game described in the JSON file. We explored the expressiveness of Stick&Click by creating parts of a few point-and-click games, mockups for user interfaces with navigation, and a minimalistic adventure game with gameplay similar to LCD games (see https://archive.org/details/handheldhistory). A later version of the transpiler was able to create a single-page application (i.e. a SPA) starting from a JSON specification file and the images for the stickers. For us the advantage of a SPA as that the player would always resume from the correct place in the visual novel, and the LocalStorage-based persistence would still suffice to be able to stop and resume playing.
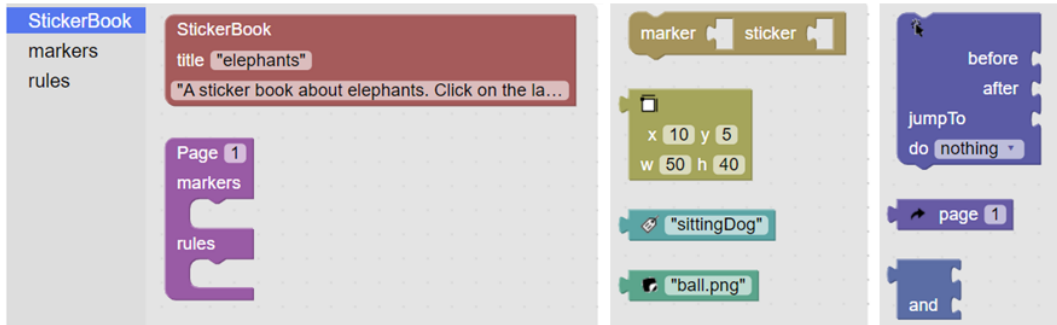
Figure 3. Instructions of the Stick&Click Blockly language.

Certainly we did not expect teachers and pupils to be able or interested in writing a JSON file to define a game, hence we manually designed a Blockly language based on our Stick&Click JavaScript library. Google's Blockly offers a visual GUI to create custom Blockly languages (see https://opensource.google.com/projects/blockly). We spent a couple of months learning Blockly and we decided to take advantage of the evaluation mechanism to export JSON files: for each Stick&Click game visually defined using our blocks, the Blockly language was able to export the JSON file needed to create the actual webpages for the game (with the Node.js transpiler described above). The instructions of the Blockly language are shown in Figure 3.
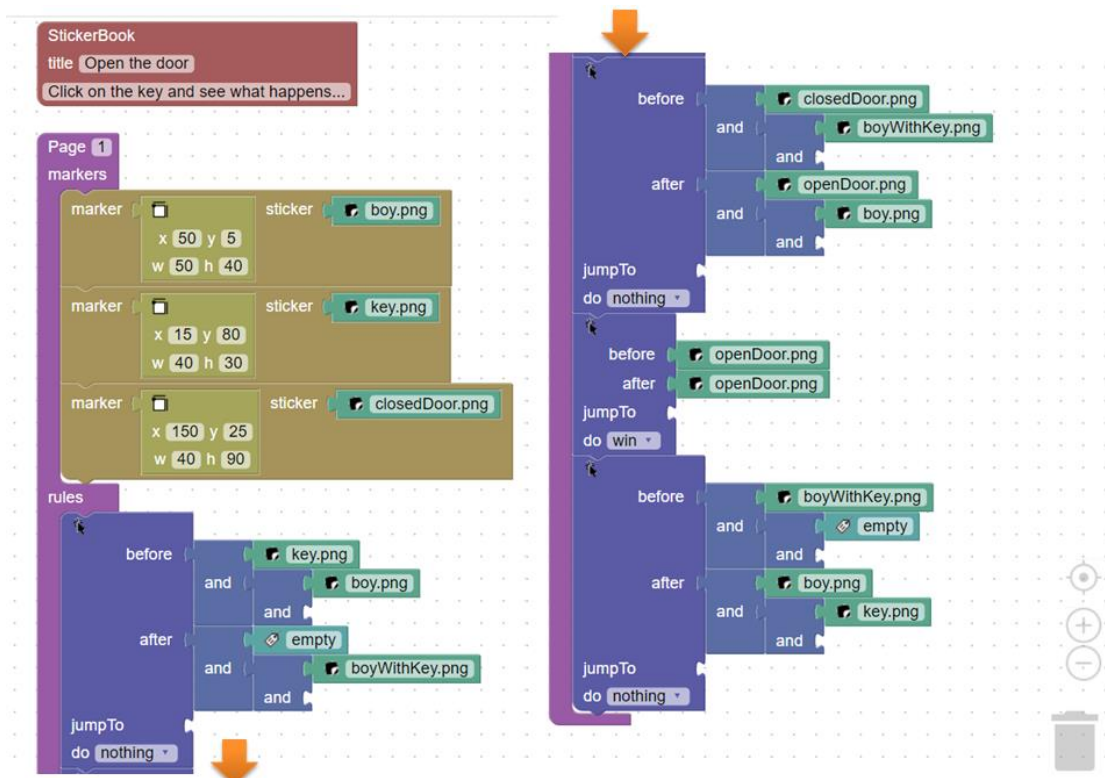
Figure 4. The game from Figure 1, redefined with the Stick&Click Blockly language.

43

To declare a new game with the Blockly-based visual GUI for Stick&Click, the author creates a "StickerBook" (see block on the top-left of Figure 4), and she provides a title and a description for the game. The sticker book also contains pages, each numbered, and each page has a list of markers (which define the initial layout as in Figure 1) and a list of rules. A marker is defined by a rectangle and a sticker, which in turn can be an actual image or a label. Rules are defined by specifying the list of images and labels that should match (i.e the *before* clause) and how they should be changed (in the *after* part of the rule); by default, the first sticker of the *before* clause is the one clicked by the player. Each rule can also force the game to change page, via its jumpTo clause, or even stop the game and display a Win or Lose message to the player.

As an example, Figure 4 shows the same simple game in Figure 1, defined using the Blockly language. Using this new toolchain, the Blockly language and the Node.js transpiler, it was very simple for us to reimplement all our previous test games, hence gain better understanding of the expressive power and versatility of Stick&Click. However, these rapidly developed spikes were never meant to become complete authoring tools, instead we surveyed various languages and platforms that we could use to create an actual, testable prototype, to show to our contacts in local primary and early secondary Danish schools.
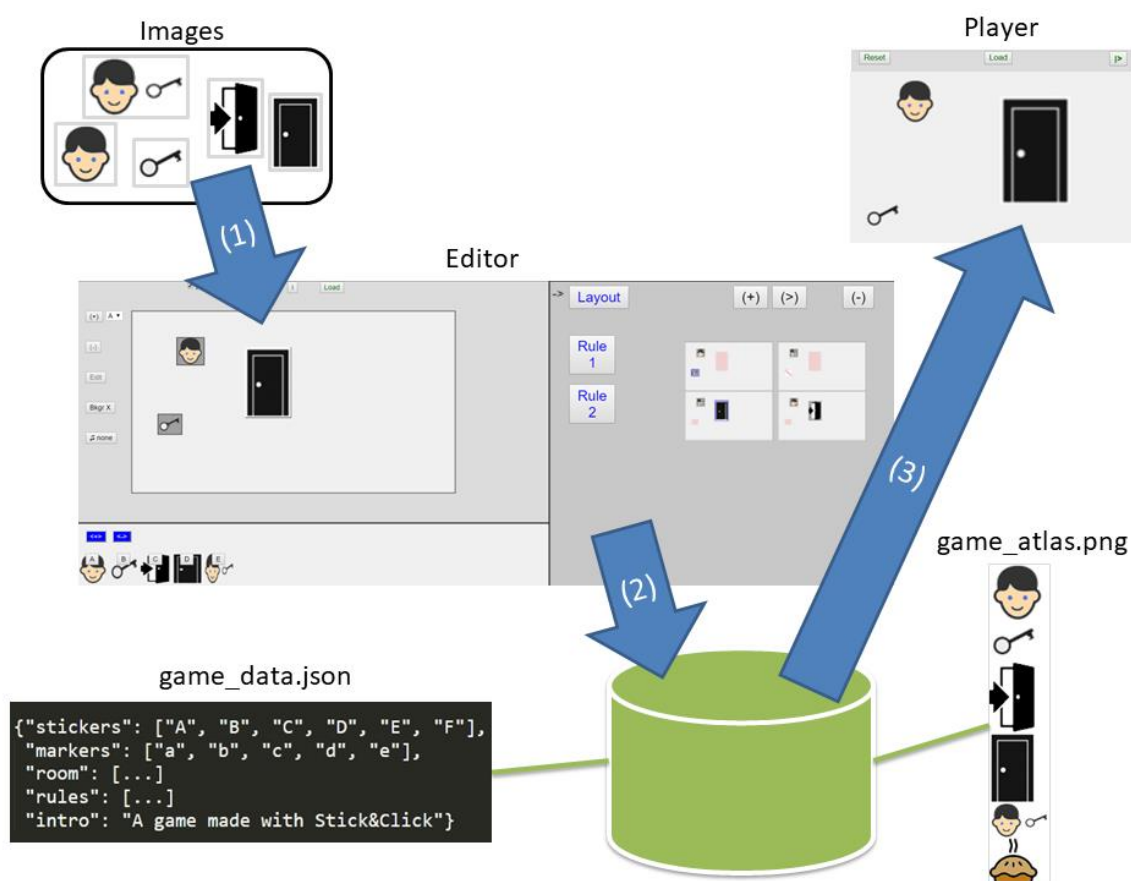
Figure 5. The game with the boy, defined inside the latest P5 prototype.

From our previous work in Valente & Marchetti (2019) we know that block-code can be intimidating for non-programmers, and in our experience it can make teachers feel tense, as they feel it shifts focus from their subjects and contents to programming; and that is another reason why we wanted a visual GUI but without hinting at code, as far as possible. Moreover, the part of Stick&Click that would benefit mostly from block-code is the definition of rules; but even for those we believe we can find less algorithmic and more directly visual ways to express them.

We considered implementing Stick&Click in various platforms; we made spikes in Processing, Java (using Android Studio), Python 3 (leveraging on the Pygame Zero library). Important features of our new tool should be the ability to run online and on mobile devices, so finally we opted for P5 (as documented in https://p5js.org/), a JavaScript implementation of Processing.

The current prototype in P5 has web-based editor and a player; its features are:

- Game author can upload her stickers images,
- Only a single page can be defined for now,
- Rules are fully implemented, in a visual before/after fashion, without block code,
- The prototype exports each project as 2 files: a JSON specification of the game a large image containing all stickers (i.e. an atlas),
- The playback webpage works by loading the 2 files representing a game, and it is fully functional, including animations for victory and playback of background audio files,
- The author can also select a background image and/or sound in the editor.

Figure 5 shows the proposed workflow of a pupil creating a game: first the pupil uploads her custom images to the web editor, then layout and rules are defined and the game description can be saved. Saving a game generates 2 files: a JSON file with the description of the game, and an image file containing a vertical list of all stickers used in the game (the atlas file). A second web-application, the player, can then be used to open the game files and play. This allows pupils to exchange their games or play games generated by their teachers.

4. Ongoing work and conclusions

Stick-n-click is still at a very early stage of design and prototyping, but it represents the latest in a number of explorations we conducted over the past decade. Through our previous studies, we found that games and design of simple paper-based games have become a spread practice in Danish primary schools, where games are seen as a resource for learning and assessment. The process of playing and creating games leads to the creation of boundary objects for reflections and reelaboration of the learning content, enabling for tinkering and shared in depth discussions with teachers and other pupils.

Within this context, digital games appear as black boxes in comparison to paper-based games, limiting the creativity of both teachers and pupils, as in order to edit them or create new ones, advanced programming skills are required. Therefore, our goal with Stick-n-click was to empower teachers and pupils, expanding their opportunity to express themselves creatively in the making of interactive digital games. This project centers on the classroom and its information ecology (Nardi & O'Day, 1999).

A main challenge in our studies was to simplify the practice and logic behind programming simple point and click games, to be accessible to teachers and pupils, without previous programming knowledge.

We are currently looking into open questions such as how to deal with global values in Stick&Click (e.g. the score of the game, which should exist and be the same in all pages of a game), or how to practically orchestrate a primary school class based on game development with our tool. Although we have performed small-scale functional testing during these early phases of development, we are planning a set of tests with teachers of a local school in Denmark, to be run in autumn 2019 and spring 2020. We intend to deploy Stick&Click and observe it within the classroom ecology, with the main goal to make the P5 protoype user-friendly and capable of covering authoring of digital game in the context of CT.

References

Cadierno, T., & Eskildsen, S. W. (2018). The younger, the better? A usage-based approach to learning and teaching of English in Danish primary schools. *European Journal of Applied Linguistics*, 6(1), 171-182.

Dunne, D. (2018). Implementing design thinking in organizations: an exploratory study. *Journal of Organization Design*, 7(1), 16.

Hoffmeyer, M., Jensen, J. J., Olsen, M. V., & Melcher, J. N. S. (2016). Assessing Digital Student Productions, a Design-Based Research Study on the Development of a Criteria-Based Assessment Tool for Students' Digital Multimodal Productions. pp. 23-27.

Fenyvesi, K. (2018). English learning motivation of young learners in Danish primary schools. *Language Teaching Research*. Sage Journals.

Löwgren, J. & Stolterman, E. (2004). *Thoughtful Interaction Design*. The MIT Press.

Marchetti, E. (2016). *Experiencing Historical Processes: Museum learning practice and digital technologies.* Aalborg Universitetsforlag. Ph.d.-series for Det Humanistiske Fakultet, Aalborg Universitet https://doi.org/10.5278/vbn.phd.hum.0004

Marchetti, E., & Valente, A. (2015). What happened to non-linear narrative? A pedagogical reflection. *Proceedings of the 15th IEEE International Conference on Advanced Learning Technologies - ICALT2015.* (pp. 233-237). IEEE. https://doi.org/10.1109/ICALT.2015.32

Marchetti, E., & Valente, A. (2016). It Takes Three: Re-contextualizing Game-based Learning Among Teachers, Developers and Learners. *Proceedings of The 10th European Conference on Games Based Learning* (pp. 399-406). Academic Conferences and Publishing International.

Misfeldt, M. and Zacho, L. (2016). Supporting primary-level mathematics teachers' collaboration in designing and using technology-based scenarios. Journal of Mathematics Teacher Education, 19(2-3), 227-241.

Møller, T. E. (2016). Collaborative learning through film production on iPad: Touch creates conflicts. *The Digital Literacy and Multimodal Practices of Young Children: Engaging with Emergent Research*, Proceedings of the first Training School of COST Action IS 1410, (pp. 127-134). University of Minho, Braga, Portugal.

Nardi, B., & O'Day, V. (1999). *Information Ecologies, Using Technology with Heart*. The MIT Press.

Preece, J., Rogers, Y., & Sharp, H. (2019). *Interaction Design. Beyond Human Computer Interaction*. Wiley and Sons.

Sutton-Smith, B. (1997). *The Ambiguity of Play*. Harvard University Press.

Valente, A., & Marchetti, E. (2011). Programming Turing Machines as a game for technology sense-making. In *Proceedings of 11th International Conference on Advanced Learning Technologies - ICALT 2011*. (pp. 428-430). IEEE Computer Society Press. https://doi.org/10.1109/ICALT.2011.134

Valente, A., & Marchetti, E. (2012). Kill it or grow it: Computer game design for playful math-learning. In *Proceedings of DIGITEL 2012: The 4th IEEE International Conference on Digital Game and Intelligent Toy Enhanced Learning* (pp. 17-24). IEEE Computer Society Press. https://doi.org/10.1109/DIGITEL.2012.11

Valente, A., & Marchetti, E. (2015). Make and play: card games as tangible and playable knowledge representation boundary objects. In *Proceedings of the 15th IEEE International Conference on Advanced Learning Technologies* (pp. 137-141). IEEE. https://doi.org/10.1109/ICALT.2015.31

Valente, A., & Marchetti, E. (2017). From Cards To Digital Games: Closing the loop. In *Proceedings of the 6th International Congress on Advanced Applied Informatics LTLE 2017* (pp. 507-510). IEEE. https://doi.org/10.1109/IIAI-AAI.2017.50

Valente, A., & Marchetti, E. (2019). Fables for teachers and pupils: incrementally defined scenario-based, interactive and spatial stories. In P. Zaphiris, & A. Ioannou (Eds.), *Learning and Collaboration Technologies: Designing Learning Experiences. HCII 2019* (pp. 206-224). Springer. Lecture Notes in Computer Science, Vol. 11590, Information Systems and Applications, incl. Internet/Web, and HCI. https://doi.org/10.1007/978-3-030-21814-0_16

Zimmerman, J. & Forlizzi, J. (2014). Research Through Design in HCI. *Ways of Knowing in HCI*, J.S. Olson and W.A. Kellogg (eds.), Springer, 167-189.

Towards Computational Thinking in Scandinavia

Kasper KRISTENSEN
Maersk Mc Kinney Moller Institute,
Embodied Systems for Robotics and Learning,
University of Southern Denmark (SDU), Denmark
kakr@mmmi.sdu.dk

Abstract: This paper describes experimentations in the introduction of Computational Thinking in Denmark. An example being the new mandatory information technology course *Informatik* in the Danish high school system, which aims to strengthen digital literacy. Furthermore, we also describe how Computational Thinking is being taught in volunteer organizations. Given the need for recognizing typical patterns in the deployment and adaptation of Computational Thinking in national contexts, the author is currently engaged in a PhD project aiming at compiling a collection of best practices to teach programming, from Asia and Scandinavia.

Keywords: Computational thinking, pedagogy

1. Introduction

The world is getting more interconnected, more reliant on technology, and changing rapidly in response to disruptive innovations. We cannot with any confidence predict the future, but we can prepare the next generation. Computational Thinking (CT) has received global recognition as an essential skill for the twenty-first century (Wing 2006). Not least in Denmark (Caspersen & Nowack 2013) where a continued effort resulted in a new mandatory IT course for HHX (branch of high school focusing on commence and business) in 2016. Furthermore, there is a strong political interest in creating a similar course for elementary school students, a tendency we see globally (Resnick et al 2006). Therefore, proper dissemination of knowledge, and identification of pedagogical approaches for teaching CT is critical.

Within Denmark the desire to introduce IT to kids and young adults developed on two fronts, one focusing on school curricula and the other more informal and practice oriented. The paper looks at these 2 settings and how they both represent adaptation of CT to different contexts of learning, and finally how both can inform the newly developed CT courses for Danish primary schools.

2. Informatik

The subject matter of the new mandatory course *Informatik* centers around the "computational world" and it is a separated subject on its own (UVM 2019). Distinct from the normal use of digital tool in other courses. Indicating a major shift from the traditional approach which since the 1980s had been to integrate IT into other subjects (Caspersen & Nowack 2013). CT is not explicitly mentioned in the courses' study plan, which instead includes structural analysis, abstraction and decomposition, all fundamental parts of CT (Wing 2006). Compared to other courses within the Danish school system *Informatik* is unique, as it specifies which pedagogical approaches should be used in teaching its subject matter, not to the exclusion of all other approaches. But it is worth noting such decisions are normally left to the teachers' discretions in courses taught in Denmark.

Software and other tools used within the course are still left to the individual teacher, including choice of programming languages, a more typical balance of responsibilities in Danish schools.

Two central pedagogical concepts used in defining *Informatik* are *Worked Examples* and *Use-Modify-Create*.

2.1 Worked Examples

The purpose of a *Worked Example* is to show a solution to a problem, and to show the thought process behind the implementation (Atkinson et al. 2000, Caspersen & Nowack 2013). *Worked Examples* are often produced with multiple modalities in mind such as audio and visual. Often in the form video, allowing students to engage with the example at their own pace. By showing the process and considerations what goes into a design *Worked Examples* demystifies the process, an aspect which is inherently absent when only showing finished code or completed problem solutions. *Worked Examples* are especially useful at the early stage of skill acquisition, lowering the cognitive load by having theory and relevant examples parts saliently shown in the material (Atkinson et al. 2000).

2.2 Use-Modify-Create

Use-Modify-Create proposed by Lee et al. (2011), as a promising pattern for teaching CT, is a pedagogical framework where we allow the students to first engage with a given product. If the product is a game the students could play it, afterwards they should modify the code behind the game. This process could be informed by improvements the students wish to implement after the use phase, or small bugs they noticed in the code. As the students understanding of the code increases, they can move from the modification phase to the creation phase. First by implementing new features to existing products and later to create completely new products (UVM 2019).

3. Volunteer Organizations

There is another side to the introduction of Computer Science for young people in Denmark, which happens outside the classrooms. Denmark has a strong culture for volunteer organizations called *clubs*, where kids and young adults play games and engage in free-time activities, after school hours. And clubs focusing on new technology, such as 3D printers, micro-controllers and robotics, have appeared over the last couple of years. Limited research has been conducted in the area as such the following section is informed by informal participant observations and the author's experience as a board member and volunteer, teaching programming and organizing activities at a local *club*.

These organizations often admit children as young as 7 years old (Coding Pirates 2019), and gradually build their curriculum in tandem with the children's growing understanding and curiosity within the field. This means that the members could possibly start in a technology club around the second grade of elementary school and continue all the way through high school, around 17 years old, at which point they could start a degree in computer science or similar field. Afterwards some of these members can likely become volunteers themselves.

Interestingly, many volunteers working at these clubs have a background in teaching or working within the IT field, which often gives these clubs strong technical profiles in knowledge of general pedagogical approaches, theory and practical working knowledge. Therefore, these organizations could offer valuable insights for creating new elementary school courses. These volunteer organizations are working from the bottom up, where the ministry is working from the top-down to expose pupils to IT contents.

4. Discussion and conclusion

Even if both a mandatory course like *Informatik* and a volunteer organization offer courses to the same age group, they still have a very different profile. Generally, in the ladder the elective nature of the activity predicts higher perceived competence and Intrinsic motivation for the students (Ferrer-Caja & Weiss 2002). Because of these fundamental differences a pedagogical approach which is highly successful in one setting might still need adaption in another or might need to be discarded entirely. Therefore, it is very difficult to directly base a new CT course for elementary schools, merely on the

pedagogical patterns that exist in *Informatik* or those that are used in the *clubs*. More verification and observations are needed.

However, it is to be expected that simple methods like *Worked Examples* or *Use-Modify-Create* might emerge as pedagogical practices in other countries attempting the same implementation of CT in schools.

This paper lays the initial conditions and groundwork for a larger PhD project, which in the long term aims at compiling a comprehensive collection of the best practices and typical pedagogical patterns to teach programming, taking inspiration from similar attempts being implemented in various countries. Therefore, the main objectives for this project will be to observe and catalogue CT techniques in the classroom in Asia, discover best practices, and compare them to those in Denmark. Furthermore, there will be an intriguing opportunity to deploy qualitative methods in the Asian context, where quantitative approaches are typically considered essential for IT-related studies in education.

References

Atkinson, R. K., Derry, S. J., Renkl, A., & Wortham, D. (2000). Learning from examples: Instructional principles from the worked examples research. *Review of educational research*, *70*(2), 181-214.

Caspersen, M.E. & Nowack, P. (2013). Computational Thinking and Practice — A Generic Approach to Computing in Danish High Schools, *Proceedings of the 15th Australasian Computing Education Conference,* ACE 2013, Adelaide, South Australia, Australia, pp. 137-143.

Coding Pirates (2019, September) *Spørgsmål og svar*. Retrieved from https://codingpirates.dk/faq/

Ferrer-Caja, E., & Weiss, M. R. (2002). Cross-validation of a model of intrinsic motivation with students enrolled in high school elective courses. *Journal of Experimental Education*, 71, 41–68

Lee, I., Martin, F., Denner, J., Coulter, B., Allan, W., Erickson, J., ... & Werner, L. (2011). Computational thinking for youth in practice. *Acm Inroads*, *2*(1), 32-37.

Resnick, M., Maloney, J., Monroy-Hernandez, A., Rusk, N., Eastmond, E., Brennan, K., et al. (2009). Scratch: Programming for all. *Communications of the ACM*, 52(11), 60-67.

UVM (2019, Marts). *Informatik C, hhx, htx, stx, hf — Vejledning*. Retrieved from https://www.uvm.dk/gymnasiale-uddannelser/fag-og-laereplaner/laereplaner-2017/hhx-laereplaner-2017

Wing, J.M. (2006). Computational Thinking, *Communications of the ACM*, Vol. 49 (3), pp. 33-35.

WORKSHOP 2 - New Computer Simulations in STEM Education

Enhancing Primary School Students' Higher Order Thinking Skills in Data Handling through Active Learning with Smart Board

Hon-Mun SOH[a], Abdul Halim Abdullah [b] & Mahani Mokhtar [c]
[a]*School of Education, Universiti Teknologi Malaysia, Malaysia*
[b] *School of Education, Universiti Teknologi Malaysia, Malaysia*
[c] *School of Education, Universiti Teknologi Malaysia, Malaysia*
*munmun1103@live.com.my

Abstract: Data Handling is a very important subtopic in statistics that brings learners out into the real world of seeing data; however, the level of Higher Order Thinking Skills (HOTS) in Data Handling among Malaysian students is declining. Thus, this study was conducted to evaluate the effectiveness of active learning using smart board programme in enhancing HOTS in Data Handling among students in Malaysian primary schools. The quasi-experimental design, non-equivalent control group design with pretest and post-test was used. Ninety year five students were split into three groups equally; two experimental groups (Active learning using smart board programme and active learning instruction) and one control group (conventional learning method). This study was conducted for eight weeks where quantitative data were collected and analysed. Pretest posttest, and a set of rubric for cognitive domain in HOTS were used. ANOVA test results indicated that there were significance differences between the mean scores of post-test. Comparison of the mean score of each cognitive domain for pretest and posttest showed that active learning using smart board programme contributed the largest improvement to students in HOTS regarding Data Handling (applying = 70.9%, analysing = 110.8%, evaluating = 200.4%, and creating = 460.8%). Consequently, active learning using smart board programme can be assumed suitable to be applied in schools with smart board as it could help students enhancing their HOTS effectively.

Keywords: Data Handling, active learning, smart board, higher order thinking skills, primary school

1. Introduction

Since the 1980s and 1990s, the need for higher order thinking skills (HOTS) among students has been documented since complicated real life problems often require complicated solutions, which are gained through higher level thinking processes (McDavitt, 1993; Son and VanSickle, 1993). Through the years, variations in meaning of HOTS have been accrued. King, Goodson, and Rohani (1998) define HOTS as including logical, critical, metacognitive, reflective and creative thinking. HOTS expand the use of mind to cater new challenges (Rajendran, 2008).

In Malaysia, the four levels of cognitive thinking in HOTS are applying, analysing, evaluating and creating (Lembaga Peperiksaan Malaysia, 2013). On the level of applying, students need to use learned material in new and concrete situations. It involves applying rules, methods, concepts, principles, laws and theories (Truschel and Deming, 2007). Next, analysing emphases on the process of investigating and breaking information into various parts through identifying the purposes or reasons to build an organisational structure that can be easily understood (Krathwohl, 2002; Noble, 2004). On the level of evaluating, students need to be able to defend and present ideas by making judgements about information, quality of work based on a set of criteria, or the validity of ideas (Krathwohl, 2002; Noble, 2004). Lastly, in the cognitive domain, creating compiles information from different elements by offering alternative solutions or joining the elements in a new meaning. The major emphasis is given on the formulation of structures or new patterns, creating stresses on a person's creative behaviours and actions (Krathwohl, 2002; Noble, 2004).

Lately, HOTS has been given a major concern in Malaysia mathematics education field, where the Ministry of Education announced the policy that by the year 2000, a minimum of 60% of the public examination questions in Malaysian schools will test the analytical and creative thinking skills of the students. At least 40% of the questions for the Ujian Pencapaian Sekolah Rendah (UPSR) examination are of higher order thinking questions, whereas 50% of the Sijil Pelajaran Malaysia (SPM) questions are of HOTS by 2016 in Malaysian schools (Malaysia Ministry of Education, 2012). This revolution in the mathematics assessments design means that teachers in school will give less emphasis on guessing questions and topics and are asked on the examination and drilling for content recall. Within the Malaysia education system, the steady increase in influence of HOTS is important in mathematics education.

In mathematics education, Data Handling is a crucial aspect of mathematics. Data Handling allows children to make sense of information, to identify patterns and trends and to predict and plan for the future (Griffiths, 2001). It is taught in Malaysian primary schools since students start their first year of schooling. It is an important subtopic of statistics which brings a learner out into the real world of seeing data, reflecting upon it socially or individually, and make decisions from it (Shaughnessy, 1992). However, previous results showed that Malaysian students generally performed badly in data handling in two international assessments namely: Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Assessment (TIMSS). Generally, the students did not possess HOTS in data handling.

One of the reasons for the low HOTS levels in Malaysia is that the teaching and learning process focuses on lower-level cognitive activities (Idris, 2010; Ng, 2004; Wenglinsky, 2002; Zohar, 2013). A study in the Preliminary Report of the Malaysia Education Blueprint 2013-2025 showed that in most mathematics lessons in primary schools, teachers rely on the lecture format and do not adequately engage students in constructive thinking where the traditional "chalk and talk" methods of teaching and learning were still in use. Most importantly, the learning focus is still on achieving surface-level content understanding or directed at the recalling of facts rather than cultivating HOTS (Malaysia Ministry of Education, 2012). Consequently, systematic and rigorous studies need to be carried out to develop strategies and methods for effective learning and to enhance HOTS among primary school mathematics students in Malaysia.

At the same time, the Malaysian education system is undergoing dramatic change; ICT was integrated into the education system to enhance the overall quality of education. The smart board has become one of the interactive technology tools widely used in schools to facilitate teaching and learning practice. Smart board was introduced by MOE in Malaysia in 2004 (Malaysia Ministry of Education, 2004). Empirical evidence demonstrated that smart board prepares an environment that allows students to construct their knowledge while mastering more advanced thinking skills (Beeland, 2001; Glanville, and Wildhagen, 2007; Marks, 2000; Painter, Whiting, and Wolters, 2005; Smith, Hardman, and Higgins, 2006). The integration of smart board facilitates active learning, which is fundamental to the mastery of skills. Therefore, it is crucial to identify the potential of using smart board with active learning in enhancing HOTS in Data Handling among primary school students. Findings from the data can be used to develop more strategies and activities for effective learning in order to enhance HOTS in Data Handling among primary school students in Malaysia.

2. Research Objective

The objective of this research was:
  i. To evaluate the effectiveness of the Active learning using smart board programme in enhancing HOTS in Data Handling among students in Malaysian primary schools.

3. Methodology

This study used quantitative research approach to identify the potential of using smart board with active learning in enhancing HOTS in Data Handling among students in Malaysian primary schools. It was conducted in a Malaysian public primary school. Ninety year five students were involved in the study.

The selection of students in this study was based on purposive sampling. They were from different classes with average academic achievement in mathematics.The quasi-experimental design, nonequivalent control group design with pretest and posttest is used in the study. Based on a quasi-experimental research design, the students are split into three groups equally; two experimental groups and one control group, and then introduced to a change in both experimental groups, i.e., the active learning using smart board programme for one of the experimental groups and active learning instruction for the other experimental group. Meanwhile, the control group uses the conventional learning methods. Three groups are used in this study to compare, check for the significant difference and evaluate the effectiveness of each treatment. The study used pretest, posttest, and a set of rubric for cognitive domain in HOTS. All the research instruments were validated by experts who are knowledgeable in HOTS in mathematics and have many years of experience on the development and design of active learning. The quantitative data collected in this study was analysed based on the descriptive and inferential statistics using SPSS Statistics 23. One-way ANOVA is used to analyse students' scores in the pretest and posttest.

4. The Active Learning Using Smart Board Programme Activities, Active Learning Instruction Activities, and The Conventional Learning Activities

The teaching and learning process of Data Handling consists of set induction, step one, step two, step three and closure. A model of active learning (L. Dee, 2010) is used to design the active learning using smart board programme and the active learning instruction. Teachers can implement various active learning activities effectively and make learning meaningful for every student actively involved. In the other hand, conventional learning method involves the traditional teacher-centred learning with most of the students are in the passive receiver mode. Students usually listen to a lecture in a classroom. Table 1 shows the learning activities of the active learning using smart board programme, active learning instruction, and the conventional learning method.

Table 1

The Learning Activities of Each Teaching and Learning Phase

	Active Learning using Smart Board Programme	Active Learning Instruction	Conventional Learning Method
Set induction	• Experience of observing (Using visualizer and smart board software such as Flipbook, Sphere 2, as well as IQ Interactive Education Platform to demonstrate a divergent event or phenomena by showing pictures or diagrams, a short practical activity, present a problem to be thought through, a video clip or film show through internet and experiment.)	• Experience of observing (Demonstrating a divergent event or phenomena by showing pictures or diagrams, a short practical activity, present a problem to be thought through, a video clip, film show and experiment.)	Teacher demonstrating a divergent event or phenomena by showing pictures or diagrams, present a problem to be thought through.
Step 1	• Dialogue with self • Dialogue with others • Experience of observing • Experience of doing (Using visualizer and smart board software such as Flipbook, Sphere 2, as well as IQ Interactive Education Platform Discussion during experiment, discourses in small groups, brainstorming, concept mapping, practical work, practical work, question-answer session, interview of events, drawing pictures to illustrate science phenomena and presentation.)	• Dialogue with self • Dialogue with others • Experience of observing • Experience of doing (Discussion, experiment, discourse in small groups, brainstorming, concept mapping, practical work, practical work, question-answer session, interview of events, drawing pictures to illustrate science phenomena and presentation.)	Teacher shows the solutions of a problem to students.
Step 2	• Dialogue with self • Dialogue with others • Experience of observing • Experience of doing (Using visualizer and smart board software such as Flipbook, Sphere 2, and IQ Interactive Education Platform during small group discussion, project, investigations, experimentation, demonstration, practical work, simulation and presentation.)	• Dialogue with self • Dialogue with others • Experience of observing • Experience of doing (Small group discussion, project, investigations, experimentation, demonstration, practical work, simulation and presentation.)	Students' small group discussion to solve given problems. Then, teacher shows the solutions.
Step 3	• Experience of doing (Using visualizer and smart board software such as	• Experience of doing (Solving problems in various but related	Individual activities

	Flipbook, Sphere 2, and IQ Interactive Education Platform to solve problems in various but related circumstances, innovating, and worksheets.)	circumstances, innovating, worksheets and writing of individual's report on the project work.)	(worksheets for students)
Closure	• Dialogue with self • Dialogue with others (Using visualizer and smart board software such as Flipbook, Sphere 2, and IQ Interactive Education Platform during group discussion.)	• Dialogue with self • Dialogue with others (Writing of individual's report on the project work, group discussion, personal notes.)	Teaher summarise the lesson.

5. Findings of The Study

The quasi-experimental design, nonequivalent control group design with pretest and posttest design was used to identify the potential of using smart board with active learning in enhancing HOTS in Data Handling among students in Malaysian primary schools. The student were splited into three groups equally; the active learning using smart board programme for experimental group A and active learning instruction for experimental group B. Meanwhile, the control group uses the conventional learning methods. The quantitative data obtained from the pretest and posttest were analysed based on the descriptive and inferential statistics using SPSS Statistics 23. The findings from the quantitative method are presented below:

5.1 Analysis of The Mean of Each Level of The Cognitive Domain in HOTS in Data Handling among Each Student Group

Pretests and posttests were used to discuss the consequences of learning using the active learning using smart board programme, active learning instruction and conventional learning method in enhancing each level of the cognitive domain in HOTS which is applying, analysing, evaluating, and creating in Data Handling among students. The mean score of each cognitive domain between the pretest and posttest of each student group, experimental group A, experimental group B and control group was analysed to show the improvement of the level of HOTS before and after implementing the active learning using smart board programme, active learning instruction and conventional learning methods. Figure 1 shows the result of the analysis.

Figure 1. Comparison of The Mean Score of Each Cognitive Domain in HOTS between Pretest and Posttest among Each Student Group.

Regarding Figure 1, the mean score of each cognitive domain in HOTS for the posttest among each student group was significantly higher than the pretest which indicated improvement in HOTS in Data Handling among each student group. Experimental group A which used the active learning using smart board programme in learning Data Handling recorded the largest improvement in HOTS in Data Handling as experimental group A has the largest difference on each cognitive domain in HOTS between pretest and posttest, Applying = 3.14, Analysing = 3.8 Evaluating = 4.47, and Creating = 5.53. In the other hand, control group which used the conventional learning method in learning Data Handling recorded the smallest improvement in HOTS in Data Handling as control group has the

smallest difference on each cognitive domain in HOTS between pretest and posttest, Applying = 1.7, Analysing = 0.9, Evaluating = 0.86, and Creating = 1.27. Besides, the highest mean score is Applying from experimental group A for the pretest, 5.43 as well as posttest, 7.57. The lowest mean score is Creating from experimental group A and control group for the pretest, 1.20; control group for the posttest, 2.47. The highest improvement between the pretest and posttest is Creating from experimental group A, 5.53 and the lowest improvement is Applying from control group A, 0.7.

Next, the difference in mean value is explained by the ANOVA test. Figure 2 shows the analysis from the one-way ANOVA for mean scores of each cognitive domain in HOTS in the posttest. The results indicate that there are significant differences (sig. value = < 0.000) between the mean scores of posttest in the 95% confidence interval. The significance value is < 0.000, which is below 0.05 and therefore, we can conclude that there is a statistically significant treatment effect between the mean scores of each cognitive domain in HOTS in the posttest.

Applying	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	93.956	2	46.978	118.925	.000
Within Groups	34.367	87	.395		
Total	128.322	89			

Analysing	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	127.089	2	63.544	147.817	.000
Within Groups	37.400	87	.430		
Total	164.489	89			

Evaluating	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	201.689	2	100.844	193.106	.000
Within Groups	45.433	87	.522		
Total	247.122	89			

Creating	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	273.422	2	136.711	234.131	.000
Within Groups	50.800	87	.584		
Total	324.222	89			

Figure 2. One-way ANOVA for Mean Scores of Each Cognitive Domain in HOTS in The Posttest.

In conclusion, the findings of the quantitative analysis as discussed above indicate that the active learning using smart board programme is the best method for enhancing creating a domain in Data Handling among students compared with active learning instruction and conventional learning methods.

6. Discussion
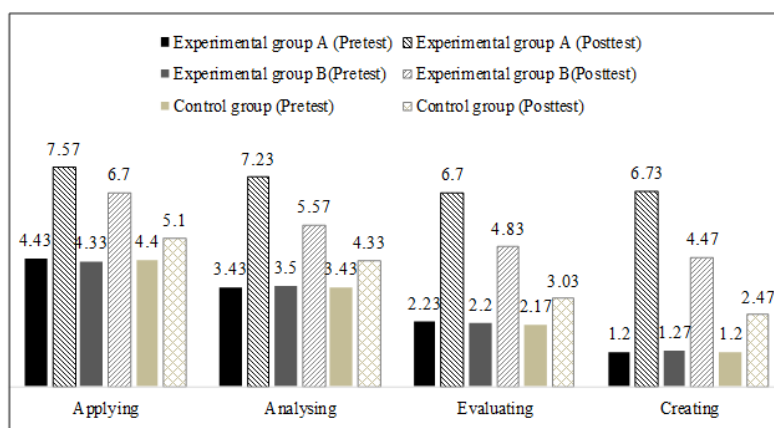
From the mean score of each cognitive domain in HOTS between pretest and posttest among each student group as shown in Figure 1, there was an improvement of HOTS among the students. However, experimental group A which used the active learning using smart board programme in learning Data Handling recorded the largest improvement in HOTS in Data Handling. Most of the students were unable to answer the questions that were designed to evaluate their HOTS before the active learning using smart board programme was introduced to them. However, after the students went through the learning of Data Handling with the active learning using smart board programme, they were more able to solve the HOTS questions correctly compared with the students who learn Data Handling using active learning instruction and conventional learning methods. This is indicated by the improvement of the mean scores of each cognitive domain in HOTS in the posttest. A smart board as an interactive technology tool facilitates students' learning practice and enhances HOTS. A similar finding was reported by Beauchamp and Kennewell (2010) in which the interactivity in the classroom by using the smart board is influenced by the students, and when the students' engagements with the smart board change from viewer to the active user. The results from the research were also consistent with those reported by other researchers who use smart board to promote HOTS where smart board is use as an efficient tool for orchestrating the interaction and lesson, students' HOTS can be improved be improved (BECTA, 2008; Jones, Kervin, and McIntosh, 2011; Tenneille, 2012).

7. Conclusion

To put in a nutshell, the findings from this study have shown the potential of the active learning using smart board programme in enhancing each level of HOTS in Data Handling among students in Malaysian primary school. The encouraging results give positive implication to the student of learning Data Handling. Most importantly, the effectiveness of the active learning using smart board programme

has demonstrated the potential of smart board integrates with active learning in supporting learning and enhancing HOTS. Students can actively be involved in building their knowledge, use of various computer resources and effective methods to support students' learning, provides greater flexibility in the presentation of the materials, simulates the real experience and offer students to do the real thing as well as support students mastering more advanced thinking skills. It is clear that learning experiences, which improve the HOTS of the students will soon become a common practice in a rapidly changing technological society. This is of utmost importance as the development of information technology has become ubiquitous in the Malaysian education system. This humble attempt would be resourceful in offering an alternative for technology-supported learning, especially for those who intend to improve their HOTS.

Acknowledgement

References

Beauchamp, G. and Kennewell, S. (2010). Interactivity in the Classroom and Its Impact on Learning. Computers and Education, 54(3), 759-766.

BECTA. (2008). Harnessing technology schools survey 2007: Analysis and key findings.

Beeland, W. (2001*). Student engagement, visual learning and technology: Can interactive whiteboards help?,* Paper presented at Annual Conference of the Association of Information Technology for Teaching Education, Trinity College, Dublin.

Glanville, J.L. and Wildhagen, T. (2007). The measurement of school engagement: Assessing dimensionality and measurement invariance across race and ethnicity. Educational and Psychological Measurement, 67, 1019-1041.

Griffiths, R. (2001). What's your favourite data? Data Handling Activities. *Lower Numeracy, 21*(4), 34-35.

Idris, N. (2010). *Penyelidikan dalam Pendidikan.* Malaysia: Mc Draw Hill (Malaysia) Sdn. Bhd.

Jones, P., Kervin, L., and McIntosh, S. (2011). The interactive whiteboard: Tool and/or agent of semiotic mediation. Australian Journal of Language and Literacy, 34(1), 38-60.

King, F.J., Goodson, L., and Rohani, F. (1998). Higher order Thinking Skills: Definitions, Strategies, and Assessment.

Krathwohl, D. R. (2002). A revision of bloom's taxonomy: An overview. Theory into Practice, 41(4): 212-218.

L. Dee Fardanesh, H. (2010). A Classification of Constructivist Instructional Design Models Based on Learning and Teaching Approaches. *Online Submission*, 16.

Lembaga Peperiksaan Malaysia. (2013). Pentaksiran Kemahiran Berfikir Aras Tinggi (p. 168). Putrajaya: Kementerian Pendidikan Malaysia.

Malaysia Ministry of Education. (2004) Annual Report Ministry of Education 2004, Putrajaya: Ministry of Education Malaysia.

Malaysia Ministry of Education. (2012). Malaysia Education Blueprint 2013-2025: Preliminary report.

Marks, H. M. (2000). Student engagement in instructional activity: Patterns in elementary, middle, and high school years. American Educational Research Journal, 37 (1), 153-184.

McDavitt, D. S. (1993). Teaching for understanding: Attaining higher order learning and increased achievement through experiential instruction. (ERIC Document Reproduction Service No. ED 374 093).

Ng, A.K. (2004). Liberating the Creative Spirit in Asian Students. Pearson Prentice Hall.

Noble, T. (2004). Integrating the revised bloom's taxonomy with multiple intelligences: A planning tool for curriculum differentiation, Teachers College Record, 106: 193. Blackwell Publishing Limited.

Rajendran, N. (2008) Teaching and Acquiring Higher order Thinking Skills: Theory and Practice. Tanjong Malim Perak: Penerbit Universiti Pendidikan Sultan Idris.

Shaughnessy, J. M. (1992). Research in probability and statistics: Reflections and directions. In D. A.Grouws (Ed.), Handbook of research on mathematical teaching and learning (pp. 465-494). New York: Macmillan.

Smith, F., Hardman, F., and Higgins, S. (2006). The impact of interactive whiteboards on teacher-pupil interaction in the national literacyandnumeracy strategies. British Educational Research Journal, 32(3), 437-451.

Son, B., and VanSickle, R. L. (1993). Problem-solving instruction and students' acquisition, retention and structuring of economics knowledge. (ERIC Document Reproduction Service No. ED 366 627).

Tenneille Terrel Lamberth. (2012). Interactive Whiteboard Use: The Catalyst of Student Achievement" Dissertations. 711.

Truschel, J., and Deming, W. E. (2007). What tutors can do to enhance critical thinking skills through the use of Bloom's Taxonomy.

Wenglinsky, H. (2002). How schools matter: The link between teacher classroom practices and student academic performance. *Education Policy Analysis Archives*, *10*(12).

Zohar, A. (2013). Challenges in wide scale implementation efforts to foster higher order thinking (HOT) in science education across a whole wide system. *Thinking Skills and Creativity, 10,* 233-249.

Pedagogy Designs to Augment the Impact of Computer Simulations

Hsin-Yi CHANG[a]*, Cai-Ting WEN[b], Ming-Hua CHANG[b] & Chen-Chung LIU[b]
[a] *National Taiwan Normal University, Taiwan*
[b] *National Central University, Taiwan*
*hychang@ntnu.edu.tw

Abstract: In this study, we compare the effects of two different pedagogical designs around a computer simulation on students' scientific literacy in the case of learning science concepts relating to sinking and floating. We also compare the effects of teaching with simulations versus traditional teaching to provide baseline information. A total of 75 eighth-grade students participated in the study. Data collected include the students' pretest and posttest data that indicate scientific literacy. The results provide evidence for the effectiveness of a student-centered pedagogical design. Reflection and discussion on how to augment the impact of computer simulations are provided.

Keywords: Pedagogy designs, computer simulations, critique, scientific literacy

1. Introduction

Computer simulations allow learners to conduct virtual experiments such as changing the parameters and values of the simulation to test their hypotheses and theories, enabling learners to engage in core authentic scientific practices, especially on phenomena that cannot easily be observed or investigated in real-life situations. However, students may have difficulties conducting mindful and purposeful virtual experiments, given the openness of the interactive simulation environment (McElhaney, Chang, Chiu, & Linn, 2015). Therefore, teaching guidance is needed to support learners' inquiry with interactive simulations to conduct productive and mindful virtual experiments (Efstathiou et al., 2018). How to design effective pedagogies for teaching with computer simulations to address students' difficulties and promote their science learning has become an important issue.

In this study, we worked with two science teachers at the participating school to create two versions of pedagogy designs for a computer simulation focusing on the phenomenon of sinking and floating, which has been developed via the CoSci platform (http://cosci.tw/). One version involves teacher demonstration, and the other involves students' critique activities (detailed in the next section). We compared the effects of the two designs on students' performance of scientific literacy after the treatments. Both of the designs are for teaching with simulations. Since the unit of sinking and floating is usually taught conventionally without the use of simulations, we were also interested in how the effects of teaching with simulations compared to the effect of conventional, lecture- and textbook-based teaching. The learning outcome focused on is students' scientific literacy in the context of phenomena relating to sinking and floating. Developing future citizens' scientific literacy involves the goal of educating young people to become critical users of scientific knowledge, including developing their ability to explain phenomena scientifically, evaluate and design scientific inquiry, and interpret data and evidence scientifically (OECD, 2016). This goal has been emphasized in science education standards in Taiwan (Taiwan Ministry of Education, 2014) and globally (e.g., NGSS Lead States, 2013). The results of this study provide insights into how to develop effective pedagogies around computer simulations to foster students' scientific literacy.

2. Pedagogy Designs for Teaching with Computer Simulations

2.1 The Teacher Demonstration Design/Treatment

In the teacher demonstration treatment, the teacher spent one class period (45 minutes) demonstrating how to conduct experiments with the CoSci sinking and floating simulation. She selected one inquiry question provided in the CoSci simulation learning environment and showed her students how to formulate hypotheses, design and conduct virtual experiments, collect and analyze data and make conclusions to address the inquiry question. All materials needed for the demonstration were prepared in advance as PowerPoint slides. During the demonstration the teacher lectured following the slides and occasionally paused to ask students questions to engage them in the lecture. Then the students were allowed to conduct their own inquiry with the simulation for two class periods. The students' inquiry was guided by the system through provided inquiry questions and prompting hints and questions.

2.2 The Student Critique Design/Treatment

In the student critique treatment, the students worked on worksheets prepared by the science teachers that asked the students to critique fictitious experiments with the CoSci sinking and floating simulation. For example, the students were given an inquiry question and a series of experiment designs and were asked to critique "whether these designs can answer the inquiry question or not? If not, how can you improve the designs?" The students were also asked to critique whether a given set of data could be used to support a given conclusion, and how to improve the conclusion. The students spent one class period completing the critique worksheets. The teacher also led whole class discussions to engage the students in discussing their critiques. Then the students were allowed to conduct their own inquiry with the simulation for two class periods. The students' inquiry was guided by the system through provided inquiry questions and prompting hints and questions. The design of the student critique activities was based on Chang and Linn (2013) who indicated that critiques involving reflection facilitate knowledge integration.

3. Methods

Three classes of eighth-grade students at a public junior high school in Taiwan participated in this study. Each class was randomly assigned to one of the three treatments: teacher demonstration followed by student inquiry with simulation (n=24), student critique followed by student inquiry with simulation (n=26), or traditional lecture without student inquiry with simulation (n=25). The first two involved the use of the CoSci simulation (as detailed in the previous section). The traditional lecture treatment also involved three class periods but teaching through lecture- and textbook-based lectures with no simulation. The three groups did not differ in terms of their prior scientific literacy as measured by the pretests [$F(2, 72)=0.085$, $p=.919$].

Each individual student took pretests before (about one class period) and posttests after (about one class period) the treatment. The pretests consisted of eight constructed-response items to measure students' scientific literacy in the context of near transfer from the context of the simulation. In addition to the eight items, the posttests (a total of 14 items) comprised six additional items that measured students' scientific literacy in the context of far transfer from the context of the simulation. The items went through several rounds of revision by three science educators to ensure content and construct validity.

Detailed scoring rubrics were developed to score students' scientific literacy performance. 20% of the tests were coded by two independent coders following the rubrics, and the inter-coder agreement reached 96%, with Cohen's Kappa = 0.94. ANCOVA was employed to test the differences among the three treatments, using the posttest score as the dependent variable, the pretest score as the covariate, and the treatment as the independent variable. In addition, we calculated effect sizes between any two mean scores of the posttests with the difference between two means divided by the combined standard deviation for those means, according to Cohen (1988).

4. Results

The students' pretest and posttest mean scores and standard deviations are summarized in Table 1. The ANCOVA result indicates that there is a significant treatment effect ($F=7.908$, $p=0.001$). Paired comparisons with a modified Bonferroni correction reveal significant differences between the Student

Critique treatment and the traditional teaching treatment, but no significant difference between any two of the others. The effect sizes are large between any two of the three treatments, given that the mean differences are large and the standard deviations are very small. Overall, the results indicate that the effect of teaching with the sinking and floating computer simulation can be augmented by the pedagogical design that engages students in critiquing experiments with simulations prior to their inquiry with the simulation. This effect is specifically significant when compared to traditional teaching that employs lecture- and textbook-based approaches.

Table 1

Pretest and Posttest Means, Standard Deviations (in Parentheses), and Effect Sizes

	Pretest	Posttest	Effect Size (d)
Teacher Demo Treatment	8.71 (4.11)	11.82 (0.75)	Student Critique/ Teacher Demo= 2.96;
Student Critique Treatment	9.23 (3.64)	13.97 (0.70)	Teacher Demo/ Tradition =2.51; Student Critique/Tradition= 5.61
Traditional teaching Treatment	8.92 (5.58)	9.96 (0.73)	

5. Concluding Remarks

The study provides evidence that coupling computer simulations with student-centered critique activities can better benefit students' scientific literacy than the traditional lecture approach. Although the teacher demonstration approach coupled with student inquiry with simulations had a large effect compared to the traditional approach, this effect did not reach statistical significance. Also, the relative effect between the teacher demonstration and student critique approaches is large but not significant. In a previous study (Wen et al., under review) we found that the effect of student inquiry with simulation on students' scientific literacy would significantly appear in delayed posttests but not in posttests based on the growth of a learning curve for literacies (Horton, 2001). We are conducting and collecting data using delayed posttests to further discern the effects of the treatments.

Acknowledgements

References

Chang, H.-Y., & Linn, M. C. (2013). Scaffolding learning from molecular visualizations. *Journal of Research in Science Teaching*, *50*(7), 858-886.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences (2nd Edition).* Hillsdale, NJ: Lawrence Erlbaum Associates.

Efstathiou, C., Hovardas, T., Xenofontos, N. A., Zacharia, Z. C., deJong, T., Anjewierden, A. et al. (2018). Providing guidance in virtual lab experimentation: The case of an experiment design tool. *Education Technology Research and Development, 66*(3), 767-791.

Horton,W. (2001). Evaluating e-learning. Alexandria, VA : American Society for Training & Development.

McElhaney, K. W., Chang, H.-Y., Chiu, J. L., & Linn, M. C. (2015). Evidence for effective uses of dynamic visualizations in science curriculum materials. *Studies in Science Education, 51*(1), 49-85.

Ministry of Education (MOE). (2014). *Curriculum outlines of the 12-year basic education curriculum-the master outline*. Taipei: Ministry of Education Publishing.

NGSS Lead States. (2013). *Next generation science standards: For states, by States.* Washington, DC: The National Academies Press.

OECD. (2016). *PISA 2015 Assessment and analytical framework: Science, reading, mathematic and financial literacy.* Paris: OECD Publishing.

Augmented reality research output from 1990-2018: A bibliometric analysis

Kaushal Kumar BHAGAT

Indian Institute of Technology Kharagpur, India
*kkntnu@hotmail.com

Abstract: This aim of this study was to analyze the research output of augmented reality (AR) using a bibliometric analysis. A total of 1737 related documents were published from 1990 to 2018. The results showed that the USA and the National University of Singapore were the most productive country and Institute publishing articles on AR, respectively. The most productive journal was IEEE Transactions On Visualization And Computer Graphics with the number of publications (22). This study provides an overview of the AR research and suggests future directions.

Keywords: Augmented reality (AR); bibliometric analysis; research trend

1. Introduction

Currently, AR has emerged as one of the most popular interactive technologies among the researchers. AR not only provides 3-D interactive visualizations in real time, but has other advantages (Chen, 2013):

- Multimedia and multisensory
- Portable and cost-effective
- User-friendly

AR is being used across many domains. It has several educational benefits that include better learning performance, motivation, and promotes active learning (Cai, Wang, & Chiang, 2014; Ferrer-Torregrosa, Torralba, Jimenez, Garcia, & Barcia, 2015; Yilmaz & Goktas, 2017). The present study attempted to present an overview of research conducted on AR by applying bibliometric analysis method.

2. Methodology

Scopus was used as a database using the following keyword syntax combination: (TITLE-ABS-KEY ("augmented reality") OR TITLE-ABS-KEY ("augmented learning") OR TITLE-ABS-KEY ("mobile augmented reality") AND TITLE-ABS-KEY ("learning") OR TITLE-ABS-KEY ("education") OR TITLE-ABS-KEY ("simulation") OR TITLE-ABS-KEY ("training") OR TITLE-ABS-KEY ("interactive learning environment")) to extract all the target publications. This study employed bibliometric method to analyze the research trend of AR research from 1990 to 2018. Data visualization was performed using VosViewer software.

3. Results

3.1 General trends

A total of 1737 documents were obtained. Figure.1 shows that there is an exponential growth in the publications related to AR. This suggests that the domain of AR research has got a lot of attention from the researchers, which is a good sign. This may be due to the low-cost and availability of AR technology compared to other available interactive technologies like virtual reality.
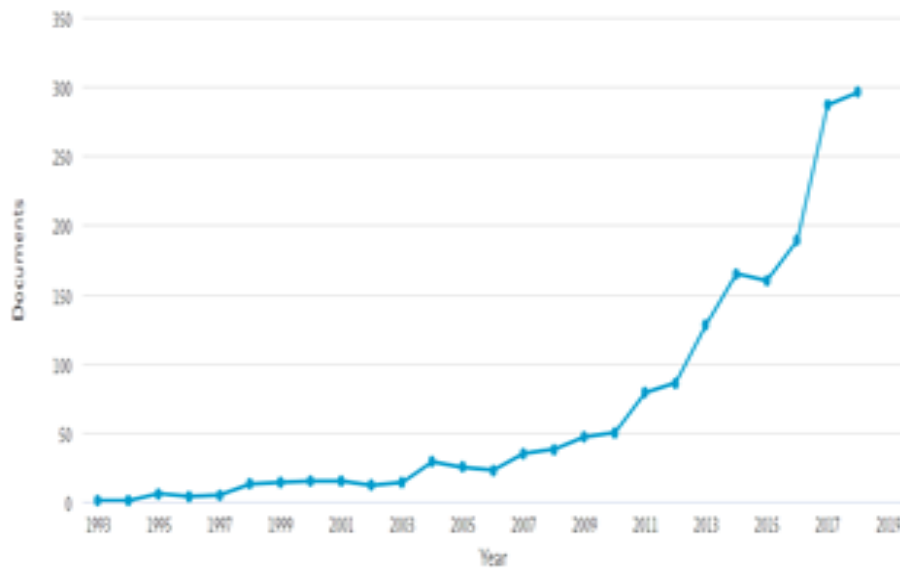
Figure 1. Number of publications per year

3.2 Document types and language of publication

Four different document types were identified that includes journal articles (1632), book series (65), trade publications (27), and conference proceedings (13).A total of 1626 (93.6%) publications were published in English language. This result indicates English is the dominating language in the domain of AR research. This analysis was restricted only journal articles because journal articles provide more detailed information compared to other document types.

3.3 Major journals and their publications

The top most productive journal is IEEE Transactions on Visualization and Computer Graphics with 22 publications (see Table 1.). Table 1 shows that AR is popular in computer science, medical field, and education.

Table 1. Top 10 productive journals based on total number of publications

Journal	Number of articles
IEEE Transactions on Visualization and Computer Graphics	22
Multimedia Tools And Applications	20
Virtual Reality	19
International Journal Of Computer Assisted Radiology and Surgery	18
IEEE Computer Graphics and Applications	17
Surgical Endoscopy	17
Computers and Graphics Pergamon	16
Eurasia Journal Of Mathematics Science And Technology Education	16
Computers in Human Behavior	15
Educational Technology And Society	14

3.4 Most-prolific authors

The most prolific author is *Andrew Y.C. Nee* from National University of Singapore, Singapore with 14 published articles (see Figure 2.).
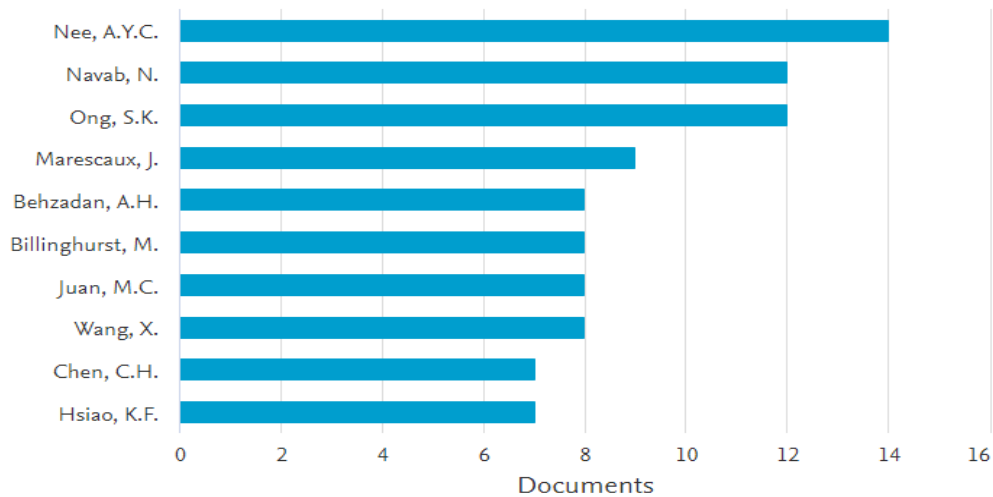
Figure 2. Top 10 most-prolific authors based on total number of articles published

3.5 Geographic distribution and international collaboration

USA is the most dominant country with 351 articles (see Table 2.) in AR research. All the top productive countries are developed countries except China. 3 out of the top 10 institutions are from Taiwan, and 5 out of 10 institutions are from Asia (see Table.3). National University of Singapore is the most productive institution with twenty three published articles. Figure.3 displays the network visualization between countries which are involved in AR research.
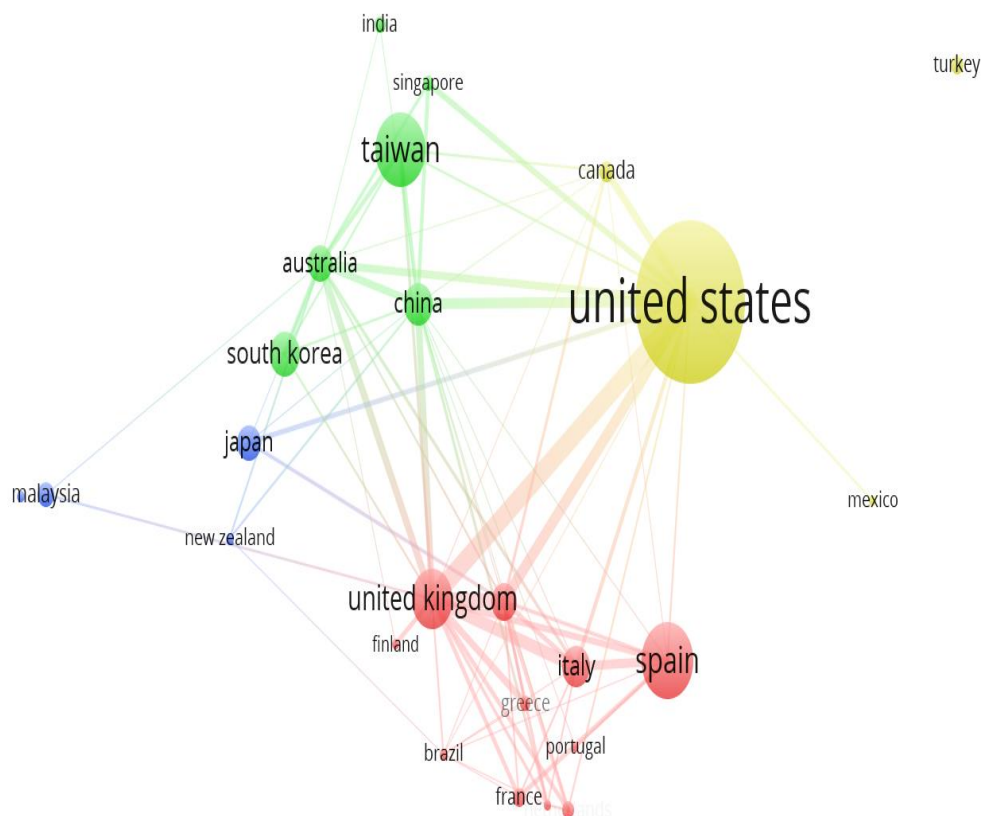
Figure 3. Network diagram showing collaboration between countries with a minimum number of fifteen articles

Table 2. Top 10 most productive countries based on total number of articles published

Country	Number of articles
USA	351
Spain	133
Taiwan	121
UK	114
Germany	99
South Korea	95
China	91
Italy	78
Japan	65
Australia	54

Table 3. Top 10 most productive institutes based on total number of articles published

Institute	Country	Number of articles
National University of Singapore	Singapore	23
Technical University of Munich	Germany	22
National Taiwan University of Science and Technology	Taiwan	21
University of Central Florida	USA	18
Imperial College London	UK	17
National Taiwan Normal University	Taiwan	16
Universitat Politècnica de València	Spain	14
Universiti Teknologi Malaysia	Malaysia	13
National Cheng Kung University	Taiwan	12
University of Wisconsin Madison	USA	12

3.6 Most frequently author keywords used

Table 4 lists the top 10 keywords used by the authors. The result indicates that AR has been used for teaching and training purpose. Only 9 keywords of the total occurred 20 or more than 20 times (see Figure 4.).
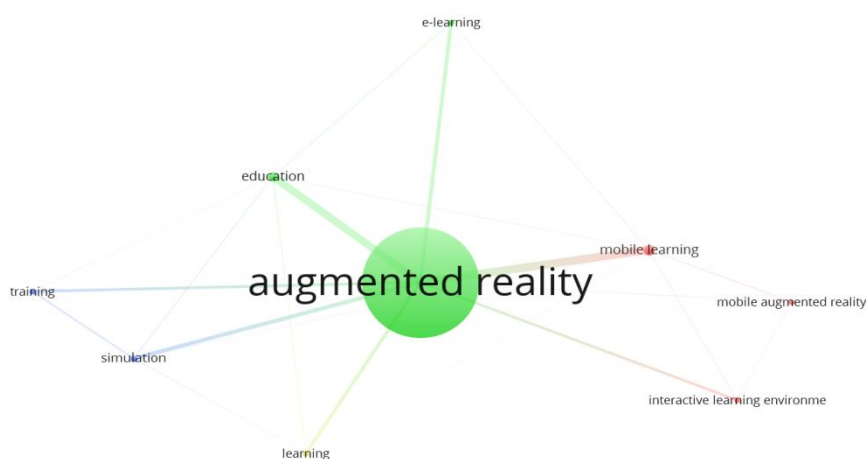
Figure 4. Network diagram 9 keywords that meet the threshold of occurrence at least 20 times

Table 4. Top 10 high frequency author keywords

Keywords	Frequency
Augmented reality	711
Mobile learning	57
Education	52
Simulation	34
Interactive learning environment	30
Learning	24
Mobile augmented reality	23
Training	23
e-learning	22

4. Conclusion and future directions

This study presented research trend of AR quantitatively using bibliometric analysis. Most of the studies were conducted in the developed countries. Asian countries are leading in AR research. More effort is needed in order to bring developing and under developing countries in the main stream of AR research.

References

Cai, S., Wang, X., & Chiang, F.-K. (2014). A case study of Augmented Reality simulation system application in a chemistry course. *Computers in Human Behavior, 37*, 31-40. doi: 10.1016/j.chb.2014.04.018

Chen, Y.-C. (2013). *Learning Protein Structure with Peers in an AR-Enhanced Learning Environment.* (Ph.D. thesis), University of Washington. Retrieved from https://www.learntechlib.org/p/124052

Ferrer-Torregrosa, J., Torralba, J., Jimenez, M. A., Garcia, S., & Barcia, J. M. (2015). ARBOOK: Development and Assessment of a Tool Based on Augmented Reality for Anatomy. *Journal of Science Education and Technology, 24*(1), 119-124. doi: 10.1007/s10956-014-9526-4

Yilmaz, R. M., & Goktas, Y. (2017). Using augmented reality technology in storytelling activities: examining elementary students' narrative skill and creativity. *Virtual Reality, 21*(2), 75-89. doi: 10.1007/s10055-016-0300-1

Easy Java/JavaScript Simulations as a tool for Learning Analytics

Francisco ESQUEMBRE[a*], Félix J. GARCÍA CLEMENTE[b], Rafael CHICÓN[c], Lawrence WEE[d], Leong Tze KWANG[d] & Darren TAN[d]
[a]*Department of Mathematics, University of Murcia, Spain*
[b]*Department of Computer Engineering and Technology, University of Murcia, Spain*
[c]*Department of Electromagnetism and Electronics, University of Murcia, Spain*
[d]*Ministry of Education, Singapore*
*fem@um.es

Abstract: In this paper we introduce the new and planned features of Easy Java/JavaScript Simulations (EJS) to support Learning Analytics (LA) and Educational Data Mining (EDM) research and practice in the use of simulations for the teaching and self-learning of natural sciences and engineering. Simulations created with EJS can now be easily embedded in a popular Learning Management System using a new plug-in that allows creation of full-fledged instructional units that also collect and record fine-grained, instructional-savvy data of the student's interaction with the simulation. The resulting data can then be mined to obtain information about students' performance, behaviors, or learning procedures with the intention to support student learning, provide instructors with timely information about student performance, and also help optimize the pedagogic design of the simulations themselves. We describe the current development and architecture, as well as future directions for testing and extending the current capabilities of EJS as a modelling and authoring tool to support LA and EDM research and practice in the use of simulations for teaching science, in particular in the context of the increasingly popular on-line learning platforms.

Keywords: Simulations, Learning Analytics, Educational Data Mining, EJS

1. The need for Learning Analytics for simulations

Teaching science and engineering with simulations (also known as virtual laboratories) is common ground nowadays (Christian et al. 2015) (Perkins et al. 2006). The combined benefits of the visualization and interaction capabilities of a well-designed simulation with the use of a correct pedagogical approach has been the subject of much educational research. The literature offers plenty of references for this successful topic and, consequently, there exist also several collections of ready-to-use simulations and associated curricular material, mainly in the fields of Physics and Control Engineering (OSP 2019) (PhET 2019) (Sáenz et al. 2015).

However, most of this educational research was conducted in controlled classrooms, where typically a not too large number of students used the materials under the direct supervision of the teacher. The proliferation of online courses, of which the most prominent examples are Massive Online Open Courses (MOOC), has opened new ways for instructors to use course materials, including simulations, with a large number of students and in scenarios where students may not be under the direct supervision of a teacher, leaving room for self-exploration and a growing need to consider student's own learning strategies and procedures (Dervić et al. 2018) (Chamberlain et al. 2014). It is not clear, at this moment, that simulations designed for classroom use can be used with the same success in on-line, perhaps unsupervised, courses. This new ground constitutes both a challenge and a whole new world of research possibilities. And it comes with an entry bonus: tons of data.

Since the very beginning, MOOC and other on-line pedagogic platforms, such as Learning Management Systems (LMS), have been a great source for those seeking feedback from the students' use of the curricular material at their disposal (Breslow et al 2013). Software clients (programs running on students' computers or devices acting as interfaces to the material) can capture information about when and how students access the data. Computer servers providing the material can then store this data

and offer them back to researchers, together with other relevant personal or contextual information about students themselves.

This new and large availability of data has fueled research fields that measure and analyze this data with the purpose of monitoring, supporting, understanding and optimizing student learning, learning materials and even the learning environments. Two of these fields are Learning Analytics (LA) and Educational Data Mining (EDM), which are actually closely related. The differences between them are whether researchers have a more human perspective in their approaches and methods (LA), or rely more on automatic discovery (EDM) (Viberg et at. 2018). (We may, however, refer in this paper to both approaches just as *learning analytics*.)

However, although collecting general information from user interaction with the materials on an LMS or MOOC is relatively easy, it is not always clear that an *all-the-information-we-can-get* policy is the most suitable form to collect the most relevant *features* for applying machine learning algorithms or statistical studies that will produce correct predictions on the retention and performance of students or, better yet, recognize improved students' learning outcomes. More and more authors now claim that empirical LA and EDM studies should always be carried out in the context of a sound theoretical framework of how learners learn. Only through the standard scientific process of hypothesis-validation within a theory can concrete exploration findings be converted into accepted explanations and lead to sensible pedagogic actions of general applicability (Wise & Shaffer 2015) (Gašević et al 2015) (Fincham et al. 2019).

An analysis of the different methods applied to data collected from online sessions revealed that predictive methods (those trying to predict students' retention and grades) have been dominating the field, at least until 2016. But researchers are currently shifting towards methods seeking a deeper understanding of student's learning experiences (Viberg et at. 2018). As a consequence, more research in being directed towards considering learning as a process, one in which learning *events* form a sequence of cognitive operations or *patterns* leading to possible learning outcomes (Winne et al. 2019), with some authors claiming that "while learning trace data provide granular details about students' realized intentions, there is an uncertainty in how to connect patterns in traces of digital behavior with the features of the learning process" (Jovanović et al. 2019). Clearly, much research lies ahead.

This is where we think we can help. Easy Java/JavaScript Simulations (EJS) is a free software modeling and authoring tool designed to help instructors design, implement and deploy computer simulations of scientific and engineering processes. EJS was conceived and developed with the goal of putting the power of creating simulations directly in the hands of teachers and educational researchers, a process that we refined during years of close work with them. EJS facilitates the numerical, computing, graphical user interface building, and deployment tasks of developing simulations so that instructors and curricula developers can concentrate on the pedagogical aspects: how to model a given phenomenon, how to visualize it, what interaction to offer to students, how to use the simulation in a given pedagogical context…

The result is an award-winning software tool that uses a standardized structure, both simple and powerful, for the creation of a simulation, in particular for programming its model and designing its user interface or view (Esquembre 2004). This standardization has permitted the creation of hundreds of educational simulations, mostly in the field of Physics and in Control Engineering (Christian et al. 2011) (Esquembre 2015) (Wee et al. 2015), that can not only be used 'out-of the-shelf' in educational webs or LMS, but that are also adoptable and adaptable. That is, their source code can be easily inspected by instructors other than the author and even modified to custom-tailor them to particular needs.

Our approach to turning EJS into a tool for helping conduct Learning Analytics and Educational Data Mining research and practice is based both on the standardized structure of the simulations created with EJS and in the vast number of examples already available, particularly for Physics instructions in the Open Source Physics (OSP) collection of the ComPADRE library (OSP 2019) and the Singapore collection of OSP simulations (OSP@SG 2019). Downloading and inspecting the simulation with EJS allows the instructor to become familiar with the pedagogic features of the simulation. In particular, with the different user interface controls (*view elements,* in EJS dialect). Recompiling the simulation with the latest version of EJS automatically produces a standard HTML simulation that can be readily deployed via any web page. Moreover, using a dedicated plug-in of our creation, the simulation can be readily included in any Moodle course that, when operated by the user, will collect data of the user interaction with the simulation. Moodle is a very popular LMS (Moodle 2019).

Besides collecting *classical* data of the student interaction with the LMS or the simulation (such as student ID, activity, start time, end time, idle time, mouse clicks and drags, keystrokes…) which can be used for statistical or even machine learning analysis and prediction (Hussain et al. 2019), the EJS generated simulation also collects information of the view element that was interacted with. Since the instructor knows the action invoked by this view element, she or he can use this information for more fine-grained study of the learning event that was intended by the student. (For instance, to recognize that the student is running the simulation with different sets of initial conditions, or attempting to visualize the system in different forms.) Additionally, the instructor can modify the simulation to add to each interaction record information about particular model variables, or slightly change the model of the simulation to automatically generate custom records at particular times or states. (For example, to distinguish idle time from time when the student is observing the simulation while it runs.) The instructor will later collect and study this custom information according to her or his pedagogic interest, (For instance, searching for inquiry-based learner's strategies).

We believe that the combination of these features can help EJS users to create a number of different scenarios for conducting LA and EDM research about the use of simulations in the teaching and learning of science and engineering in on-line, perhaps unsupervised learning platforms. We plan to conduct such a study ourselves with a number of teachers and students of Physics, both as a proof of concept of the tool, but also to fine-tune the amount and diversity of information that EJS generated simulations should offer to researchers, and to study how a particular learning analytic approach can help assist and improve student learning in this context, and also help improve the simulation design itself.

The rest of the paper is organized as follows. Section 2 explains briefly the architecture of EJS to show where LA and EDM researchers can look and edit an existing simulation to learn and decide about the user interaction information collected. Section 3 describes the learning analytics scenario now possible with EJS simulations. Section 4 shows the Moodle plug-in we have created to install the simulation in a Moodle course and collect the data generated by it, together with a simple dashboard that uses the collected information for teacher supervision of students' participation. Finally, Section 5 draws some conclusions and describes future work.

2. EJS architecture

EJS follows a Model-View-Controller software design pattern and provides developers with a corresponding simplified interface for creating a simulation. Using this interface, authors (typically science or engineering instructors) specify *at a high level* the model of a simulation (i.e. the set of variables that defines the system under study, and the equations and algorithms that specify how it evolves in time o reacts to user interaction), and its view (the graphical user interface that allows students to visualize the state of the system and to interact with it to control the execution of the simulation or to change the value of variables).

Specifying the model requires a little bit of programming, although EJS facilitates standard tasks such as organizing the computational flow of the simulation, declaration of variables and numerical processes such as solving ordinary differential equations (ODE). (See Figure 1.)
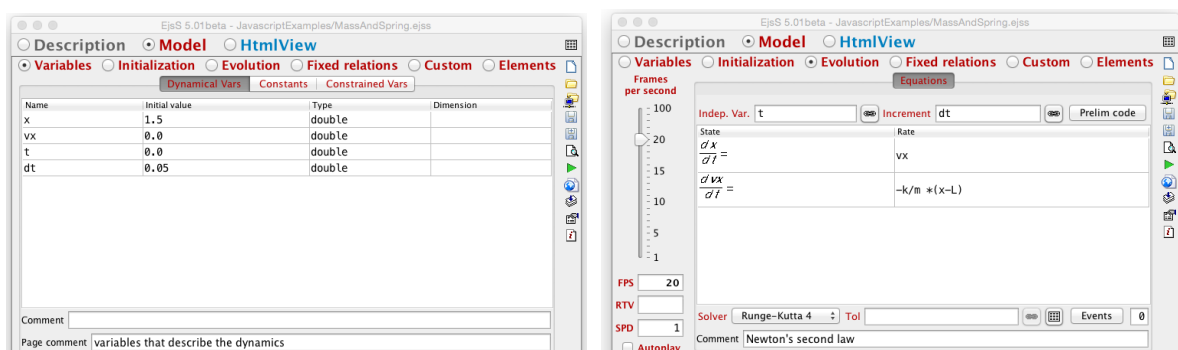

Figure 1. Declaration of variables (left) and use of the ODE editor (right) for the model of a mass and spring system.

To design the view of the simulation, instructors select from a wide palette of *view elements*, individual graphic components each specialized in a given type of visualization or user interaction, to build a tree of elements that turns into a sophisticated HTML interface. A typical view contains a button to reset the simulation to its initial state, fields and sliders to set those initial conditions or modify parameters, and buttons to play, pause, or run the simulation step-by-step. The view also includes animated graphic elements that move in a two- or three-dimensional canvas, providing a virtual representation of the phenomenon being simulated or graphs of data generated as the simulation evolves in time (Figure 2). Model variables are linked to view elements properties to make both the view visualize the state of the system and its evolution, and the model respond to user interaction.
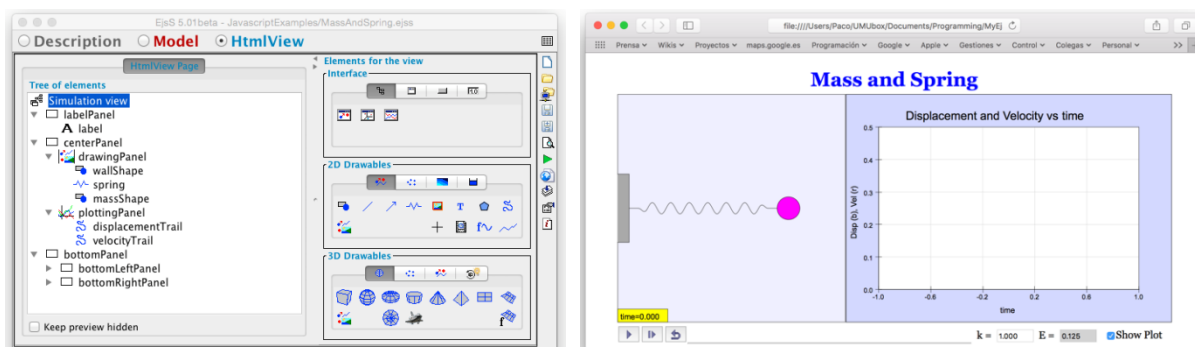

Figure 2. Tree and palette of view elements (left) and final HTML user interface (right) for the mass and spring system.

Creating a simulation from scratch requires some training (a three-days workshop can be enough to get a good start). However, inspecting a simulation created by another instructor is straightforward. And modifying the simulation slightly to include new view elements for visualization or control is also relatively simple. Once the simulation is designed, a simple click generates automatically all the code required for a full-fledged simulation that uses a supportive advanced JavaScript library (Garcia Clemente et al. 2014). The generated simulation can then be run in any web browser with standard HTML support on any kind of computer or device, including smartphones or tablets.

3. Learning Analytics scenario with EJS simulations

When an EJS generated simulation runs, the underlying library manages all the design information provided by the author within the standard architecture. In particular, the library handles every student interaction with the view in order to execute the corresponding actions to the model (resetting the simulation, stepping it in time, changing a given model variable or parameter…) and can now be instructed to send this interaction information to an external repository in real-time. By default, the system identifies three types of interactions:

- *Mouse and touch events*. These events allow to know how users interact with the simulation. The event information is composed of position, timestamp and target.
- *Actions on view elements.* Every view element has one or more predefined action properties that can be triggered by user interaction. Perhaps the most common ones are the *OnClick* action triggered when pushing a button and the *OnDrag* action triggered when dragging an interactive 2D element. When an action is fired, all the information related to the action is registered.
- *Actions on the model*. The allowed actions on the model are play, pause, step, reset and initialize.

The collected information with these interactions alone is so detailed that it is possible to reproduce the user session, keeping the original timing, like in a video player. This can be of interest when studying the behavior of a given user. However, this information alone cannot be sufficient for some kind of automated studies and may be overkill in others. For example, for a LA study, it could be interesting to know the variables of certain variables (f. i. the initial conditions and parameters) every

time the student plays the simulation. Or the value of the time when she or he stops it. This could lead to guesses about a possible student's learning strategy. On the other hand, a machine learning algorithm used in EDM could get too many features using all the information contained in very click, leading to overfitting and therefore poor generalization.

For this reason, EJS JavaScript object-oriented library provides a built-in object called _recorder_ that can be used to configure the behavior of the information recorded for each interaction. This object has a number of functions that can be called from within the model of the simulation to fine-tune what information is sent, and when it is sent, to the external repository. For instance, in the mass and spring example displayed in Figures 1 and 2, the _recorder_ could be instructed to send the value of the model variables x, vx and t (but not all others), every time an interaction happens. Or it could be instructed to send a non-interaction triggered record whenever a given programmatic condition takes places (for instance whenever the graph reaches a maximum). We can only now guess the purpose and needs of the LA or EDM researcher as she or he studies the use of a given simulation by a large number of students. This is perhaps the main advantage of the use of EJS simulations in learning analytics: researchers can customize the information to obtain from user interaction by inspecting the simulation (perhaps one of the many hundred already existing in public libraries) and fine-tuning the captured information using the _recorder_ object.

EJS simulations need other agents in order to collect, store and manage the information thus generated to provide learning analytics facilities to researchers. In the first place, a server needs to serve the simulation HTML page to the student, preferably as part of a curricular unit or course. In the second place, a Learning Record Store (LRS) is needed to store all user interactions produced by the simulation in real-time using a specific repository. Learning Management Systems can help satisfy these two requirements. Instructors can use an LMS to create a training course or program that includes the simulation, together with other accompanying material (theory reviews, instructions, tests…). And an LRS can be integrated into an LMS, capturing the interaction information together with other, particular information about the user (student level, use of other resources, test grades…). See Figure 3.
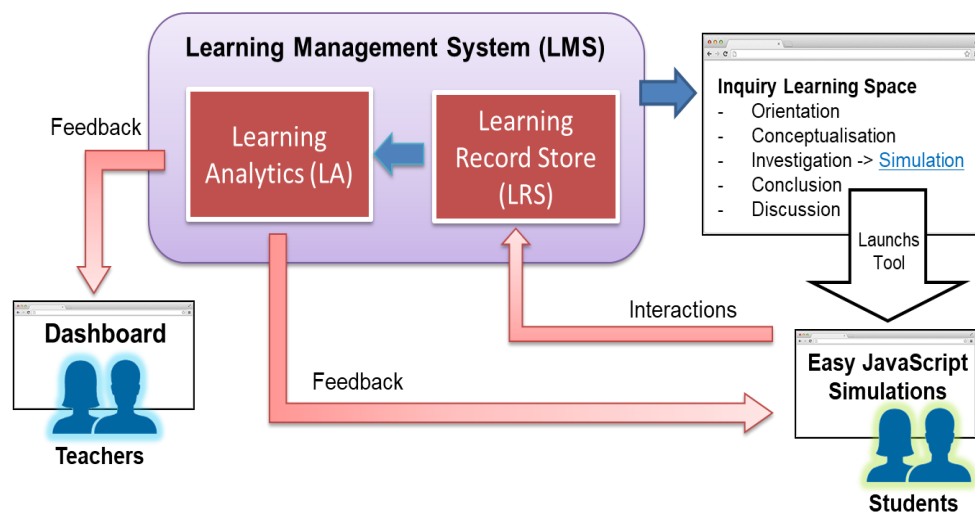
Figure 3. Learning Analytics scenario with EJS simulations.

The use of the feedback thus obtained is now a question of choice by the LA or EDM researcher. EJS has always been *pedagogically neutral* (that is, it neither presumes nor fosters any particular pedagogic approach) and will remain so also for the analytic support now offered. This open-minded approach is also responsible for the wide adoption of EJS by instructors, and our intention is to collaborate with researchers interested to expand the capabilities of the _recorder_ object as new features are requested. We expect that statistical and machine learning analysis and prediction methods will be applied to this information and there will be a need to refine features extraction from the interaction of students with the simulation.

4. Learning Analytics Moodle extension for EJS simulations

We have created a first development to evaluate and validate the previous scenario using Moodle as LMS (Garcia Clemente et al. 2019). The Moodle extension (plugin) that we have developed monitors and records, in real-time, all the standard student interactions with the EJS simulation. This information is displayed on the instructor's dashboard with a metric of each individual student degree of being "on task" and also shows students' current state on the simulation (Figure 4).

Figure 4. An EJS Simulation (left) and the Student Interaction Summary displayed in Moodle (right).

The Moodle plugin[1] is installed on the Open Source Physics at Singapore Moodle server[2], and provides learning analytics capability for teachers running courses based on EJS simulations. This data-rich virtual laboratory functionality can be extended to existing EJS simulations by regenerating the simulation from the source code with version 6.0 of the EJS authoring toolkit, installing our Moodle plugin, and using the simulation in a Moodle course.
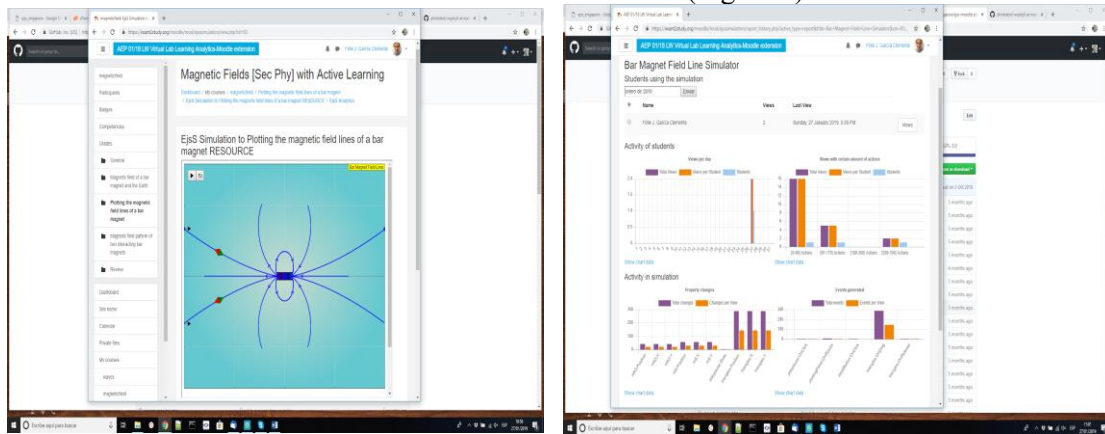
5. Conclusion and future work

We believe that there is a need for conducting research on the design and use of simulations in the context of online, perhaps unsupervised student learning. This research can be based on techniques of Learning Analytics and Educational Data Mining, always in close connection with the theoretical findings on the use of simulations for teaching natural sciences and engineering.

We wanted to offer support for conducting this research and have adapted the EJS authoring tool to generate simulations that can collect data from student interactions in a customizable, fine-grained, instructional-savvy form, so that researchers can choose what features they want to collect for human-directed or automated studies. We have also created a Moodle plugin to integrate the data collection of simulations with a Learning Record Store and have also provided a first, basic teacher dashboard for monitoring students' activity.

Besides working on improving current facilities in cooperation with interested researchers in a neutral way (without imposing any particular type of analysis or pedagogic approach), we plan to conduct our own research, applying machine learning techniques to detect students not just at risk of dropping or failing a course, but also those not producing correct learning outcomes, while at the same time distilling information on how to improve the simulations design to care for them.

Acknowledgements

---

[1] The plugin can be obtained freely from https://github.com/felixgarcia/ejss-moodle-plugin

[2] https://iwant2study.org/moodle/

References

Breslow, L., Pritchard, D.E., DeBoer, J., Stump, G.S., Ho, A.D. & Seaton, D.T. (2013). Studying Learning in the Worldwide Classroom: Research into edX's First MOOC. Research & Practice in Assessment, 8:13-25.

Chamberlain, J.M., Lancaster, K., Parson, R. & Perkins, K.K. (2014). How guidance affects student engagement with an interactive simulation. *Chemistry Education Research and Practice*, 15:628-638.

Christian, W., Esquembre, F. & Barbato, L. (2011). Open Source Physics. *Science*, 334:1077–1078.

Christian, W., Belloni, M., Esquembre, F., Mason, B. A., Barbato, L. & Riggsbee, M. (2015). The Physlet Approach to Simulation Design. *The Physics Teacher*, 53:419. https://doi.org/10.1119/1.4931011

ComPADRE (2019) Compadre Resources for Services for Physics Education. https://www.compadre.org. Accessed: 2019-08-14.

Dervić, D., Glamočić, D.S., Gazibegović-Busuladžić, A., & Mešić, V. (2018). Teaching physics with simulations: teacher-centered versus student-centered approaches. *Journal of Baltic Science Education*, 17(2), 288-299.

Esquembre, F. (2004). Easy Java Simulations: a software tool to create scientific simulations in java. *Computer Physics Communications*, 156 (2), 199-204.

Esquembre, F. (2015). Facilitating the Creation of Virtual and Remote Laboratories for Science and Engineering Education. *IFAC-PapersOnLine*, 48 (29), 49-58.

Fincham, E., Whitelock-Wainwright, A., Kovanović, V., Joksimović, S., van Staalduinen, J.P., & Gašević, D. (2019). Counting Clicks is Not Enough: Validating a Theorized Model of Engagement in Learning Analytics. In C. Brooks, R.Ferguson & U. Hoppe (Eds), *Proceedings of LAK'19* (pp. 501-510). New York, NY, USA: ACM Press.. https://doi.org/10.1145/3303772.3303775

Garcia Clemente, F.J. & Esquembre, F. (2014). EjsS: A javascript library and authoring tool which makes computational-physics education simpler. *XXVI IUPAP Conference on Computational Physics* (CCP), Boston, USA.

Garcia Clemente, F.J., Loo Kang, W., Esquembre, F., Tze Kwang, L. & Darren, T. (2019). Development of Learning Analytics-Moodle Extension for Easy JavaScript Simulation (EjsS) Virtual Laboratories. *GIREP-MPTL Conference*, Budapest, Hungary.

Gašević, D., Dawson, S. & Siemens, G. (2015). Let's not forget: Learning analytics are about learning. *TechTrends*, *59(1)*. DOI: 10.1007/s11528-014-0822-x

Hussain, M. & Abidi, R. Hussain, M., Zhu, W., Zhang, W., Muhammad, S. & Abidi, R. (2019). Using machine learning to predict student difficulties from learning session data. *Artificial Intelligence Review*, *52 (1)*, 381-407. https://doi.org/10.1007/s10462-018-9620-8

Jovanović, J., Gašević, D., Pardo A., Dawson, S. & Whitelock-Wainwright, A. (2019). Introducing meaning to clicks: Towards traced-measures of self-efficacy and cognitive load. In C. Brooks, R. Ferguson & U. Hoppe (Eds), *Proceedings of LAK'19* (pp. 511-520). New York, NY, USA: ACM Press. https://doi.org/10.1145/3303772.3303782

Moodle (2019) Moodle site. https://moodle.org. Accessed: 2019-08-15.

OSP (2019) Open Source Physics project. http://www.compadre.org/osp. Accessed: 2019-08-14.

OSP@SG (2019) Open Source Physics @ Singapore (2019) https://iwant2study.org/ospsg. Accessed: 2019-08-14.

PhET (2019) PhET Interactive Simulations for Science and Math. https://phet.colorado.edu. Accessed: 2019-08-14.

Perkins, K. Adams, W., Dubson, M., Finkelstein, N., Reid, S., Wieman, C. & LeMaster, R. (2006). PhET: Interactive Simulations for Teaching and Learning Physics. *The Physics Teacher*, *44(1)*, 18-23.

Sáenz, J., Chacón, J., De la Torre, L., Visioli, A. & Dormido, S. (2015). Open and Low-Cost Virtual and Remote Labs on Control Engineering. *IEEE Access*, *3*, 805-814.

Viberg, O., Hatakka, M., Bälter, O. & Mavroudi, A. (2018). The current landscape of learning analytics in higher education. *Computers in Human Behavior*, *89*, 98-110.

Wee, L. K., Lee, T. L., Chew, C., Wong, D., & Tan, S. (2015). Understanding resonance graphs using Easy Java Simulations (EJS) and why we use EJS. *Physics Education*, 50(2), 189-196. doi:10.1088/0031-9120/50/2/189

Winne, P.H., Teng, K., Chang, D., Lin, M.P-C., Marzouk, Z., Nesbit, J.C., Patzak, A., Raković, M, Samadi, D. & Vytasek, J. (2019). nStudy: Software for Learning Analytics about Processes for Self-Regulated Learning. *Journal of Learning Analytics*, *6(2)*, 95-105. https://doi.org/10.18608/jla.2019.62.7

Wise, A. F. & Shaffer, D. W. (2015). Why theory matters more than ever in the age of Big Data. *Journal of Learning Analytics*, *2(2)*, 5-13.

The impact of sensory simulations on young children's science learning

Cai Ting Wen[1], Shao Mei Chen[1], Chen Chung Liu[1*], Chia Jung Chang[2], Ming Hua Chang[1], Shih Hsun Fan Chiang[1], Fu Kwun Hwang[3], Hsin Yi Chang[3], Chih Wei Yang[4]

[1] National Central University, Taiwan
[2] Takming University of Science and Technology, Taiwan
[3] National Taiwan Normal University, Taiwan
[4] National Taichung University of Education
*ccliu@cl.ncu.eud.tw

Abstract: Simulation was found to be an effective tool for learners to learn science. However, young children might have difficulty to integrate their understanding and the simulation because of inability to process virtual and abstract information. This study proposed a sensory simulation which helps young children learn science. The results show that the sensory simulation help the young children assimilation the concept and reflect in some questions while it did not enhance learning in other questions. More qualitative interview data should be collected to understand the cognitive process of using sensory simulation.

Keywords: primary school students, science simulation, science education, conceptual understanding

1. Introduction

Previous studies have shown that simulations (or virtual laboratory) could be the integrative tools for science inquiry. It has been found that computer simulations facilitate higher cognitive skills (Lin et al., 2014) such as modeling performance (Wen et al., 2018). However, it is a controversial issue that whether simulations help young children learn science. Some studies found that simulations enhance primary students' learning performance, and improve their perceptions about science inquiry (Sun, K. T., Lin, Y. C., & Yu, C. J. , 2008; Unlu, Z. K., & Dokme, I., 2011). Conversely, students simply view the result as the other facts which is different from their experience of life and did not integrate the simulation with their prior understanding (Jaakkola, T., & Nurmi, S., 2008).

It might be because young children might lack the experience in processing virtual and abstract information given by the simulations. To address this issue, it is indicated in the literature that embodied cognition have positive influence on learning. Embodied interaction enhances the effectively reflect and rethink the core concept (Lindgren, Tscholl, 2016). Sensory simulations, which strengthens students' physical or sensory sense of the simulated phenomena based on users' cognitive level, were shown to help learners construct solid cognitive grounding (Zacharia, 2015).

Nevertheless, few studies have examined how sensory simulations help young children learn science. Therefore, this study proposed a sensory simulation design for primary school students and discovered the influence of different simulation design on young children's science learning. The research question is how primary school students improve their conceptual understanding after using the sensory simulation?

2. Method

2.1 Participants

The participants of this study were 75 5-grade students from two primary schools. None of them reported experiencing of using simulations in science learning. There were 34 students in the control

group who were from two classes in a school. The other 41 students in the experimental group were from two classes of another school. Two to three students were teamed up randomly and seated nearby in a traditional classroom. They were encouraged to discuss with each other and equipped with an iPad to operate the simulation collaboratively.

2.2 Procedure

The learning activity of the two groups was implemented in a 90-minute session. Pre-test and post-test were conducted in the first and the last 10 minutes. After taking the pre-test, the students were instructed to understand the context of the simulation for 5 minutes. Each student was given a worksheet which guided them to predict, collect and record data, make conclusions with teammates. A whole class reflection activity was led by the teacher after they concluded their findings. All the students were asked to present their conclusions and discussed with the teacher and the student peers. After that, they were asked to apply their findings in an application pen-ended questions on the worksheet. The learning activity and the discussion lasted for 65 minutes.

2.3 Simulation Designs

The simulations were developed based on the platform CoSci (https://cosci.tw) (Chang et al., 2017), which provides scientists and teachers to create simulations by a graphic user interface. To discover how the simulations influence young children's conceptual understanding, this study developed two types of simulation design: conceptual simulation and sensory simulation. The conceptual simulation composed of the graphic representations for students to learn the concept of the target science phenomenon. The sensory simulation is designed based on a representation that is sensible for the cognitive level of the target students. This study designed both simulations to simulate a problem: whether an individual will get less wet or not if he/she run faster from place m to place n in the rain. The students were guided to manipulate the velocity of the character and observe the top rain, the side rain, and the relationship between the total rain and the top and side rain volume.

2.3.1 Conceptual Simulation

The conceptual simulation shown as Figure 1 below were used by control group (CS group). The top, side and total rain accumulated with different running velocity were dynamically displayed in different bar charts respectively to help students to compare and learn whether the running velocity influence the top, side and total rain volume falling onto the man.
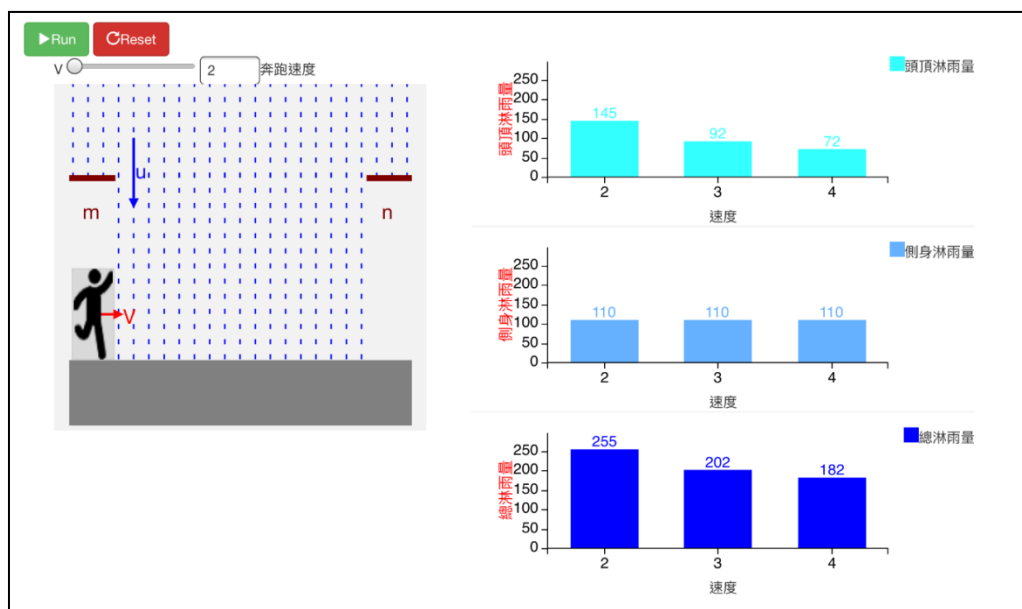

Fig 1. Conceptual simulation design

2.3.2 Sensory Simulation

The sensory simulation, shown in Figure 2, is composed of the bar charts, the animations and the slider for students to manipulate the running velocity. Different from the conceptual simulation, the animation adopts a sensory representation, displaying the rain in a form of countable raindrops, so that students can measure the rain volume by counting the raindrops falling onto the top and the side surfaces of the yellow box. The charts of the rain volume on the right side will also change according to the raindrops received by the yellow box. The students in the experimental group (SS group), were asked to count the number of the rain drops. It was expected that such sensory simulation would improve young children's conceptual understanding.
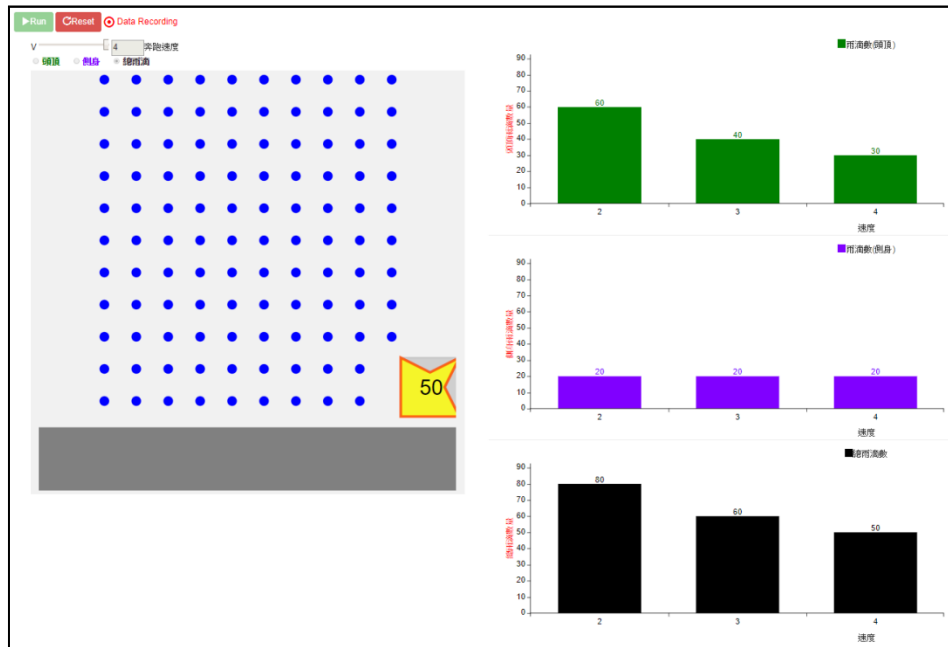
Fig 2. Sensory simulation design

2.3.3 Data Collect and Analysis

To discover how the simulation influences young children's learning, the pre-, post-test and the worksheet were collected. The pre- and post-test were both composed of two open-ended questions, one of them is a similar context about side rain and the other one is about top rain. For instance, the top rain question is: A man holding an empty cup went through the rain. Whether the man run or walk slowly will get more water in the cup? Between the pre- and post-test, students work in pairs collaboratively on a worksheet to answer two similar questions.

The students' answers of opened-ended questions were rated by two of the researchers. The rubrics is listed as Table 1 below. The inter-rater reliability is xx for pre-test, worksheet and post-test respectively, indicating acceptable reliability.

Table 1. Rater rubrics

Score	Description	Example
0	Blank or wrong answer.	**Top** - No matter the velocity, the accumulated rain would be the same. Because that there are same rain volume in place A (origin) and in the place B (destination). **Side** - Run faster would get wetter, because that when the bus drive faster, the speed of wind would get faster.

1	Correct answer without explanation	**Top** - Slow. Slower would get more accumulated top rain. **Side** - The accumulated rain would be the same. No matter the velocity, the accumulated rain would be the same.
2	Correct answer and describe the explanation the life experience or simulation results.	**Top** - Slow. It is just like the accumulated top rain. **Side** - Run or not the accumulated rain volume would be same. Because the running velocity would not influence the accumulated side rain volume.
3	Correct answer and describe the correct reason.	**Top** - Slow. Because run slowly would lead to be more time in the rain, the object would get more rain. **Side** - Run fast or slow would be the same. Because the distance is the same.
4	Correct answer and give the correct explanation by life experience or	**Top** - Run slowly. Because the time in the rain would be lasted longer, and the accumulated top rain volume would increase also. **Side** - None of students got 4 points.

3. Results
3.1 Conceptual Change Process of both group

The figure 3 and 4 show how the simulation influences primary school students' understanding of the target phenomenon. The numbers in the circle represent how many persons achieved a specific score. The line connected between two circles represent how many students change from one score to another along with the pre-test, worksheet and post-test.

Figure 3 displays the two group students' conceptual understanding of top rain. As indicated in Figure 3, only a few CS students improved their conceptual understanding to 3 point in the worksheet (5 students, 11%) and the post-test (11 students, 32%). On the contrary, more SS students got more than 3 point in the worksheet (16 students, 39%) and the post-test (17 students, 41%).
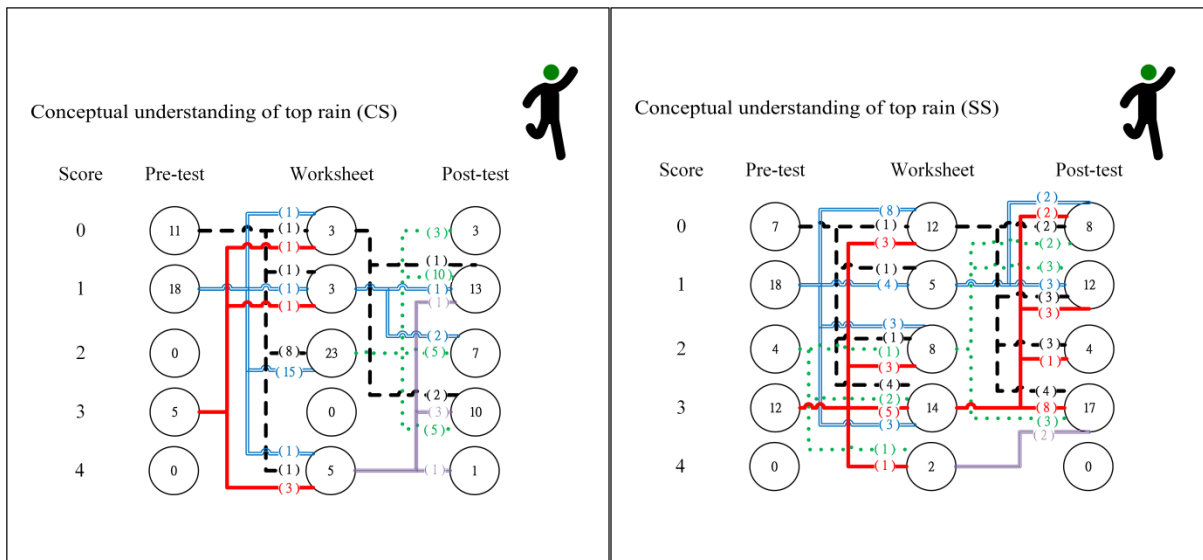
Fig 3. The CS and SS students' conceptual understanding of top rain.

The figure 4 presents the conceptual understanding of the side rain of the two groups. In the two groups, most of students (32 students, 94% in the CS group; 40 students, 98% in the SS group) got 0 point in the pre-test. However, in the worksheet, half of students (16 students, 47% in the CS group; 17 students, 41% in the SS group) got 2 points, the other half students still got 0 point after the learning activity. In the post-test, most of the students performed similar to what they did in the post-test. Notably, only one students in the SS group reported the distance would affect the side rain volume accumulated, but the velocity wouldn't affect it.
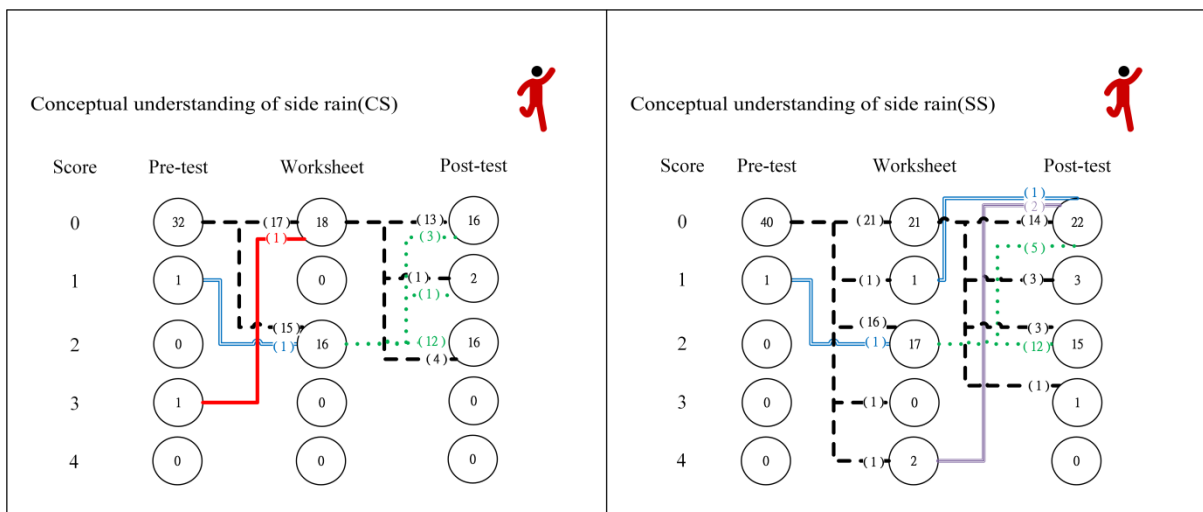
Fig 4. The CS and SS students' conceptual understanding of side rain.

4. Discussion and Conclusion

This study proposed a new simulation design and investigated how the simulation would influence primary school students' conceptual understanding. This study found that the sensory simulation facilitates the young children's conceptual understanding in the top rain question.

Because the side rain problem deviates from the life experience of the students, both SS and CS group did not perform well in this question. However, more SS students could scientifically explain the target phenomenon than the CS students did. It was indicated that the CS group students who used the conceptual simulation tended to only memorize the result of the simulation. It is aligned with the previous study that students tend to separate their experience in using the simulation and their existing understanding of the world. In other words, they can understand the concept represented by the simulation. However, they do not necessarily integrate the simulation with their existing understanding of the problem (Jaakkola, T., & Nurmi, S., 2008). However, this study found that the SS group students could observe and analyze the result of the simulation to understand the phenomenon on the top rain

question. Such findings suggest that sensory simulation might help young children to understand the meaning of the information presented in the simulation. Future studies may be necessary to integrate more qualitative interview to understand the cognitive process when students are using the two simulations.

Acknowledgements

References

Chang, C. J., Chang, M. H., Chiu, B. C., Liu, C. C., Chiang, S. H. F., Wen, C. T., ... & Wu, S. W. (2017). An analysis of student collaborative problem solving activities mediated by collaborative simulations. *Computers & Education*, *114*, 222-235.

Jaakkola, T., & Nurmi, S. (2008). Fostering elementary school students' understanding of simple electricity by combining simulation and laboratory activities. *Journal of Computer Assisted Learning*, *24*(4), 271-283.

Lin, P. C., Hou, H. T., Wu, S. Y., & Chang, K. E. (2014). Exploring college students' cognitive processing patterns during a collaborative problem-solving teaching activity integrating Facebook discussion and simulation tools. *The Internet and Higher Education*, *22*, 51-56.

Lindgren, R., Tscholl, M., Wang, S., & Johnson, E. (2016). Enhancing learning and engagement through embodied interaction within a mixed reality simulation. *Computers & Education*, *95*, 174-187.

Sun, K. T., Lin, Y. C., & Yu, C. J. (2008). A study on learning effect among different learning styles in a Web-based lab of science for elementary school students. *Computers & Education*, *50*(4), 1411-1422.

Unlu, Z. K., & Dokme, I. (2011). The Effect of Combining Analogy-Based Simulation and Laboratory Activities on Turkish Elementary School Students' Understanding of Simple Electric Circuits. *Turkish Online Journal of Educational Technology-TOJET*, *10*(4), 320-329.

Wen, C. T., Chang, C. J., Chang, M. H., Chiang, S. H. F., Liu, C. C., Hwang, F. K., & Tsai, C. C. (2018). The learning analytics of model-based learning facilitated by a problem-solving simulation game. *Instructional Science*, *46*(6), 847-867.

Zacharia, Z. C. (2015). Examining whether touch sensory feedback is necessary for science learning through experimentation: A literature review of two different lines of research across K-16. Educational Research Review, 16, 116-137.

Linking the learning processes to learning engagement and learning outcomes: How well did the students learn in modeling-based computer simulation activities?

Ya-Joe Wang [a], Silvia Wen-Yu Lee [a*], Pai-Chuan Lin [a] & Chen-Chung Liu [b]
[a] *National Changhua University of Education, Graduate Institute of Science Education, Taiwan*
[b] *National Central University, Department of Computer Science and Information Engineering, Taiwan*
*silviawyl@cc.ncue.edu.tw

Abstract: The purpose of this study was to investigate the relationships between students' different extent of completion of modeling activity and the students' modeling competences and learning engagement. Research participants were 76 11-th grade students in Taiwan. The students participated in modeling-based computer simulation activities (MBCSA). We designed and learning patterns was analyzed through lag sequential analysis (LSA). Research instruments included pre- and post-modeling competence tests, engagement questionnaires, and online students' worksheets. Students' activity logs were also recorded by the computers. The students' online worksheets were scored and used for grouping the students into three levels of completion of MBCSA: the Low-Score Group (LSG), Middle-Score Group (MSG) and High-Score Group (HSG). The results showed that, first, in analyzing the students' pre- and post-modeling competences test, ANCOVA results showed HSG and MSG were significantly higher than LSG on model representation (MR). Second, in analyzing the engagement questionnaires, ANOVA results showed HSG was significantly higher than MSG on positive behavioral engagement and positive social engagement, and LSG was significantly higher than HSG on negative cognitive engagement, negative behavioral engagement and negative social engagement. Third, by using the LSA, six activity patterns were identified in this study. Students in the three groups showed different tendencies of the sequences of completing the modeling activities.

Keywords: scientific modeling, modeling competences, computer simulation, lag sequential analysis

1. Introduction

Models and modeling play a large role in scientific discovery and science learning at all levels of education (Gobert et al., 2011). Modeling has been considered as one of the core disciplinary practices in science and science education (Campbell and Oh, 2015). Model and modeling facilitate students' learning of science concepts, methodological processes and the development of an awareness of how science operates (Hodson, 1993). Science education is growing interest in modeling-based learning to promote students' modeling competences.

Modeling involves an iterative process that uses appropriate representation to capture integral features of a science phenomenon and link the relationship between these features in an attempt to provide mechanistic explanations of the science phenomenon (Sengupta and Clark, 2016). In comparison with textbooks and lectures, a learning environment with a computer simulation has the advantages that students can systematically explore hypothetical situations, interact with a simplified version of a process or system, change the time-scale of events, and practice tasks and solve problems in a realistic environment without stress (Berkum & Jong, 1991). Other researchers also believed that simulations are a key way that students can interact with models (D'Angelo et al., 2014). Simulations

are tools which can help students to organize their knowledge of a system, or phenomena, and allow them to reevaluate their ideas with new information (Gouvea & Passmore, 2017).

Empirical research has shown that computer simulations can increase the students' understanding of science concepts and scientific phenomena (Gouvea & Passmore, 2017; Yoon et al., 2017; Windschitl & Andre, 1998). However, a study investigating the effectiveness of integrating computer simulations in science and engineering practices for developing and using models showed that computer simulations were just as effective as traditional teaching methods (Mohondro, T., 2018). The impact of MBCSA on students' modeling competences was inconclusive. Additionally, a review research including modeling-based instruction and modeling software argued that there was no dominant software used for research studies aiming to develop the modeling competence (Nicolaou & Constantinou, 2014). Modeling-based computer simulation activity (MBCSA) in physics domain was rare. Therefore, in this study, our goal is to explore the insights into the impact of MBCSA on students' modeling competences and students' activity patterns in MBCSA.

In this study, we pose three research questions:
1. What is the relationship between students' different levels of completion of MBCSA and students' modeling competences?
2. What is the relationship between students' different levels of completion of MBCSA and students' learning engagements?
3. What patterns of behavior sequences can be identified in completing MBCSA? And how did these patterns relate to the students' levels of completion of MBCSA?

2. Method

2.1 Participants

The participants of the study were 76 11th-grade students (48 female and 28 male) from three classes at two senior high schools in central Taiwan. Before the modeling activity, they had learned the basic concepts of force and friction in the physics courses in their senior high schools. However, they had not learned the concepts that were required to solve the target problem. Therefore, they had to construct the scientific models embedded in MBCSA to solve the target problem. The students were invited to a computer classroom and divided into 36 groups for collaboration. Each group consisted of 2~3 students.

2.2 The Modeling-Based Computer Simulation Activity (MBCSA)

The MBCSA we designed based on Model-Centered Instructional Sequence (MIS) (Baek et al., 2011) and Predict-Observe-Explain (POE). The activity provided a challenging question -- which children touched the ground first when playing on the slides in the playground. The students have to analyze the data presented by the simulation, construct their model of Newton's second law on a frictional horizontal surface and slope, experiment with and test their model, and then use their model to solve the problem. The MBCSA includes the following sessions: Problem, Prediction, Investigation 1, Investigation 2, Final model, and Evaluation. Although the students were encouraged to complete the activities sequentially from "Problem" to "Evaluation", the students could revisit any sessions at any time to review or re-edit the answer. The system kept track of all the editing history.
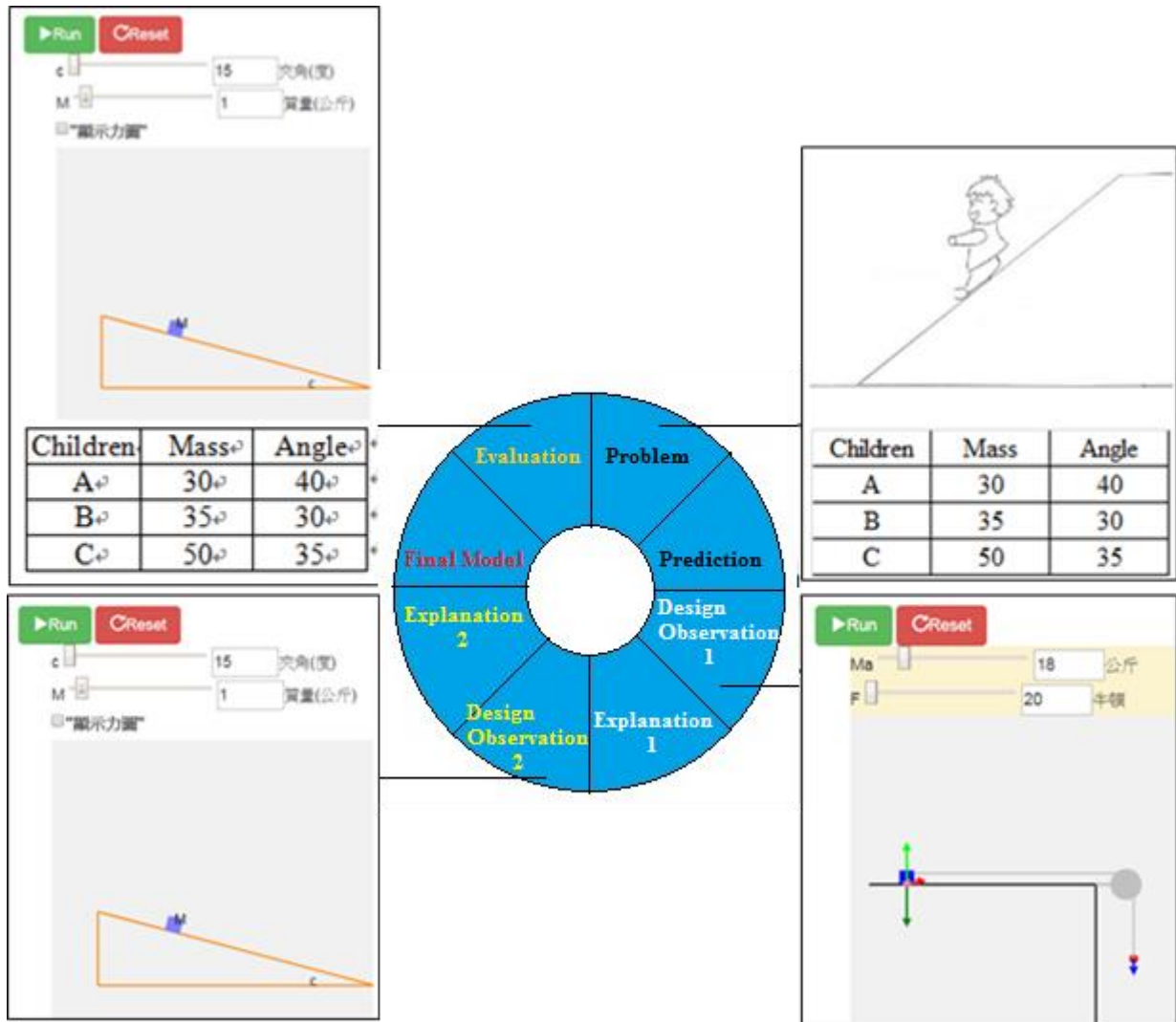
Figure 1. The MBCSA

2.3 Data Collection

2.3.1 Modeling Competence Test

Modeling competence test includes twelve modeling items (Wang and Lee, 2018). The test focuses on assessing the students' understanding of modeling products based on three modeling-oriented assessments (MOA) dimensions (Namdar & Shen, 2015), namely, model construct, model representation and model coherence. The scientific content in the assessment covers "simple machines" and "Newton's second law".

2.3.2 Engagement

The Math and Science Engagement Scale (Wang et al., 2016) were conducted after the MBCSA to analyze students' engagement. This questionnaire includes four subscales: cognitive engagement, behavioral engagement, emotional engagement, social engagement. The four sub-scales are further divided into positive and negative dimensions. A five-point Likert scale (i.e. 1 = strongly disagree, 2 = disagree, 3 = not sure, 4 = agree, and 5 = strongly agree) was used with all the items.

2.3.3 Modeling Processing Scores

Students' answers for the "Design and Observation 1", "Explanation 1", "Design and Observation 2" and "Explanation 2" sessions (8 short answers in total) were scored. Students' answers were recorded automatically by computer. Scoring was based on rubrics developed in this study.

2.3.4 Activity Logs

The raw activity logs record detail actions that each student performed in a chronological form. The raw activity logs were then processed and mapped to the MBCSA activities.

2.4 Data analysis

To discuss whether students with different modeling processing scores have a difference on modeling competences and engagement. 36 groups were divided into Low-Score Group (**LSG**) which has 10 groups, Middle-Score Group (**MSG**) which has 14 groups and High-Score Group (**HSG**) which has 12 groups according to their modeling processing scores. One-way ANCOVA was conducted to analyze the students' modeling competences among **LSG**, **MSG** and **HSG**. The pre-test scores of modeling competence served as the covariate in our analysis of covariance (ANCOVA) when comparing the students' post-test scores of modeling competence after participating in the MBCSA. Additionally, the ANOVA was conducted to analyze the students' differences of engagement in MBCSA among LSG, MSG and HSG.

2.4.1 Pattern of Modeling Behavior

The students' activity logs were analyzed through lag sequential analysis (LSA). The LSA utilizes the transition diagram to represent how the students transited among different types of activities to develop their learning models. The transition diagram contains only the significant transitions to display the students' activity patterns in the modeling activity (Wen et al., 2018). We interpreted the different patterns of modeling based on the different LSA diagrams.

3. Results

3.1 Students' modeling competence and modeling processing scores
Results indicated that there is significant difference on model representation (MR) among three groups, $(F_{(2,66)}=7.21, p<.01)$ of large effect (eta square = .18). The strength of effect measured by eta square values of .01, .06, and .14 can be considered to be small, medium, and large, respectively (Cohen 1988). Post-hoc comparisons using the LSD test revealed that **HSG** and **MSG** were significantly higher than **LSG**, but there was non-significant difference between **HSG** and **MSG**.

3.2 Students' engagement and modeling processing scores
An ANOVA was conducted to analyses the students' engagement among **LSG**, **MSG** and **HSG**. Results indicated that positive behavioral engagement and positive social engagement are significantly different among **LSG**, **MSG** and **HSG** $(F_{(2,65)}=4.17, p<.05, F_{(2,65)}=4.85, p<.05)$. Post-hoc analyses revealed that **HSG** were significantly higher than **MSG**. Negative cognitive engagement, negative behavioral engagement and negative social engagement are significant different among the three groups $(F_{(2,65)}=5.14, p<.01, F_{(2,65)}=6.72, p<.01, F_{(2,65)}=8.82, p<.001)$. Post-hoc analyses revealed that the **LSG** was significantly higher than the **HSG**. The results showed no association between the students' level of completion of the students' performance in the modeling process and emotional engagement.

3.3 Students' modeling behavior and modeling processing scores

Each group's activity log was analyzed independently to reveal the activity patterns of each individual group in the MBCSA. Six activity patterns emerged from the LSA data. These activity patterns are (1) Step-by-step (SS), (2) Prediction-focused (PF), (3) Between investigations (BI), (4) Investigations to evaluation (IE), (5) Evaluation-centered (EC), (6) Final model to evaluation (FE).

The result showed that students in **LSG** tended to focus on the prediction session (i.e., PF pattern) and revisit the process from investigation to evaluation in MBSCA. In terms of **MSG**, except for the SS, the majority of groups belong to **BI, IE, and EC** behavioral patterns, and none belong to **FE**. In other words, the **MSG** students probably more focused on investigation and evaluation activities in MBSCA. In terms of **HSG**, most of the groups showed behaviors of PF, IE, EC, and FE pattern. Especially **FE** activity pattern only was found in **HSG**. Compared to the other two groups, some of the HSG students' emphasized reflecting from final model session to the evaluation session.

4. Conclusions and suggestions

This study illustrated the importance of looking into the students' learning process in terms of levels of completion of the modeling tasks and their behavior patterns in a computer simulation environment. This study showed that the computer simulations and the modeling activities can promote the students' competence in model representations if the students can correctly complete more than half of the activities. We also found that students' engagement in the learning activities were associated with the students' levels of completion. Future studies can use more complex statistics models to build the relationships between engagement, completion of activities, and modeling competence. Also, there is a need for designing modeling-based activities of good quality as well assessment items for promoting and evaluating modeling competence in future studies (Nicolaou & Constantinou, 2014).

References

Baek, H., Schwarz, C., Chen, J., Hokayem, H. & Zhan, L. (2011). Engaging Elementary Students in Scientific Modeling: The MoDeLS Fifth-Grade Approach and Findings. Models and Modeling (pp.195-220). Netherlands：University of Leiden.

Blum, W. (2002). Application and Modelling in Mathematics Education–Discussion Document, *Educational Studies in Mathematics 51*, pp. 149–171.

Campbell, T., & Oh, P. S. (2015). Engaging students in modeling as an epistemic practice of science: An introduction to the special issue of the Journal of Science Education and Technology. *Journal of Science Education and Technology, 24*(2–3), 125–131.

D'Angelo, C., Rutstein, D., Harris, C., Bernard, R., Borokhovski, E., & Haertel G. (2014). Simulations for STEM learning: Systematic review and meta-analysis. Menlo Park, State: *SRI International*.

Gobert, J. D., O' Dwyer, L., Horwitz, P., Buckley, B. C., Levy, S. T., & Wilensky, U. (2011). Examining the relationship between students' understanding of the nature of models and conceptual learning in biology, physics, and chemistry. *International Journal of Science Education, 33*(5), 653–684. doi:https://doi.org/10.1080/09500691003720671.

Gouvea, J., & Passmore, C. (2017). "Models of" versus "models for": Toward an agent-based conception of modeling in the science classroom. *Science & Education, 26*(1-2), 49-63. doi:10.1007/s11191-017-9884-4.

Hudson, D. (1993). Re-thinking old ways: Towards a more critical approach to practical work in school science. *Studies in Science Education, 22*(1), 85–142.

Mohondro, T., (2018). Computer Simulations with Developing and Using Models in the NGSS Curriculum. *Capstone Projects and Master's Theses*. 294.

Namdar, B., & Shen, J. (2015). Modeling-Oriented Assessment in K-12 Science Education: A synthesis of research from 1980 to 2013 and new directions. *International Journal of Science Education, 37*(7), 993-1023. doi: 10.1080/09500693.2015.1012185

Nicolaou, C. T., Constantinou, C.P. (2014). Assessment of the modeling competence: A systematic review and synthesis of empirical research. *Educational Research Review, 13*, 52-73.

Sengupta, P., & Clark, D. (2016). Playing modeling games in the science classroom: The case for disci- plinary integration. *Educational Technology, 56*(3), 16–22.

Wang, Y. J. & Lee, S. W. Y. (2018). Developing a Modeling-oriented test items Based on Force Concepts in Physics. 2018 International Conference of East-Asian Association for Science Education.

Wen, C. T., Chang, C. J., Chang, M. H., Chiang, S. H. F., Liu, C. C., Hwang, F. K., & Tsai, C. C. (2018). The learning analytics of model-based learning facilitated by a problem-solving simulation game. *Instructional science, 46*(6), 847-867. doi: 10.1007/s11251-018-9461-5.

Windschitl, M., & Andre, T. (1998). Using computer simulations to enhance conceptual change: the roles of constructivist instruction and student epistemological beliefs. *Journal of Research in Science Teaching, 35*(2), 145–160.

Yoon, S. A., Anderson, E., Koehler-Yom, J., Evans, C., Park, M., Sheldon, J., & Klopfer, E. (2017). Teaching about complex systems is no simple matter: Building effective professional development for computer-supported complex systems instruction. *Instructional Science: An International Journal of the Learning Sciences, 45*(1), 99- 121. doi 10.1007/s11251-016-9388-7.

WORKSHOP 3 - Emerging Technologies for Teachers' Professional Development at Scale

The Development of a Teacher's Guide for English Proficiency Games

Monica MORENO[a,b]*, Dominique Marie Antoinette MANAHAN[b], Marika Gianina FERNANDEZ[b], Jose Isidro BERAQUIT[b], Nicole BUGAYONG[b] & Ma. Mercedes T. RODRIGO[b]
[a]*Department of Education, Ateneo de Manila University, Philippines*
[b]*Ateneo Laboratory for the Learning Sciences, Ateneo de Manila University, Philippines*
*mmoreno@ateneo.edu

Abstract: English proficiency is vital in today's global employment market. Digital games have been shown to help improve learners' language competencies. However, it is sometimes difficult for teachers to maximize digital games as educational resources. In this paper, we discuss the development of a teacher's guide as a companion to the digital games *Ibigkas!* and *Learning Likha.* Both games are intended to help improve the English proficiency of Filipino learners from 9 to 12 years old.

Keywords: teacher's guide, digital games, English proficiency, second language learning, reading comprehension, Filipino learners

1. Introduction

English is the world's second largest native language, the official language in 70 countries, and spoken in countries responsible for 40% of the world's total GNP (Torres, 2019). Thus, mastery of English is critical for international communication, business and science. However, acquiring English as a second language can be daunting for learners. Such is the case in the Philippines where, despite the wide use of spoken and written English, many young Filipinos have inadequate command of English. When tested in 2015 and 2016, Filipino university graduates averaged a Common European Framework of Reference of Language (CEFR) score of B1, achieving English proficiency marks lower than the CEFR B2 proficiency target set for high school graduates in Thailand and Vietnam (Romero, 2018). Furthermore, many public elementary school students have average to poor mastery of English (Ocumpaugh et al., 2018). To help improve English proficiency, teachers can make use of digital games, which have been shown to improve language skills such as listening, vocabulary, and grammatical accuracy (Sykes, 2013). Teachers are positive about the idea of using digital games for teaching, and are aware of their benefits. However, many encounter obstacles in integrating games into the teaching process (Felicia, 2009; Wastiau, Kearney & Van Den Berghe, 2009). This study describes the development of a teacher's guide as a companion to two games, *Ibigkas!* (translated as *"Speak Up!"* in English*)*, and *Learning Likha*, which are intended to help improve the English proficiency of 9- to 12-year old Filipino learners.

2. The English Proficiency Games

Two digital games were developed to help improve specific English literacy skills. The first game, *Ibigkas!,* focuses on the recognition of English words, specifically students' knowledge of rhymes, synonyms, and antonyms. It is a drill-type mobile game that can be played in single player or multiplayer mode. When in multiplayer mode, the game makes heavy use of collaboration and teamwork. All players must have mobile devices connected to a network. To start the game, one must act as the game host and select the content to be used -- whether rhymes, synonyms or antonyms. See Figure 1 for the Ibigkas! Mobile game settings interface.
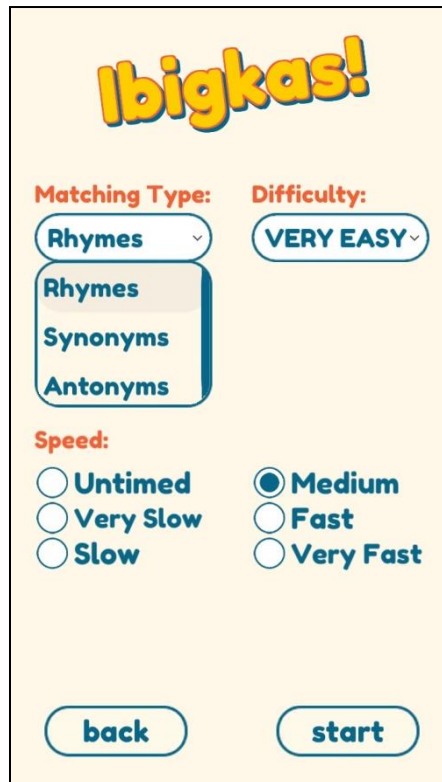
Figure 1. Ibigkas! Mobile: Game Settings

Each player then receives three different word choices on their device. Only one receives a target word which randomly appears on a screen. The player that gets it has to say the word aloud (hence the game's name) for the other players to hear. All players then have to check their word choices to see which one is either a rhyme, synonym or antonym of the target word. See Figure 2 for an illustration. There can only be one correct answer. The player with the correct match shouts out the answer and taps it on his screen. Once the correct answer is tapped, the screen flashes green, and a new round begins.

Figure 2. Ibigkas! Mobile: Mechanics

Ibigkas! also has a card game version with the same educational goals and collaborative style, albeit slightly different game mechanics. This was developed to answer the need for a technologically-independent version for school teachers who had limited access to mobile devices. Figure 3 shows a portion of the set up of the target word cards and answer word cards.

Figure 3. Ibigkas! Card game

The second game, Learning Likha, is a narrative-centered mobile game that targets the comprehension skill of noting explicit details through written, oral and visual language. Here, the gameplay is based on the story of the main character Likha, and her friend Taro the tarsier. Likha and Taro need to help their bandmates prepare for town festivities by fetching their indigenous Filipino musical instruments from different shops in the town. A player immerses himself in the narrative by first typing in his name as a friend of Likha's. Thereafter, as the game progresses, the player is periodically asked to help Likha and Taro by selecting from a town map the correct shop where a specific instrument may be found. Players are aided by written descriptive details about the shop, as well as spoken dialogue. See Figure 4 for the town map's screen.
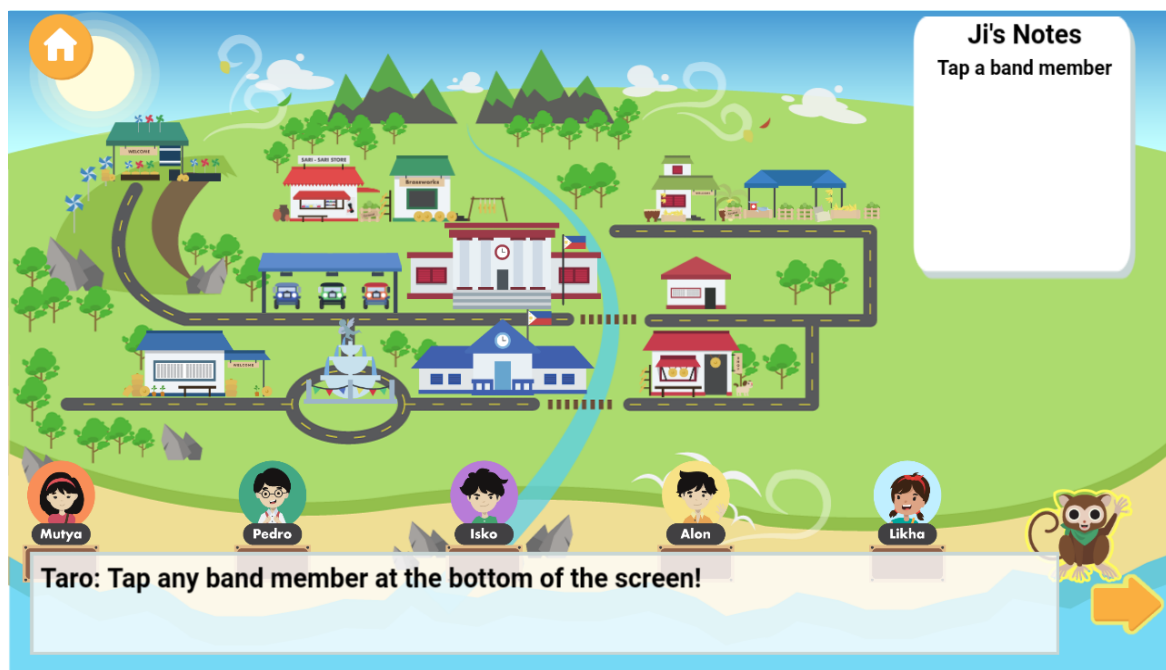
Figure 4. Learning Likha – Town Map

Once the right shop is selected, the player listens to a dialogue between Likha and the shopkeeper in which the musical instrument is described. See Figure 5 for an example.

The player then selects the correct instrument from among three choices, aided by written descriptions on the game screen. The story moves on in this manner until all instruments have been collected for each bandmate and they can all play together in the town festivities.
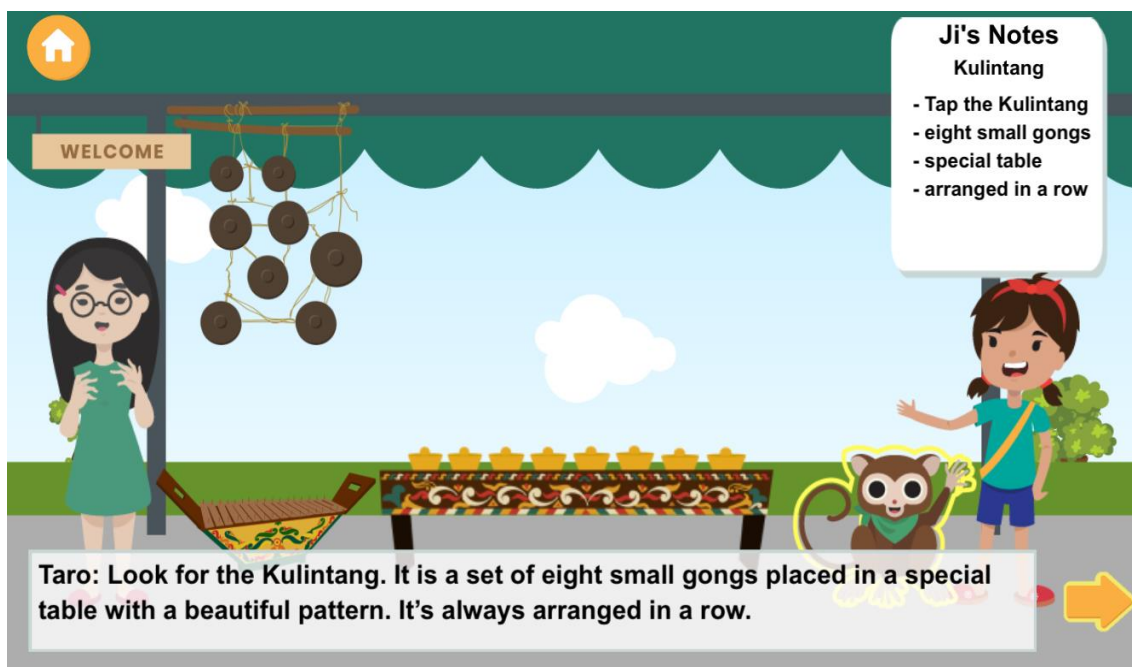
Figure 5. Learning Likha – Inside the shopkeeper's shop

3. User Test Feedback

The games were tested on learners in Grades 4, 5 and 6 from two public elementary schools and a tutorial center that catered to underprivileged students. A total of 85 learners and 39 public school teachers played the *Ibigkas!* mobile game (Rodrigo, Ocumpaugh, Diy et al, 2018; Banawan, Lumapas, Ocumpaugh et al, 2019), while 91 learners tried out *Learning Likha (*Moreno, Manahan, Fernandez et al, 2019; Rodrigo, Agapito & Manahan, 2019).

Teacher and student reactions towards both games were generally positive. The students enjoyed the collaborative nature of *Ibigkas!*, and they said they acquired new words through social learning. In addition, the students enjoyed the narrative content and challenges of *Learning Likha* and were motivated to complete the game. Teachers also enjoyed the games and appreciated their educational goals. These findings suggest that the games can be applied as relevant and engaging educational resources in the context of English language learning.

In this light, a guide to help amplify the games' educational impact was deemed to be useful for teachers. Detailed teaching guides are effective in developing classrooms by presenting strategies that work with specific materials to best deliver a learning objective (Bridge, 2018). Thus, this would enlighten teachers on how to best use the games to maximize English proficiency in 9-12 year old Filipino learners.

4. The Design Process

To conceptualize the teacher's guide, we conducted a group interview with 7 teachers from AHA Learning Center, a center that gives free after-school programs to disadvantaged learners. We combined a focused group discussion with a co-design workshop to gather feedback and ideas on using the *Ibigkas!* Mobile, *Ibigkas!* card game and *Learning Likha* as learning tools inside the classroom so that a teacher's guide could be developed for these three games. A lead facilitator first welcomed the participants and stated the objectives of the session. Then, an instructional video introducing *Ibigkas!* Mobile game and demonstrating the mechanics for the single player mode was shown to the participants. After this segment, the research team distributed mobile phones and tablets to each participant for them to try playing *Ibigkas!* Mobile in single player mode. Then, the participants were asked to group into triads so they could try playing *Ibigkas!* mobile in multiplayer mode.

4.1 Focused Group Discussion

After the participants played *Ibigkas!* in single player and multiplayer mode, they were asked what they thought about the game, which part of the lesson would the game/s be useful for, and how they would use the games as part of the lesson or class activity. The participants shared their answers with the group while the research team took notes. The questions were posed again after the participants played the *Ibigkas!* card game and *Learning Likha*. After the gameplay, the lead facilitator led the discussion of the group on their thoughts and ideas on how to maximize the games inside the classroom.

4.2 Co-design Workshop

After the focused group discussion, the participants were grouped into pairs or triads. Provided with paper and pens, each small group brainstormed with their teammates on possible classroom tasks using all the games. The following guide questions were used:
1) What do you think is the purpose of the material?
2) For what specific topics or subjects would the material be appropriate?
3) How would you use this material in a lesson?
4) Can you devise a lesson plan where this could be used as the:
   a) Motivation or introduction
   b) The main lesson (used to teach the concept)
   c) Follow-up activity
   d) Evaluation

Thirty minutes was allocated for this segment. When the time expired, each pair/group presented their draft lesson plans. Their outputs were then collected and acted as a reference for the creation of the Teacher's Guide. We saw that their workshop outputs largely focused on creating activities for the *Ibigkas!* card game, perhaps to lower barriers to participation. The teachers felt that this material was very flexible and could be appreciated by learners from Grades 3 until 5 (8 till 10 years old) for various purposes -- learning about synonyms and antonyms, and using words from the card game to expand their spoken and written vocabulary. One group focused on *Learning Likha* as a material to teach the following of directions. The workshop outputs were in the form of lesson plans that outlined the sequence of activities for each learning objective. All lesson plans had a motivation phase and a group activity which made use of either the game itself or some aspect of it (e.g., some *Ibigkas!* game cards). Some lesson plans contained follow-up or assessment activities. Table 1 is a sample lesson plan from the workshop:

Table 1

Sample Workshop Output

Grade, Topic	Grade 3, Synonyms and Antonyms
Objective/s	At the end of the lesson, the students should be able to: 1. Differentiate synonyms from antonyms 2. Cooperate with their group mates while playing with the Ibigkas! Card game 3. Play a modified "Trip to Jerusalem" (A game wherein a group of 4or more players dance around chairs, which are fewer than the number of players. The goal is to be able to sit on one of the chairs when the music stops. For each round, a person who was not able to sit will be eliminated, and a chair will be removed.) using the Ibigkas! cards
Motivation	• Show things and let the students give adjectives that would describe these. Have them add words and encourage them to give other adjectives. • Ask them to point words with the same meaning

	● As them to give a pair of words that are opposite
Lesson Proper	1. List the antonyms in a column, and then synonyms in another one. 2. Write "Antonyms" and "Synonyms" above each column 3. Ask them the definition of the two words
Game/Activity	1. Divide the class into two groups. Give them the set of cards - antonyms and synonyms 2. Give instructions.Play the game. Ask for help for additional facilitators> Instead of using chairs, students will have to find the words that are the antonyms or synonym of the word they have after the music stops
Generalization	● Ask the kids to say what the lesson was about and give examples for each
Quiz/Assessment	● Paste cards on the board and ask them to write their antonyms or synonyms

5. The Teacher's Guide

To fill in the gaps in the lesson plans and ensure the use of all games in the classroom, the research team first broke down the workshop outputs into separate lessons. For instance, the workshop output above described lessons to teach synonyms and antonyms. At the end of this lesson, students were expected to be able to use adjectives and differentiate synonyms from antonyms. For the teaching guide, these learning objectives were broken down into three separate lessons -- "I Can Describe Things", "Words Can Have Similar Meanings", and "Words Can Have Opposites". In the same workshop output, *Ibigkas!* cards were used as a word bank for a modified "Trip to Jerusalem" game. The lesson ended with self-generation of antonyms and synonyms using the cards as target words. In the guide version, these activities were re-classified into another lesson called "Building A Wide Vocabulary", which builds upon previous lessons that present synonyms and antonyms separately. Other tasks were shaped around these activities to lengthen exposure to the topic. Finally, activities using *Learning Likha* and *Ibigkas!* Mobile were also added to complete the teacher's guide. The full guide is available at http://penoy.admu.edu.ph/~alls/ibigkas-downloads for free. Table 2 presents an excerpt from the teaching guide's version of the workshop output above.

Table 2

Excerpt from Teacher's Guide version

GRADES, TOPIC	Building a Wide Vocabulary, Gr 1 - 6
OBJECTIVES	Distinguish a synonym from an antonym
STRATEGIES	**Presentation** 1. Place one card from each stack, as organized according to the same symbols, in different places around the classroom. Keep the rest of the stack. 2. From the stack on-hand, randomly give students one word card each. Play music and have students dance in a circle. Stop the music arbitrarily, and

	wait for students to go to the card that is an antonym or synonym of their word. Students who stand in the wrong place (e.g. have the wrong synonym or antonym) will be asked to step out of the circle. 3. Rearrange the posted cards around the classroom. Have students return their word cards to the stack. Shuffle the cards, then hand them out randomly again to the students. 4. Play the music again, and repeat steps (2) until (5). Remove one or two of the cards posted around the classroom, and repeat steps (2) until (5). Stop the game when there are few students left. ***Extension Activity 1*** 1. Shuffle the antonym cards. Distribute these among the students and teacher face-up (i.e. showing the word). The cards are arranged face-up in front of each player. The teacher displays two cards. If they are antonyms of each other, they are placed side by side as two columns. If they are synonyms, they are placed one underneath each other in a column. If they are not related, they are spaced apart. 2. The next player turns up two cards. If any are related to the previous cards as a synonym or antonym, this new card is placed in the appropriate column. If the new cards are related to each other, they are placed side by side, or underneath each other, in new columns. If they are not related to any card at all, they are spaced apart. 3. Step (3) is repeated for each player, until all cards have been laid out. The class now checks each card, looking at the back of each to see if the symbol is the same. Students choose two antonyms and two synonyms, and use each in a sentence. Usage in a paragraph is optional.

The entire guide is structured to scaffold the interaction between the teacher, students and materials, and promote the following benefits (Bridge, 2018):

Support of student mastery and teachers' pedagogical knowledge. The teacher's guide contains the important elements of a detailed lesson plan (Murray, 2002). It provides information about the topic or lesson objectives, recommended grade levels and the materials needed to carry out the lesson. Instructional procedures are grouped by function -- a set of presentation instructions (which also includes motivation tasks), followed by a set of extension activities. The latter are arranged from simple to complex and can be used either as follow-up activities to increase student exposure to the topic or as assessment tasks. These activities include both group and individual work. This way, teachers can focus on student mastery without having to brainstorm about other activities to give.

Increased opportunities for students to improve a core set of skills in a more dynamic classroom environment. Ibigkas! and *Learning Likha* were originally developed to improve the English proficiency of Filipino learners. The games focus on specific language skills -- word recognition in the form of rhymes, synonyms and antonyms, following directions, and comprehension in the form of noting details. The topics and activities in the guide center on the awareness and use of these skills as group and individual tasks to suit various teaching-learning situations and provide opportunities for interaction.

6. Conclusions and Recommendations

Apart from the playing of games themselves to deliver educational content, some teachers need support on how particular games can best be used. In this light, a teacher's guide on the *Ibigkas!* mobile, *Ibigkas!* card game and *Learning Likha* game was developed to give teachers ideas on how to use the games in presenting a lesson, as a motivational activity, or as a group activity. The guide is meant to serve as a companion to the three games, but by no means is it definitive. As teachers become more organized and

confident about using the games, they can eventually create their own procedures, tasks, and be more innovative as to how they would support their students' learning of English.

It is recommended that the use of the teacher's guide be monitored through systematic observations of the teachers' implementation of the activities inside the classroom. Its effects on teaching strategies, student engagement, and English language proficiency skills would be an interesting topic for future study. Since the study respondents were limited to teachers from only one learning center, it is recommended for the testing and development of the teacher's guide to be done with more teachers from different regions of the Philippines.

Acknowledgements

References

Banawan, M.P., Lumapas, R., Ocumpaugh, J.L. & Rodrigo, M.M.T. (2019). *An Investigation of Affect within Ibigkas!: An Educational Game for English.* In Shih, J. L. et al. (eds.), Proceedings of the 27th International Conference on Computers in Education. Taiwan: Asia-Pacific Society for Computers in Education.

Bridge International. (2018). *The Benefits of Detailed Teacher Guides.* Retrieved from https://www.bridgeinternationalacademies.com/the-benefits-of-detailed-teacher-guides/

Felicia, P. (2009). Digital games in schools: Handbook for teachers. Retrieved from https://hal.archives-ouvertes.fr/hal-00697599/document

Moreno, M., Manahan, D.M.A.M., Fernandez, M.G., Banawan, M., Beraquit, J.I., Caparros, M.R.M., Caceres, P., Diy, W.D., Sarcilla, L.R., Amante, F. & Rodrigo, M.M.T. (2019). *Development and Testing of a Mobile Game for English Proficiency Among Filipino Learners.* Paper submitted to the 27th International Conference on Computers in Education, Taiwan.

Murray, B.P. (2002). *The New Teacher's Complete Sourcebook: Grades K–4.* New York: Scholastic Books.

Ocumpaugh, J., Rodrigo, M. M., Porayska-Pomsta, K., Olatunji, I., & Luckin,, R. (2018). Becoming Better Versed: Towards the Design of a Popular Music-based Rhyming Game for Disadvantaged Youths. In Proceedings of the 26th International Conference on Computers in Education. Asia-Pacific Society for Computers in Education.

Rodrigo, M.M.T., Agapito, J.L. & Manahan, D.M.A.B. (2019). *Analysis of Student Affect and Behavior while Playing a Mobile Game for English Comprehension.* In Shih, J. L. et al. (eds.), Proceedings of the 27th International Conference on Computers in Education. Taiwan: Asia-Pacific Society for Computers in Education.

Rodrigo, M.M.T., Ocumpaugh, J., Diy, W.D., Moreno, M., De Santos, M., Cargo, N., Lacson, J., Santos, D., Aduna, D., Beraquit, J.I., Bringula, R., Caparros, M.R.M., Choi, A.T., Ladan, S., Lim, J., Manahan, D.M.A., Paterno, J.M.G., Saturinas, K., Tabanao, E., Tablatin, C., Torres, J., Porayska-Pomsta, K., Olatunji, I., Luckin, R. (2019) Ibigkas!: The Iterative Development of a Mobile Collaborative Game for Building Phonemic Awareness and Vocabulary. *Computer-Based Learning in Context*, 1(1), 28-42.

Romero, P. (February 22, 2018). Senate to probe declining English proficiency. *The Philippine Star.* Retrieved from: https://www.philstar.com/other-sections/education-and-home/2018/02/22/1790069/senate-probe-declining-english-proficiency#Y0y9qcde2LAIrFPi.99

Sykes, J.M. (October, 2013). Technology – Just Playing Games? A Look at The Use of Digital Games for Language Learning. *The Language Educator*. Retrieved from https://www.actfl.org/sites/default/files/pdfs/TLE_pdf/TLE_Oct13_Article.pdf

Wastiau, P., Kearney, C., & Van Den Berghe, W. (2009). How are digital games used in schools? Final report. Retrieved from http://games.eun.org/upload/gis-full_report_en.pdf

WORKSHOP 4 - The 7th Workshop on Technology-enhanced STEM Education (TESTEM Workshop)

Effects of the Interdisciplinary Robotic Game to Elementary School Students' Abilities of Computational Thinking and STEM

Hsin-yin HUANG [a*], Ju-ling SHIH[b], Shu-hsien HUANG[c], Jyh-Chong LIANG[d]
[a] *Department of Information and Learning Technology, National University of Tainan, Taiwan*
[b] *Graduate Institute of Network Learning Technology, National Central University, Taiwan*
[c] *Department of Information Management, National Chin-Yi University of Technology, Taiwan*
[d] *Program of Learning Sciences, National Taiwan Normal University, Taiwan*
d10655004@gm2.nutn.edu.tw, juling@cl.ncu.edu.tw, shushein@gm.ncut.edu.tw, aljc@ntnu.edu.tw

Abstract: In 21st century, problem solving, computational thinking (CT) and collaborative skills are essential skills to achieve. In this study, problem-solving aptitude including five CT dimensions and STEM attitudes were examined through questionnaires. Total of ninety-nine 5th-graders were involved in the interdisciplinary robotic game <STEM Port>, which is designed to enhance the effectiveness of the new learning structure in the context of Great Voyage. It is found that CT dimensions has intersected correlations to the STEM aspects. Interdisciplinary education has positive effects to the students, and the curriculum would lead them to have better performance in the complex problem-solving situations.

Keywords: Interdisciplinary robotic game, game-based learning, computational thinking, stem education.

1. Introduction

The application of robotics game in learning is one of the various learning technological advancements that have been highlighted in recent years. The robotic is a unique learning tool which could offer hands-making and fun activities. Therefore, the interdisciplinary education of CT and STEM has become the world trend. CT is regarded as one of the basic key skills of fundamental problem solving skills beyond the computing. Many countries aim to develop students' CT skills for improving problem-solving skills through interdisciplinary curriculum (Bocconi, Chioccariello, Dettori, Ferrari, & Engelhardt, 2016; Shih, Huang, Lin, & Tseng, 2017). We designed interdisciplinary Robotic Game to stimulate students' skills of CT and STEM due to most robotic game that was designed for just one disciplinary or single activities. This isn't the same as the complex surroundings in real life. CT includes five basic dimensions, such as algorithm, evaluation, decomposition, abstraction and generalization; and STEM refers to science, technology, engineering, and mathematics. Both usually integrate problem-based learning concept (PBL) to cultivate learners' problem-solving skill in real life.

In order to enhance students' learning motivation and to observe their CT skills and STEM performances, we used an interdisciplinary robotic game <STEM Port> to allow the students to apply their existing knowledge, CT and problem-solving skills to win the game. The game is designed for the students to use block coding to control the robots to navigate on the big map to the predicted locations. Students discuss how to control the robot to the right location and whether to trade or fight. Teachers often use competitive psychology to stimulate students' learning motivation and enhance learning effectiveness (Lin, Huang, Shih, Covaci, & Ghinea, 2017). Therefore, the strategic mechanism, which allows the learners to cooperate and compete with other players in order to achieve the goals. The use of interdisciplinary robotics game improve the students' problem solving and CT skills in this study. Results of this research suggested that the pedagogical value of robots lies in making learners to get interdisciplinary knowledge to identify and solve problems. But it's could not apply to all fields.

2. Related Work

2.1 Game-based Learning

Game-based learning (GBL) refers to an educational system that implements game or game-elements as a motivational driver for students (Park, Kim, Kim, & Mun, 2019). It is perceived as a potentially engaging form of supplementary learning that could enhance the educational process and has been used at all levels of education including primary education (Hainey, Connolly, Boyle, Wilson, & Razak, 2016). Passive learning becomes more active (Liu & Chen, 2013; Papastergiou, 2009), and children learn to construct knowledge in the process. Students explore the issues assigned by teachers from various perspectives, work with peers to find answers, and then develop the skill to communicate, coordinate, and do creative thinking and problem solving. Game activities involve problem solving spaces and challenges that provide learners with a sense of achievement (Qian & Clark, 2016).

Traditional games like Scrabble and chess are examples of appropriate vehicles for evoking the higher-order skills that are necessary for effective problem-solving. It also promote learning in an engaging and entertaining manner and to underpin the skills and attitudes of CT (Apostolellis, Stewart, Frisina, & Kafura, 2014). Games provide learning opportunities and learners learn infinitely more such as to take in information from many sources and make decisions quickly; to create strategies for overcoming obstacles; to understand complex systems through experimentation.

While implement game mechanisms and elements in activities, such as scoring, ranking, getting badges, doing competition and interaction, can turn the entire teaching activity into a gamified activity (Curzon, Dorling, Ng, Selby, & Woollard, 2014; Perrotta, Featherstone, Aston, & Houghton, 2013). Motivation is the most important factor that drives learning. The definition of motivation is a learners' willingness to make an extended commitment to engage in a new area of learning (Gee, 2003).

2.2 Computational Thinking

CT represents a cognitive ability to apply fundamental concepts and reasoning that derive from computer science in general and computer programming/coding in particular, including real life activities and to solve daily life problems. As a cognitive ability, CT was argued to be one of the most important skills in the 21st Century (Mohaghegh & McCauley, 2016), and should be fostered in childhood (Tsarava, Moeller, & Ninaus, 2018; Wing, 2006).

The skill of abstraction is a way to accelerate the efficacy of thinking, analyzing, and taking actions. Problem solutions can be produced through analyzing problems, making judgments and decisions, and integrating tools and resources to carry out. The purpose is to help students to solve problems by assessing the appropriate tools and strategies to be used in specific situations. CT has been studied by many scholars since Wing put forward it, and Selby, Dorling, and Woollard (2014) defined the five core concepts: *A) Algorithm* is to develop rules that can solve similar problems step by step and be implemented repeatedly. *B) Evaluation* is the process of ensuring an algorithmic solution is a good one. *C) Decomposition* is a way of thinking about problems, algorithms, artefacts, processes, and systems in terms of their parts. The separate parts can then be understood, solved, developed, and evaluated separately. This makes complex problems easier to solve and large systems easier to design. *D) Abstraction* is another way to make problems or systems easier to think about. It simply involves hiding details and removing unnecessary complexities. *E) Generalization* is a way of quickly solving new problems based on previous problems solved. It is to take an algorithm that solves specific problems and adapts the algorithm to solve a whole class of similar problems. Generally speaking, CT is a type of analytical thinking that employs mathematical and engineering thinking to understand and solve complex problems within the constraints of the real world (Voskoglou & Buckley, 2012). To help produce future generations with these competencies, we should teach these concepts at a young age, and continue using a spiral curriculum to reintroduce elements of CT in interdisciplinary and different years (Apostolellis et al., 2014).

2.3 STEM and Robotic Game

Existing research mentioned the importance of foundational coding skills for STEM learning by suggesting young children to learn various skills and concepts through playing apps and computer games (Pila, Aladé, Sheehan, Lauricella, & Wartella, 2019). STEM is a cohesive learning paradigm based on real-world application (Afari & Khine, 2017). It is not limited to those subjects which often includes other domains such as social studies, English language arts, art, and more (Breiner, Harkness, Johnson, & Koehler, 2012). It uses an interdisciplinary approach (Barak & Assal, 2018) by breaking down the "silos" of discipline-independent teaching that students often encounter throughout the day, and making connections to the context of the real world (Breiner et al., 2012; Honey, Pearson, & Schweingruber, 2014).

Robotics provides a very rich and attractive learning environment for STEM education (Barak & Assal, 2018). Robot is a learning tool that enhances student experiences through hands-on, mind-on learning. It also provides a fun and exciting learning environment because of its hands-on nature and the integration of technology (Afari & Khine, 2017). The hands-on, project-based and goal-oriented learning experience that an educational robotics competition provides has long-lasting impacts on students' learning and motivation for further exploring in STEM or STEM related fields (Eguchi, 2016). Educational Robotics creates an environment where children can interact with the context and work with real-world problems.

3. Research Design

3.1 Game design of <STEM Port>

<STEM Port> is an interdisciplinary game designed by the research team which is based on the historical context of Great Voyage. In the game, a big map in the size of 600 x 400 cm showed the geographic area covered in the Age of Discovery in the 17th century (Figure 1). Students were divided into five groups and role-play one of the five countries such as England, Netherland, Portugal, Spain, and France. Robots represent the ships of respectively countries by colored lights. The players took turns to move their ships by block coding to go to designated colonies to trade for spices. Whichever country completed its spice tasks first won.

Learners should apply their interdisciplinary knowledge and CT skills to complete the tasks of the game. They "decompose" the task requirements and rules of the game; try to obtain the goals in limited rounds. Then, apply "algorithm" skills to calculate the distance, angle, of the robots, and do "abstraction" to turn the measurement into coding blocks. They "evaluate" the differences between the predict and the actual paths, and make decisions to their actions in the next round. As the students solicit the main strategies for the game, they can "generalize" the patterns to different rounds and quickly use the resources around them to solve the problems.

This robotic game mechanism required the students to use block coding (Figure 2), in this case was mBlock, to control robot ships to move forward or turn. They had to estimate the distance to go to their destinations, and used the limited game points to move the robots. In the navigation process, they had to decide whether they would do trading or going into battles. By using simple and basic commands, the students would focus on using the coding skills to solve the game problems and to complete their tasks. Thus, a coding-based and problem-solving-oriented CT were functioned at the same time in the game. This programming environment can cultivate students' CT abilities during programming activities by enabling them to concentrate on the problem solving process as they learn (Kong, Chiu, & Lai, 2018). Robotics offer a broad range of challenges and opportunities for learners to develop disruptive thinking, innovative ideas, and other learning skills needed in the classroom and outside the school (Constantinou & Ioannou, 2018).

Figure 1. Game design of <STEM Port>.   Figure 2. mBlock coding program.

3.2 Computational Thinking & STEM Questionnaire

In this study, four classes of 5th graders in an elementary school in southern Taiwan participated the activity. There were 65 boys and 34 girls with a total of 99 students. Each class played an individual game in four different days. This study used mBot robots and navigation route prediction records as well as computational thinking and stem questionnaires as research tools to assess learners' CT performances and STEM attitudes in the robotic game.

Before the start of the game, the CT questionnaire was distributed to the students as the pre-test. Then, the students played the game <STEM Port> for about 60 minutes. After the game was finished, post-test CT and STEM questionnaires was conducted. The results of the questionnaires were cross-analyzed with the students' gaming outcomes with regressions in CT and Pearson Correlation Coefficient in STEM.

The CT questionnaire used in this study was newly designed based on the relevant literature (Atmatzidou, Demetriadis, & Systems, 2016; Curzon et al., 2014; Dagienė, Sentance, & Stupurienė, 2017; Selby, Dorling, & Woollard, 2014) and taking the principles of International Challenge on Informatics and Computational Thinking as the main reference. To construct a valid and reliable questionnaire for computational thinking, two faculty members specializing in education validated the items twice (Chu, Liang, & Tsai, 2019).

The questionnaire includes five dimensions, each with 5 questions. For example, "I will try to dissect the big problems into small parts" is to test out the students' perception to the Decomposition skills; "I will try to think of the most efficient way to solve the problems" is to test out their Evaluation skills; "I will figure out the detailed steps for problem-solving" is for the Algorithm skills; "I will try to find out the key factor of the problem" and "I will try to use previous experience to solve new problems" is to test their Abstraction and Generalization skills respectively. The analysis showed that the correlation coefficients of the overall divergence ranged from 0.42 to 0.61, and both reached significant ($p<.01$), which was a medium-high correlation, indicating that each dimension has a certain degree of correlation. The reliability Cronbach' α of this scale is 0.91. The reliabilities for the five dimensions ranged from 0.74 to 0.83. The pattern coefficient of all dimensions is above 0.4. It shows that the reliability and validity of questionnaire is good.

The STEM questionnaire used in this study is designed based on the relevant literature (Lou, Diez, Hsiao, Wu, & Chang, 2009; Unfried, Faber, Stanhope, & Wiebe, 2015).The questionnaire includes three dimensions: Mathematic, Science, and ET (Engineering and Technology). There are 9 questions in Mathematics, 9 questions in Science and 12 questions in ET with total of 30 questions. For example, "In the future, I could do harder math problems." is to test out the students' perception to the Mathematics attitude; "Science will be important to me in my life's work." is to test out the students' perception to the Science attitude. "I am good at building and fixing things" and "I would like to use creativity and innovation in my future work" is to test out the students' perception to the ET attitude. The reliability Cronbach's α of these three dimensions scale is ranged from .568 to .897. The values is above .5。

Two invalid copies of the questionnaire were excluded which ended up with 97 copies for analysis. The analysis is to answer the research questions: "Could this game improve the elementary

school students' computational thinking skills?" and "What is the relationship between <STEM Port> game and students' computational thinking skills and STEM attitude?"

4. Result and Discussion

4.1 Computational Thinking Skills

In order to explore how the students' CT skills influence their gaming outcomes, regression analysis was conducted using the five dimensions of the CT skills as predictors (Huang, Huang, Shih, Tsai, & Liang, 2019). Overall speaking, the CT skills of LA (low algorithm) group were not related to the outcome, therefore, only the CT skills of HA (high algorithm) group were briefly discussed in the following explanations.

In the beginning Round, the analysis result showed that HA group's Decomposition skill was positive (t=2.96, p=.004), indicating that if the students know how to dissect the problem into small parts, they can have better performance in this interdisciplinary robotic game. As such good performance, the HA group also could dissect the next path into some parts well and get the right location. Thus the decomposition is typically discussed in terms of breaking apart problems into manageable parts, so the complex problems can be broken into smaller parts by HA group in the <STEM Port>(Rich, Binkowski, Strickland, & Franklin, 2018).The analysis result of the Generalization skill was negative (t=-1.94, p=.057<.1), indicating that making reference of their current strategies to the new round was not what the students should do at this stage. In Round 2, the analysis result of the HA group's Generalization skill was negative (t=-1.64, p=0.106), indicating that the students were still familiarizing with the game and programming skills.

In the end Round, the analysis result of the HA group's Decomposition skill was negative (t=-3.46, p<0.001), which is different from Round 1, indicating that the Decomposition skill was not as important at the end stage since they were supposed to be very familiar with the game mechanism and programming. However, the result of Evaluation skill was positive (t=2.25, p=0.029), indicating that being able to know what strategies were good or bad for their victory, and to apply correct strategies became the most important at the end of the game.

The results showed that this activity was helpful to explore the functions of the CT skill dimensions of the students. For the HA group, and the students' skill of Decomposition and Evaluation were closely correlated to their gaming outcomes. Generally speaking, students with high algorithm skill performed better than those with lower algorithm skill. Algorithmic thinking is the core element of CT, and is difficult for the LA group. It is our aim to plan curriculum that would increase students' algorithmic thinking thus better fill up the gap between the LA and HA students. Based on this result, we aim to further investigate what might influence students' CT skills in terms of their STEM attitude.

4.2 STEM Attitude

In order to assess how the interdisciplinary robotic game influence students' STEM attitude with their gaming outcomes, analysis was conducted using the three dimensions of the questionnaire (Table 1). The results of STEM t-test between HA/LA groups (Table 2) indicated that the STEM attitude of HA group was better than LA group.

Table 1. *STEM attitude Cronbach's Alpha value*

STEM	N	Item	Mean	Std.	Cronbach's α
Math	94	9	3.212	.527	.568
Science	94	9	3.063	.784	.865
Engineering/Technology	94	12	3.791	.698	.897

Table 2. *The STEM attitude t-test of HA group and LA group*

STEM	Std. Error	t
Math	.199	2.252*
Science	.191	2.378*
Engineering/Technology	.178	2.339*

*p<.05, **p<.01

4.3 Relationship between CT skills and STEM Attitude

After the game, as shown in table 3, all STEM aspects of the students are correlated with Decomposition and Generalization skills. Engineering and technology are correlated with Algorithm skill. In <STEM Port> students decomposed the entire path into some sections of codes which compose the ship routes, they need to apply all CT skills to solve problems.

Table 3. *Correlations between CT and STEM*

Fact	N	STEM	Pearson Correlation	Sig. (2-tailed)
Abstraction	94	Math	.147	.157
		Science	.165	.111
		ET	.142	.171
Algorithm	94	Math	.148	.154
		Science	.189	.067
		ET	.261*	.011
Evaluation	94	Math	.113	.279
		Science	.082	.431
		ET	.081	.436
Decomposition	94	Math	.356**	.000
		Science	.213*	.039
		ET	.356**	.000
Generalization	94	Math	.319**	.000
		Science	.223*	.031
		ET	.272**	.008

*p<.05, **p<.01

As shown in table 4, the HA students' math are correlated with Decomposition and Generalization. Engineering and Technology are associated with Abstraction and Decomposition. It indicates that the interdisciplinary robotic game is significant for high algorithm skill students' CT skills in Decomposition, Abstraction, and Generalization. Although the LA students' STEM attitudes are not related to CT, the gaming results show that the robotic game could raise their learning motivation. In particular, the LA students were highly motivated in their problem-solving tasks even without extrinsic rewards and scores.

Table 4. *The Correlations between CT and STEM among High & Low Algorithm skills students*

Group		High Algorithm skill		Low Algorithm skill	
N		64		30	
Fact	STEM	Pearson Correlation	Sig. (2-tailed)	Pearson Correlation	Sig. (2-tailed)
Abstraction	Math	.142	.264	-.152	.421

	Science	.101	.425	-.010	.960
	ET	.264*	.035	-.329	.076
Algorithm	Math	.071	.580	-.107	575
	Science	.012	.928	.188	.320
	ET	.205	.104	.083	.662
Evaluation	Math	.104	.415	-.236	.210
	Science	.057	.654	-.253	.177
	ET	.125	.326	-.330	.075
Decomposition	Math	.265*	.034	.268	.152
	Science	.123	.334	.038	.844
	ET	.318*	.011	.201	.286
Generalization	Math	.271*	.030	.188	.319
	Science	.118	.353	.214	.256
	ET	.152	.230	.313	.093

$^*p<.05, ^{**}p<.01$, ET: Engineering/Technology

5. Conclusion

In this study, the students can obtain the CT skills in the <STEM Port> game. From other research (DomíNguez et al., 2013), students completed the gamified experience and got better scores in practical assignments and in overall performances. Students were excited and immersed in the game. The students learn how to win the game with discussion. The game had received many positive feedbacks from the students. It is likely to reduce distractions, thereby improving the quality of learning beyond what is provided in this activity.

The students need to establish spatial concept, and use their CT skills to complete the tasks. HA group used the Decomposition skill the most in the first round, since they had to try out to dissect the tasks and transformed the route into codes. In Round 2 and 3, they were familiarizing the game mechanism and the coding skills, so their performances tend to be more stable. Until the last round, Evaluation skill started to take effects since they started to use their experiences, resources, and strategies to apply their successful experience to the end. That also indicated that the game was appropriately designed to require the students to apply different CT skills in the game. Reversely, from students' CT skills, it could even predict how the students might perform in the game since the predictors were elicited from the statistics.

In this study, games helped students to integrate and apply the interdisciplinary knowledge and skills (Plass, Homer, & Kinzer, 2015). The robotic learning environment and the pedagogical approach of involving the students in rich assignments of growing complexity were among the major factors that contributed to students' motivation and success in learning the course (Barak & Assal, 2018).

The students with low Algorithm skills cannot achieve as much as those with high Algorithm skills. It is necessary for us to help the students to have better Algorithm skills so that they can accomplish more in the strategic game and problem-solving tasks, and can have better performance in general. More dimensions of CT skills should be reinforced in our pre-activity training. CT courses should be diagnosed with the five dimensions, and make sure students were educated in a more well-rounded CT skills and STEM attitude so that they can have better performance in the complex problem-solving situations(Chen et al., 2017). Concerning the attitude of STEM, we need to foster the LA students' CT skills with informal teaching and learning approaches. The critical purpose of applying CT and sharing its elements with other disciplines is to teach students how to better solve problems and discover new questions in future. While most CT and STEM studies have focused on assessing students' learning achievement in some kinds of activities, one of the major contributions in this study is the proposal of interdisciplinary robotic game learning approach that guides students to complete problem-solving tasks in an effective and enjoyable manner.

References

Afari, E., & Khine, M. (2017). Robotics as an educational tool: impact of lego mindstorms. *International Journal of Information and Education Technology, 7*(6), 437-442.

Apostolellis, P., Stewart, M., Frisina, C., & Kafura, D. (2014). *RaBit EscAPE: a board game for computational thinking.* Paper presented at the Proceedings of the 2014 conference on Interaction design and children.

Atmatzidou, S., Demetriadis, S. J. R., & Systems, A. (2016). Advancing students' computational thinking skills through educational robotics: A study on age and gender relevant differences. *75*, 661-670.

Barak, M., & Assal, M. (2018). Robotics and STEM learning: Students' achievements in assignments according to the P3 Task Taxonomy—practice, problem solving, and projects. *International Journal of Technology and Design Education, 28*(1), 121-144.

Bocconi, S., Chioccariello, A., Dettori, G., Ferrari, A., & Engelhardt, K. (2016). *Developing computational thinking in compulsory education-Implications for policy and practice.*(No. JRC104188). Joint Research Centre (Seville site).

Breiner, J. M., Harkness, S. S., Johnson, C. C., & Koehler, C. M. (2012). What Is STEM? A Discussion About Conceptions of STEM in Education and Partnerships. *School Science and Mathematics, 112*(1), 3-11. doi:10.1111/j.1949-8594.2011.00109.x

Chen, G., Shen, J., Barth-Cohen, L., Jiang, S., Huang, X., & Eltoukhy, M. (2017). Assessing elementary students' computational thinking in everyday reasoning and robotics programming. *Computers & Education, 109*, 162-175.

Chu, Y. K., Liang, J. C., & Tsai, M. J. *The computational thinking scale for programming.* Paper presented at the 3th International Conference on Computational Thinking Education (CTE 2019), Hong Kong

Constantinou, V., & Ioannou, A. (2018). *Development of Computational Thinking Skills through Educational Robotics.* Paper presented at the EC-TEL (Practitioner Proceedings).

Curzon, P., Dorling, M., Ng, T., Selby, C., & Woollard, J. (2014). Developing computational thinking in the classroom: a framework.

Dagienė, V., Sentance, S., & Stupurienė, G. J. I. (2017). Developing a two-dimensional categorization system for educational tasks in informatics. *28*(1), 23-44.

DomíNguez, A., Saenz-De-Navarrete, J., De-Marcos, L., FernáNdez-Sanz, L., PagéS, C., MartíNez-HerráIz, J.-J. J. C., & Education. (2013). Gamifying learning experiences: Practical implications and outcomes. *63*, 380-392.

Eguchi, A. (2016). RoboCupJunior for promoting STEM education, 21st century skills, and technological advancement through robotics competition. *Robotics and Autonomous Systems, 75*, 692-699.

Gee, J. P. (2003). What video games have to teach us about learning and literacy. *Computers in Entertainment (CIE), 1*(1), 20-20.

Hainey, T., Connolly, T. M., Boyle, E. A., Wilson, A., & Razak, A. (2016). A systematic literature review of games-based learning empirical evidence in primary education. *Computers & Education, 102*, 202-223.

Honey, M., Pearson, G., & Schweingruber, H. (2014). *STEM integration in K-12 education: Status, prospects, and an agenda for research* (Vol. 500): National Academies Press Washington, DC.

Huang, H.-Y., Huang, S.-H., Shih, J.-L., Tsai, M.-j., & Liang, J.-c. (2019). Exploring the Role of Algorithm in Elementary School Students' Computational Thinking Skills from a Robotic Game. *Paper presented at the 3th International Conference on Computational Thinking Education (CTE 2019), Hong Kong.*

Kong, S.-C., Chiu, M. M., & Lai, M. (2018). A study of primary school students' interest, collaboration attitude, and programming empowerment in computational thinking education. *Computers & Education, 127*, 178-189.

Lin, C.-H., Huang, S.-H., Shih, J.-L., Covaci, A., & Ghinea, G. (2017). *Game-Based Learning Effectiveness and Motivation Study between Competitive and Cooperative Modes.* Paper presented at the 2017 IEEE 17th International Conference on Advanced Learning Technologies (ICALT).

Liu, E. Z. F., & Chen, P.-K. (2013). The effect of game-based learning on students' learning performance in science learning–A case of "conveyance go". *Procedia-Social and Behavioral Sciences, 103*, 1044-1051.

Lou, S. J., Diez, C. R., Hsiao, H. C., Wu, W. H., & Chang, S. H. (2009). *A study on the changes of attitude toward STEM among senior high school girl students in Taiwan.* Paper presented at the 2009 ASEE Annual Conference and Exposition.

Mohaghegh, D. M., & McCauley, M. (2016). Computational thinking: The skill set of the 21st century.

Papastergiou, M. (2009). Digital game-based learning in high school computer science education: Impact on educational effectiveness and student motivation. *Computers & Education, 52*(1), 1-12.

Park, J., Kim, S., Kim, A., & Mun, Y. Y. (2019). Learning to be better at the game: Performance vs. completion contingent reward for game-based learning. *Computers & Education, 139*, 1-15.

Perrotta, C., Featherstone, G., Aston, H., & Houghton, E. J. S. N. (2013). Game-based learning: Latest evidence and future directions.

Pila, S., Aladé, F., Sheehan, K. J., Lauricella, A. R., & Wartella, E. A. (2019). Learning to code via tablet applications: An evaluation of Daisy the Dinosaur and Kodable as learning tools for young children. *Computers & Education, 128*, 52-62.

Plass, J. L., Homer, B. D., & Kinzer, C. K. J. E. P. (2015). Foundations of game-based learning. *50*(4), 258-283.

Qian, M., & Clark, K. R. (2016). Game-based Learning and 21st century skills: A review of recent research. *Computers in Human Behavior, 63*, 50-58.

Rich, K. M., Binkowski, T. A., Strickland, C., & Franklin, D. (2018). *Decomposition: A K-8 Computational Thinking Learning Trajectory.* Paper presented at the Proceedings of the 2018 ACM Conference on International Computing Education Research.

Selby, C., Dorling, M., & Woollard, J. (2014). Evidence of assessing computational thinking.

Shih, J.-L., Huang, S.-H., Lin, C.-H., & Tseng, C.-C. (2017). STEAMing the Ships for the Great Voyage: Design and Evaluation of a Technology-integrated Maker Game. *INTERACTION DESIGN AND ARCHITECTURES*(34), 61-87.

Tsarava, K., Moeller, K., & Ninaus, M. (2018). Training computational thinking through board games: The case of Crabs & Turtles. *International Journal of Serious Games, 5*(2), 25-44.

Unfried, A., Faber, M., Stanhope, D. S., & Wiebe, E. (2015). The development and validation of a measure of student attitudes toward science, technology, engineering, and math (S-STEM). *Journal of Psychoeducational Assessment, 33*(7), 622-639.

Voskoglou, M. G., & Buckley, S. (2012). Problem solving and computational thinking in a learning environment. *arXiv preprint arXiv:1212.0750*.

Wing, J. M. (2006). Computational thinking. *Communications of the ACM, 49*(3), 33-35.

Enhancing STEM Knowledge and Skills by Making Electronic Sound Synthesizer based on TPACK Model

Chih-Chien Hu[abc], Hui-Chin Yeh[ac] & Nian-Shing Chen [ac*]

[a]*Research Center for Smart Learning, National Yunlin University of Science and Technology, Taiwan R.O.C.*
[b]*Bachelor Program in Interdisciplinary Studies, College of Future, National Yunlin University of Science and Technology, Taiwan, R.O.C.*
[c]*Department of Applied Foreign Languages, National Yunlin University of Science and Technology, Taiwan R.O.C.*

hucc@yuntech.edu.tw, hyeh@gemail.yuntech.edu.tw, *nianshing@gmail.com

Abstract: STEM education has received increasing attention in recent years. Thus, this study proposes a knowledge and skill enhancement framework by integrating TPACK for enhancing learners' STEM knowledge and skills. The main idea of the proposed approach was to conduct a workshop for learners to make an electronic sound synthesizer. Related data were collected along the whole process, the results revealed that the proposed approach significantly helps learners improve their learning performance and fosters their positive attitudes toward STEM.

Keywords: STEM knowledge, STEM skill, hands-on activity, learning attitude, TPACK

1. Introduction

In the science and technology-rich society, it is important to develop student awareness about the connections of science, technology, engineering, and mathematics (STEM) and to leverage the connections in ways that improve learning (Honey, Pearson, & Schweingruber, 2014). Integrated STEM education is a new way to make learning more connected and relevant for students (Falloon, 2019) and emphasize learning activities that focuses on hands-on inquiry (Kalaani, Haddad, & Guha, 2015; Wahono, & Chang, 2019). Several studies argue that STEM learning should be more connected to the context of real-world problems, so that the designed STEM activities would be more relevant to leaners (Kelley, & Knowles, 2016; Honey, Pearson, & Schweingruber, 2014). As shown in Figure 1, the key components of STEM learning include STEM knowledge and STEM skills (Benek & Akcay, 2019).
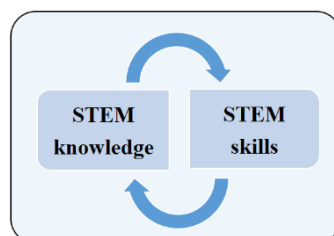
Figure 1. STEM learning.

Several studies have explored the effect of how to help students understand the theory and concept of hands-on projects, and equip them with the necessary technical skills (Lo, Lau, Chan, & Ngai, 2017). The findings showed that there are no significant differences exist between their varied backgrounds, and they also showed the multidisciplinary hands-on projects benefit these students. Some hands-on activities are intended for learners to solve some real-world problems. Thus, they were designed to integrate both STEM training activity and hands-on activity as an effective way to provide

learners the opportunity to apply their theoretical knowledge to solve the real-world problems (Kalaani, Haddad, & Guha, 2015; Lo, Lau, Chan, & Ngai, 2017). Technological pedagogical and content knowledge (TPACK) is critical to effective teaching with technology (Koehler, & Mishra, 2009). Therefore, TPACK cannot assist teachers to follow an instructional design framework for improving learners' STEM knowledge and skills.

The goal of this study is to investigate how the proposed knowledge and skills enhancement framework can affect student learning in a STEM workshop. The proposed framework includes TPACK; and the designed activities also include training activity, hands-on activity, and creative activity. Two research questions are then formulated:

RQ1: What is the effect of the proposed knowledge and skills enhancement framework on learners' learning outcomes?

RQ2: What are learners' attitudes toward using the proposed knowledge and skills enhancement framework for cultivating STEM learning outcomes?

2. Related Works

STEM education evolves into an interdisciplinary, which is often used to indicate the integration among science, technology, engineering, mathematic and real-world applications in teaching and learning process (Kelley, & Knowles, 2016). Some pedagogical knowledge practice frameworks were used to explain links to learning outcomes in STEM education (Hudson, English, Dawes, King, & Baker, 2015; Kelley, & Knowles, 2016; Christ, Arya, & Liu, 2019). Technological pedagogical and content knowledge (TPACK) combines content knowledge, pedagogical knowledge, and technological knowledge that interactively synthesizes knowledge among technology, pedagogic, and content (Mishra, & Koehler, 2006). The TPACK frameworks (Mishra, & Koehler, 2006; Akyuz, 2018; Christ, Arya, & Liu, 2019) were designed to evaluate how much the teacher's capability to use integrated technology in teaching; it can only be used as input for the development of the teacher's capability to use technology. Their frameworks cannot assist teachers to identify an instructional design framework for improving learners' STEM learning outcomes and fostering their STEM attitudes.

Recently, some training activities and hands-on activities have been developed to allow learners to build and exercise STEM projects (Hudson, English, Dawes, King, & Baker, 2015; Lau, Lo, Chan, & Ngai, 2016; Lo, Lau, Chan, & Ngai, 2017). However, learners may not always inquire or start with lower order knowledge for each STEM topic (Hu, & Li, 2017). Moreover, there was not designed to apply specifically to enhancing STEM knowledge and skills of learners, so it did not provide a ready-made categorization of instructional design for learners.

Therefore, it is important to follow an instructional design framework based on TPACK model to facilitate the learning context from specific content and various STEM topics through technology and pedagogy approach.

3. Knowledge and Skill Enhancement Framework

3.1 The proposed knowledge and skills enhancement framework

Here we introduce how to establish a framework (Fig. 2), knowledge and skills enhancement framework, to enhance learners' STEM knowledge and skill by integrating varied state-of-the-art tactics to cultivate learners' STEM learning. Particularly, facilitating training activities and hands-on activities in the STEM workshop by the framework is proposed.

The proposed framework contains three dimensions, which are (i) content knowledge (CK), (ii) technological knowledge (TK), and (iii) pedagogical knowledge (PK). CK is the subject matter such as the contents of science, technology, engineering, mathematics and so on. In this study we introduced the concept and theatrical knowledge of electrical components and electronic sound synthesizer to learners. TK is the studies about how to operate devices and relevant systems, or how to construct an electronic object by using particular knowledge. Teachers transferred their knowledge and experiences of using information technology to students throughout the workshop. Technological content knowledge (TCK)

is knowledge studied about how the CK (i.e., training content) can be examined or interacted with TK. For instance, using hands-on activity enhances learners' skills and engagements in learning environment. PK is the ability in teaching and learning management. To help manage learners' progress of content knowledge, the teacher established training activities for enhancing the students to deepen their STEM knowledge at the beginning of the workshop. The teacher also provided guidelines of hand-on activities, depicted some examples to hint learners. In this stage, the most important issues are how to represent and formulate STEM content and how technology can facilitate pedagogical approaches that make knowledge understandable by learners. Pedagogical content knowledge (PCK) and technological pedagogical knowledge (TPK) are interacted as technological pedagogical and content knowledge (TPACK). A knowledge management platform (http://km.mis.nsysu.edu.tw/) was adopted the exchange of knowledge and information between teacher and learner for tracking and archiving the learning progress.

TPACK in the proposed knowledge and skills enhancement framework can be used to support and assist learners in identifying what they need to know about the use of STEM in learning, help learners develop varied learning methods, improve knowledge and skill learning, and make learning environment more interesting (Mishra, & Koehler, 2006). Using the proposed framework, learners can effectively organize objectives and create learning plans with appropriate content and instruction to lead learners up the pyramid of learning.
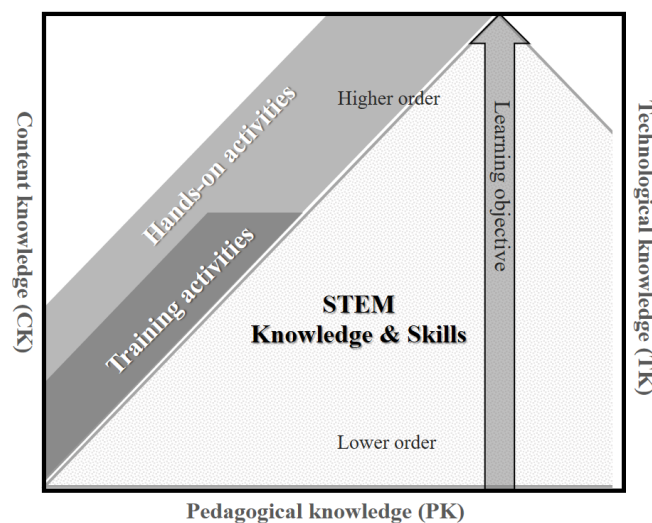
Figure 2. Knowledge and skills enhancement framework.

3.2 The design learning activity based on knowledge and skills enhancement framework

The instructional design based on knowledge and skills enhancement framework is consisted of three components: the training activity, the hands-on activity, and the creative activity, as shown in Figure 3. In this study, the procedure of applying the knowledge and skills enhancement framework was sequentially deploying the learning activities of training activity, hands-on activity, and creative activity.

Training activity: The training activities are categorized as lecturing instructions, slides, video lectures, and so on. Learners can learn the foundational theories and concepts in the activities.

Hands-on activity: To facilitate hands-on activities for completing hands-on tasks; it is more practical to adopt prior knowledge learned in training activities. Using hands-on activity enhances learners' skills and engagements in learning environment.

Creative activity: It's important that how technology can facilitate pedagogical approaches that makes it understood by learners. Learners can comprehend the knowledge about how to facilitate learning from the content through pedagogical and technological approaches by the creative activities. The objective of creative activity is to stimulate learners to develop their skills of self-learning and critical-think, and raise learners' knowledge level higher.
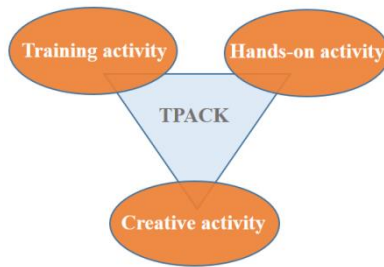
Figure 3. Instructional designs of the integrated knowledge and skills learning framework.

4. Method

4.1 Participants

To accomplish this research we examined student projects in a workshop. The present study involved 22 students. The participants interactively learned the concepts and theory of the electronic sound synthesizer used the training activities and the hands-on activities. The introductory workshop was delivered over 6 weeks.

4.2 Experimental procedure

Learners have never worked the similar tasks before. Each of the training activity and hands-on activity was allocated for 2 hours per week. A pre-test was conducted to compare the participants' prior knowledge of the course content in week 1. We then provided learners with training activities in week 2 and 3, hands-on activities in week 4 and 5. Finally, the post-test was administrated in week 6.

Figure 4 shows some of the electronic sound synthesizers created by the learners in the workshop based on the proposed framework.

Figure 4. Workshop for making electronic sound synthesizers.

4.3 Instruments

The research tools in this study included a pre-test and a post-test for measuring the learners' STEM learning outcomes. The evaluation of learning outcomes consists of twelve single-choice questions, designed by an expert with electronic engineering background. A questionnaire of STEM attitude scale was modified from the measure developed by Benek & Akcay (2019) to measure learners' attitudes.

5. Results and Discussion

Results are based on the STEM learning outcome tests. A total of 22 learners' learning outcomes were assessed. The Shapiro–Wilk test is used to test these samples of normality in frequentist statistics (Shapiro, & Wilk, 1965). Wilcoxon signed-rank test (Pratt, 1959; Chan, 2003) is a nonparametric test

that can be used to determine whether data are paired and come from the same population having the same distribution between pre-test and post-test (p < 0.05).

5.1 Learning outcomes of the training activity and hands-on activity

The results of the outcome tests for training activities (Test A) obtained from the descriptive statistics are summarized in Table 1. The outcomes of knowledge learning were significantly improved based on Wilcoxon signed-rank test. For instance, the median, mean, and standard deviation of the overall scores were 4, 4.36, and 2.13 for the pre-test (Test-A), and 9, 8.77, and 2.31 for the post-test (Test-A). The overall gain score is 4.41 for the Pre-Post (Test A) comparison. The finding reveals that the learners' learning outcomes increased since the learners learned knowledge by the training activities. The lecturing training activities significantly affected the learning outcomes of STEM knowledge.

The test result of hands-on activity (Test B) as shown in Table 1, there was a significant difference (p < 0.05) based on Wilcoxon signed-rank test in learning effectiveness favoring the hands-on activity participants. The learners' learning outcomes were improved since they experienced hands-on learning activities. The outcomes of STEM knowledge were significantly improved. For instance, the median, mean, and standard deviation of the overall score were 12, 11.73, and 3.03, respectively, for the pre-test, and 19, 18.41, and 1.50 for the post-test. The overall gain score is 6.68 (mean) for the Pre-Post (Test B) comparison. The proposed approach may support the constructive cumulative, goal oriented acquisition processes in all learners. The hands-on activities foster in learners the knowledge and skills to apply STEM learning efficiently. It is highly recommended that teachers should enhance their instructional designs of hands-on activities for learners to learn the STEM domain knowledge and skills effectively based on the proposed knowledge and skills enhancement framework.

Table 1

Learning outcomes analysis for the training activity and hands-on activity

Learning activities	Pre-test				Post-test				Comparison (Wilcoxon signed-rank test)
	N	Median	Mean	SD	N	Median	Mean	SD	*p*
Training activity (Test A)	22	4.00	4.36	2.13	22	9.00	8.77	2.31	0.000041
Hands-on activity (Test B)	22	12.00	11.73	3.03	22	19.00	18.41	1.50	0.000042

5.2 Learners' attitudes toward STEM workshop

For evaluating changes in the learners' STEM attitudes, the responses to the survey of STEM attitude scales show the median, mean, and standard deviation in Table 2. The perfect score is 5. Pre-post STEM attitude score increased for the overall score: pre-test Mean = 3.32 to post-test Mean = 3.59. The gain score of the overall attitude was 0.27.

As depicted, there is a significant improvement (p < 0.05) on the overall positive attitude while learning with the proposed approach. The dramatical improvement on the overall attitudes toward STEM since the learners were engaged in the problem-based learning with the proposed learning framework. According to the research finding, the learners' attitudes toward STEM toward using the proposed framework for cultivating STEM competence were positively improved.

Table 2

STEM attitude measurement

STEM attitude									
Pre-test				Post-test				Comparison (paired t-test)	
N	Median	Mean	SD	N	Median	Mean	SD	Gain score	*p*
22	3.25	3.32	0.89	22	3.75	3.59	0.82	0.27	0.002915

6. Conclusions

This study investigates that how the effects of the knowledge and skills enhancement framework based on TPACK to foster learners' STEM attitudes and learning outcomes. Several major findings are summarized. First, the learners' learning performance were improved significantly since they learned knowledge and skills based on the proposed approach. Moreover, the proposed learning framework affects knowledge acquisition. The training activity helped learners significantly acquire their STEM knowledge, and then the hands-on activity fosters learners on not only STEM knowledge, but also real-world skills. Hence, the proposed knowledge and skills enhancement framework helped learners have ability to solve problems and generate ideas. Additionally, the learners' attitudes toward STEM were positively improved. Further studies may be conducted by varied STEM projects based on the proposed knowledge and skills enhancement framework to analyze the difference.

References

Akyuz, D. (2018). Measuring technological pedagogical content knowledge (TPACK) through performance assessment. Computers & Education, 125, 212-225.

Benek, I., & Akcay, B. (2019). Development of STEM Attitude Scale for Secondary School Students: Validity and Reliability Study. International Journal of Education in Mathematics, Science and Technology, 7(1), 32-52.

Chan, Y. H. (2003). Biostatistics 102: quantitative data–parametric & non-parametric tests. blood pressure, 140(24.08), 79-00.

Christ, T., Arya, P., & Liu, Y. (2019). Technology Integration in Literacy Lessons: Challenges and Successes. Literacy Research and Instruction, 58(1), 49-66.

Falloon, G. (2019). Using simulations to teach young students science concepts: An Experiential Learning theoretical analysis. Computers & Education, 135, 138-159.

Honey, M., Pearson, G., & Schweingruber, H. A. (Eds.). (2014). STEM integration in K-12 education: Status, prospects, and an agenda for research (p. 180). Washington, DC: National Academies Press.

Hu, C. C., & Li, H. L. (2017). Developing navigation graphs for TED talks. Computers in Human Behavior, 66, 26-41.

Hudson, P., English, L., Dawes, L., King, D., & Baker, S. (2015). Exploring links between pedagogical knowledge practices and student outcomes in STEM education for primary schools. Australian Journal of Teacher Education (Online), 40(6), 134.

Kalaani, Y., Haddad, R. J., & Guha, B. (2015). A Hybrid Simulation and Hands-On Experimentation for Electric Machines Laboratory.

Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. International Journal of STEM Education, 3(1), 11.

Koehler, M., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)?. Contemporary issues in technology and teacher education, 9(1), 60-70.

Lau, C. K., Lo, K. W. K., Chan, S. C. F., & Ngai, G. (2016). From zero to one: integrating engineering and non-engineering students in a service-learning engineering project.

Lo, K. W., Lau, C. K., Chan, S. C., & Ngai, G. (2017, October). When non-engineering students work on an international service-learning engineering project—A case study. In 2017 IEEE Global Humanitarian Technology Conference (GHTC) (pp. 1-7). IEEE.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. Teachers college record, 108(6), 1017-1054.

Pratt, J. W. (1959). Remarks on zeros and ties in the Wilcoxon signed rank procedures. Journal of the American Statistical Association, 54(287), 655-667.

Shapiro, S. S., & Wilk, M. B. (1965). An analysis of variance test for normality. Biometrika, 52(3), 591-611.

Wahono, B., & Chang, C. Y. (2019). Assessing Teacher's Attitude, Knowledge, and Application (AKA) on STEM: An Effort to Foster the Sustainable Development of STEM Education. Sustainability, 11(4), 950.

Malaysian Students' Career Interest and Perception towards STEM Programmes and Strategies

Tiny Chiu Yuen TEY[a]*, Priscilla MOSES[a], Phaik Kin CHEAH[a] & Su Luan WONG[b]
[a]*Universiti Tunku Abdul Rahman, Malaysia*
[b]*Universiti Putra Malaysia, Malaysia*
*ttcyuen456@gmail.com

Abstract: Malaysia will need one million STEM workers by the year 2020 and eight million workers with STEM skills by 2050. However, Malaysia is suffering from STEM talent depletion due to lack of interest in STEM among students. The Ministry of Education thus implemented various changes to its education system to instil STEM interest among students and introduced STEM programmes and strategies to increase students' participation in STEM in Malaysia. Therefore, this study aimed to examine students' career interest and their perception on whether STEM programmes and strategies would enable them to choose a career in STEM. A total of 204 Form Four STEM stream students from Perak, Selangor and Federal State of Kuala Lumpur participated in this study. The data was analysed using MANOVA, followed by ANOVA. The results from MANOVA revealed that there was a statistically significant difference across the states in students' career interest at $p = .02$ and their perception on STEM programmes and strategies at $p = .01$. The findings of this study could be considered for enhancement of STEM initiatives to support STEM education in Malaysia.

Keywords: Career interest, STEM Programmes and Strategies, Malaysia

1. Introduction

STEM refers to science, technology, engineering and mathematics. In Malaysia, STEM is often linked to a nation's development. Jobs in STEM fields are often of high demand in the global workforce including Malaysia. Academy of Sciences Malaysia (2018) reported that Malaysia needs one million STEM workers by the year 2020 and eight million workers with STEM skills by 2050. The urgent need to fill the in-demand vacancies in the STEM workforce reflects the importance of effective STEM education in training and producing the desired pool of talents. Unfortunately, students' involvement in STEM has not met the expectations to fulfil the needs of the STEM workforce in Malaysia (Razali, Talib, Manaf, & Hassan, 2018).

STEM in education has become a crucial key to produce competent STEM talents who will be able to solve real-life challenges. In reality, STEM talent reduction has been an issue in Malaysia due to lack of interest in STEM among students (Haron et al., 2019). Low supply of STEM talents from schools to workforce would further worsen the current scenario.

Therefore, the Ministry of Education (MoE) of Malaysia through the Malaysia Education Blueprint 2013-2025 has established several initiatives to instil students' interest in STEM and encourage them to enrol into STEM subjects or STEM stream at school levels (MoE, 2013; Razali et al., 2018; Academy of Sciences Malaysia, 2018). In effort to consolidate STEM education in Malaysia, the MoE also introduced the Secondary School Standard Curriculum (*Kurikulum Standard Sekolah Menengah*, KSSM) to replace the previous curriculum, Integrated Secondary School Curriculum (*Kurikulum Bersepadu Sekolah Menengah*, KBSM) (MoE, 2013; Shahali, Ismail, & Halim, 2017). This newly introduced curriculum has been implemented nationwide since 2017 with STEM electives offered at the upper secondary school level. STEM electives that are offered among the upper secondary school students are Physics, Chemistry, Biology, Additional Mathematics, Additional Science, Technical Graphic Communication, Basics of Sustainability, Agriculture, Home Science, Invention, Computer Science, and Sport Science (Shahali, Ismail, & Halim, 2017).

Alongside with the reformation of the school curriculum to promote STEM in education, a wide range of STEM programmes and strategies have also been carried out to support students' involvement in STEM outside the classroom (MoE, 2013, 2016; Shahali, Ismail, & Halim, 2017). Among them are colloquiums and conference on STEM, interactive video learning, STEM projects, and STEM-based activities, outreach programmes, as well as competitions, hands-on sessions, festival and camps that are related to STEM (Shahali, Ismail, & Halim, 2017). Through these initiatives, MoE aims to deliver the STEM education aspirations as proposed in the national education blueprint to foster STEM education within the country.

Given that curriculum reformation and STEM initiatives have been implemented in schools nationwide in Malaysia, this raised the question: Do students from Malaysia differ in STEM career interest (CI) and their perception towards STEM programmes and strategies (SPS)? For that reason, this study aimed to investigate students' CI and their perception towards SPS within Malaysia, by focusing on three states namely Perak, Selangor and Federal State of Kuala Lumpur (KL).

2. Literature Review

2.1 Differences across States in Malaysia

The Malaysian education system has been on a constant strive to develop a knowledge-intensive nation to nurture adequate STEM workers for its workforce. According to its education blueprint, students begin to choose their career pathway at Form Four where streaming into the various vocations takes place (Academy of Sciences Malaysia, 2018). Generally, students in Malaysia are given the opportunity to opt for STEM, arts or vocational major after they have completed their lower secondary school (MoE, 2013).

Though this system is implemented nationwide throughout all the states in Malaysia, the education blueprint indicated that equal access to education remains a challenge in the country (MoE, 2013). Ministry of Science, Technology and Innovation (MOSTI) affirmed that equal access would strengthen STEM education in Malaysia (MOSTI, 2017). However, several reasons have been reported to be detrimental contributors of this phenomenon. Among them are low awareness of opportunities in STEM careers, and lack of STEM resources such as inadequate STEM teacher training (MOSTI, 2017).

MoE (2013) also reported that there are substantial variations across states in Malaysia as there are gaps and inequalities in terms of resources and access. Inequality between states could lead to discrepancy in informed choices on career opportunities, access to information about education pathways, and in students' performance (MoE, 2013). Therefore, this study aimed to investigate whether students' CI and SPS differ across the states in Malaysia, by comparing Perak, Selangor and KL.

2.2 Career Interest

CI is known as vocational interest which the pattern of likes, dislikes, and indifferences in terms of activities pertaining to a career or an occupation (Bonitz, Larson, & Armstrong, 2010). In this study, CI refers to a secondary school student's likes, dislikes, and indifferences towards a STEM career.

Vulperhorst, Wessels, Bakker, and Akkerman (2018) reported that research on students' choice of career in STEM has been on a rise due to high demand of STEM labour in the international workforce. In Malaysia, it was suggested that students' career choices in STEM is mainly influenced by their interest in STEM subjects (Shahali, Halim, Rasul, Osman, & Zulkifeli, 2017). Wang, Ye, and Degol (2017) explained that interest is the main element that shapes students' career pathway in STEM, and it often occurs at upper secondary school level. This is supported by Shahali, Halim, Rasul, Osman, and Zulkifeli (2017) which reported students' interest towards their career goals have greater impact at secondary school level than any other stage in life because that is where they start to make decisions about their career pathways.

Unfortunately, students' interest to pursue STEM has been on a constant drop (Academy of Sciences Malaysia, 2016; Sadler, Sonnert, Hazari, & Tai, 2012). This phenomenon could threaten the supply chain of STEM talents from the Malaysian education system to the industry (Academy of

Sciences Malaysia, 2016). In line with it, the Malaysian labour market will suffer from shortage of STEM workers in the STEM fields (Nasa & Anwar, 2016).

In Sadler et al. (2012), it was indicated that students' interest towards STEM drop from the early stage of high school, thus affect their choice of career pathways. Therefore, it is necessary to look into upper secondary school students' CI as it is an important stage where decision making on STEM career takes place. The following hypothesis was proposed considering students from different states would differ in their behaviour (MoE, 2013):

H1:   There is a significant difference in students' CI across Perak, Selangor and KL.

2.3 *Perception towards STEM Programmes and Strategies*

In tandem with the worldwide demand of STEM workforce, many countries including Malaysia have integrated complementary STEM activities into its curriculum. According to Nasa and Anwar (2016), Malaysia has held nationwide activities to promote STEM education in the country. These are programmes or strategies that offer STEM-related exposure to students, encourage students' interest for STEM learning, and to attract more students to STEM careers (Balakrishnan and Azman, 2017; MOSTI, 2017; Nasa & Anwar, 2016).

SPS are STEM-based activities initiated by the Malaysian MoE, MOSTI, and Ministry of Higher Education, other government agencies, non-government organisations, universities, members of private sectors, and industrial players to engage people to STEM (Shahali, Ismail, & Halim, 2017). SPS encompass a wide range of activities such as camps, clubs/societies, exhibitions/expos/fairs, workshops, competitions, festivals/carnivals, projects, study tours, hands-on practical sessions and mentor-mentee programmes in STEM (MOSTI, 2017; Shahali, Ismail, & Halim, 2017).

Many past studies concerning SPS in Malaysia investigated the effectiveness of specific SPS in a given group of sample (Balakrishnan & Azman, 2017; Haron et al., 2019; Halim, Soh, & Arsad, 2018). Haron et al. (2019) found that "Fun Learning Toy Library", a STEM project which was executed in a rural school in Kelantan, Malaysia could enhance STEM learning among preschool students. Besides, Balakrishnan and Azman's (2017) research revealed that a STEM outreach programme named "Professionals Back to School" successfully spurred school students' interest in STEM.

In spite of numerous SPS being executed in Malaysia, literature discussing students' perception towards SPS in general is scarce. Research on students' perception towards SPS across states in the country is also extremely limited. Given that students across the states in Malaysia would likely to perceive SPS differently (MoE, 2013), the following hypothesis was proposed:

H2:   There is a significant difference in students' perception towards SPS across Perak, Selangor and KL.

3. Research Methods

3.1 *Instrument*

This study used a survey design using questionnaire to test the research hypotheses. Three experts in relevant research areas were invited to review the questionnaire, and it was revised based on their comments to improve the content and face validity of the questionnaire.

Cognitive interviews were conducted with fifteen students to ensure the research instrument was appropriate for the target sample of the present study (Beatty & Willis, 2007). The questionnaire was subsequently amended according to the participants' feedback. The final questionnaire was made up of two sections.

The first section entailed participants' demographic information such as name and location of school. CI and perception towards SPS were measured in the latter section with twelve and ten items respectively. Each item was measured on a seven-point Likert scale from 1= Disagree to 7= Agree. The Cronbach's Alpha values for CI and perception towards SPS were 0.83 and 0.92 respectively, which were above the recommended value at 0.7 (Pallant, 2013). Hence, both the CI and SPS constructs had good internal consistency within the sample of this study.

3.2 Participants

This study was scoped to three states located in the Peninsular Malaysia. As shown in Table 1, the participants of this study were 204 students from Perak, Selangor and Federal State of Kuala Lumpur (KL). All of them were Form Four school students from the STEM stream. The data was collected from October 2018 to January 2019.

Table 1

Number of Participants

State	*N*
Perak	70
Selangor	70
KL	64
Total	204

3.3 Procedures

The researchers received approvals from the MoE, state offices of education, and the researchers' affiliation Scientific and Ethical Review Committee prior to the commencement of data collection. Before the interviews and surveys, all participants were informed on the purpose of the research. The researchers also emphasised that the research was on a voluntary basis that the participants had the rights to opt not to participate and withdraw from the study at any time of the survey. The interviews and surveys were conducted after each participant gave their informed consent to participate in the study. Each cognitive interview took approximately 30 minutes, whereas students generally spent around 20 minutes to complete the survey questionnaire.

4. Findings

4.1 Assumption Testing

The data was analysed using a one-way between-groups multivariate analysis of variance (MANOVA) with Social Science Statistical Package (SPSS) 23. Preliminary assumption test was carried out for tests on linearity, normality, homogeneity of variance-covariance matrices, univariate and multivariate outliers, and multicollinearity. There were no violations according to the results of the tests.

According to Pallant (2013), Mahalanobis distances was used to test multivariate normality for MANOVA. The recommended maximum value for two dependent variables was 13.82. The results revealed that the Mahalanobis distance value was 12.48 which was less than the recommended critical value (Pallant, 2013). Hence, there were no substantial multivariate outliers in this set of data.

Box's Test in MANOVA provides information on whether the data violates the assumption of homogeneity of variance-covariance matrices (Pallant, 2013). Results from Box's Test of Equality of Covariance Matrices shows that the significant value was at $p = .34$, hence the assumption of homogeneity of variance-covariance matrices of the data in this study was not violated.

Besides, Pallant (2013) also suggested that if each group had more than 30 subjects (or cases), the data could be considered safe from violations of normality or equality of variance. Each state in this study had over 30 participants (as shown in Table 1), thus the data did not violate the assumptions of normality and variance equality.

4.2 MANOVA

MANOVA was performed to investigate students' CI and perception towards SPS across three states namely Perak, Selangor and KL. Table 2 shows a statistically significant difference across the states on the combined dependent variables at $p < .05$ level, $F (4, 400) = 2.95$, $p = .02$; Wilks' Lambda = .94; partial eta squared = .03.

Table 2

Multivariate Tests

		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
State	Wilks' Lambda	.944	2.948	4.000	400.000	.020	.029

From the results in Table 3, when the results for the dependent variables were regarded separately, both CI and perception towards SPS reached statistical significance.

Table 3

Tests of Between-Subjects Effects

		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
State	CI	7.876	2	3.938	4.024	.019*	.039
	SPS	11.416	2	5.708	4.352	.014*	.042

* The mean difference is significant at the 0.05 level.

4.3 One-Way ANOVA

According to Pallant (2013), it is important to perform follow-up univariate analyses (ANOVA) and post-hoc tests to identify where the significant difference lie. Besides, Abdullah, Halim and Zakaria (2014) also highlighted the importance of conducting ANOVA after MANOVA to determine the significance difference in each specific comparison. Hence, one-way ANOVA was performed to further assess difference in CI and SPS across Perak, Selangor and KL.

4.3.1 ANOVA for CI

ANOVA was performed to examine students' CI across from three states namely Perak, Selangor and KL. Table 4 shows that there was a statistically significant difference in CI scores for the three groups of students F (2, 201) = 4.02, *p* = .02.

Table 4

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
CI	Between Groups	7.876	2	3.938	4.024	.019*
	Within Groups	196.684	201	.979		
	Total	204.560	203			

*. The mean difference is significant at the 0.05 level.

The difference in mean scores between the groups was rather small, though there was statistical difference. The effect size as calculated using eta squared was .04. Tukey HSD test in post-hoc comparisons (Table 5) showed that the CI mean score for Perak (M = 5.24, SD = .91) was significantly different from Selangor (M = 4.85, SD = 1.02) and KL (M = 4.81, SD = 1.03).

From the results in Table 5, it can be concluded that there was a significant difference in CI between students from between Perak and Selangor (*p* = .05), and Perak and KL (*p* = .03). However, students' CI did not differ significantly between Selangor and KL (*p* = .98).

Table 5

Tukey HSD

Dependent Variable	(I) State	(J) State	Mean Difference (I-J)	Std. Error	Sig.
CI	Perak	Selangor	.39524*	.16721	.050
		KL	.43177*	.17108	.033

Selangor	Perak	-.39524*		.16721	.050
	KL	.03653		.17108	.975
KL	Perak	-.43177*		.17108	.033
	Selangor	-.03653		.17108	.975

*. The mean difference is significant at the 0.05 level.

4.3.2 ANOVA for Perception towards SPS

On the other hand, ANOVA was also conducted to compare students' SPS across Perak, Selangor and KL. As shown in Table 6, the results indicated statistically significant difference in perception towards SPS scores across the three states F (2, 201) = 4.35, p = .01.

Table 6

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
SPS	Between Groups	11.416	2	5.708	4.352	.014*
	Within Groups	263.618	201	1.312		
	Total	275.034	203			

*. The mean difference is significant at the 0.05 level.

Similar to CI, the actual difference in mean scores was between the groups calculated using eta squared. The eta squared value was .04 which suggested that the effect size was small. Besides, Tukey HSD test in post-hoc comparisons (Table 7) indicated that there was a significant difference, p = .01 in students' SPS between Perak (M = 5.42, SD = .99) and Selangor (M = 4.85, SD = 1.17). Nevertheless, students' perception towards SPS did not differ significantly between Perak and KL (p = .15), and Selangor and KL (p = .59).

Table 7

Tukey HSD

Dependent Variable	(I) State	(J) State	Mean Difference (I-J)	Std. Error	Sig.
SPS	Perak	Selangor	.56286*	.19358	.011
		KL	.36780	.19806	.154
	Selangor	Perak	-.56286*	.19358	.011
		KL	-.19506	.19806	.587
	KL	Perak	-.36780	.19806	.154
		Selangor	.19506	.19806	.587

*. The mean difference is significant at the 0.05 level.

Overall, the hypotheses in this study were supported by the statistical results in the findings from MANOVA, while specific significant differences were examined through ANOVA. Table 8 is a summary of the results based on the hypotheses of this study.

Table 8

Summary of Results

Hypothesis	Description	Analysis	*p*-value	Result
H1	There is a statistically significant difference in students' career interest across Perak, Selangor and KL.	MANOVA	.02*	Supported
	CI: Perak - Selangor	ANOVA	.05*	Supported
	CI: Perak - KL	ANOVA	.03*	Supported
	CI: Selangor - KL	ANOVA	.98	Not Supported

H2	There is a statistically significant difference in students' perception towards SPS across Perak, Selangor and KL.	MANOVA	.01*	Supported
	Perception towards *SPS: Perak - Selangor*	*ANOVA*	*.01**	*Supported*
	Perception towards *SPS: Perak - KL*	*ANOVA*	*.15*	*Not Supported*
	Perception towards *SPS: Selangor - KL*	*ANOVA*	*.59*	*Not Supported*

*. The mean difference is significant at the 0.05 level.

5. Discussions and Conclusions

In sum, three findings could be drawn from the results. Three main findings of this study were (i) there was a significant difference in students' CI and perception towards SPS in comparison of Perak and Selangor, (ii) there was a significant difference in students' CI, but no significant difference in students' perception towards SPS in comparison of Perak and KL, and (iii) there was no significant difference in students' CI and perception towards SPS in comparison of Selangor and KL.

First, when considered the results as a whole, it was revealed that there was a significant difference on students' CI and perception towards SPS across Perak, Selangor and KL. This finding echoed the reports from MoE (2013) and MOSTI (2017) that there are disparities between different regions in Malaysia concerning access and resources, specifically in STEM awareness and opportunities. Thus, students' interest in STEM careers and their perception towards STEM activities were different across the states in Malaysia.

Second, in further explorations through ANOVA, findings showed that students from Perak reported significant differences in their CI and SPS with Selangor. It is also reflected in the results that students' CI and perception towards SPS did not differ between Selangor and KL. This finding may be due to the location of the states in which Perak is located in the northern region of Peninsular Malaysia, whereas Selangor and KL are located in the central region. Students from the central region have higher awareness of opportunities in STEM careers, informed choices on STEM career opportunities, and STEM resources (MoE, 2013) compared to Perak because the central region is the hub of the country where resources and access are prioritized. As such, CI and perception towards SPS of students' from Selangor and KL were similar but different from students from Perak.

Third, in comparison of Perak and KL, there was a significant difference in terms of students' CI but not students' perception towards SPS. Students' CI is shaped at upper secondary school level based on various elements that influence their likes, dislikes, and indifferences towards career-related activities (Bonitz et al., 2010). As such, it leads to the difference of students' CI between Perak and KL. On the other hand, there was no difference in students' perception towards SPS between Perak and KL. This is because the STEM initiatives executed in Perak and KL could be similar as the programmes and strategies were implemented nationwide through the National STEM Action Plan, hence there was no significant difference in students' perception towards SPS between Perak and KL (Shahali, Ismail, & Halim, 2017).

There are a number of limitations in this study. This study was scoped to focus on only Form Four STEM stream students from three states in Malaysia due to restrictions of the authorities, hence the findings can only be generalised to Form Four STEM stream students from Perak, Selangor and KL. Besides, the data was collected through a self-report survey which could have caused common method variance. A qualitative approach such as focus group interview and grounded theory study could potentially provide more in-depth details and underlying factors that are yet to be explored. Future studies may explore students' CI and perception towards SPS in other states within the country or beyond the current context of the present research.

The findings of this study would contribute to the understanding of career interest in STEM among the Malaysian students, as well as their perception on the STEM initiatives implemented deemed nationwide. This study would also offer meaningful data about the STEM scenario in Malaysia from the perspectives of the current STEM stream students. The findings from this study could be a meaningful up-to-date reference for the authorities and researchers and stakeholders for enhancement of STEM initiatives to support STEM education and workforce in Malaysia.

Acknowledgement

References

Abdullah, N., Halim, L., & Zakaria, E. (2014). VStops: A thinking strategy and visual representation approach in mathematical word problem solving toward enhancing STEM literacy. *Eurasia Journal of Mathematics, Science & Technology Education*, *10*(3).

Academy of Sciences Malaysia. (2016). *Science outlook 2015: Action towards vision, executive summary 2015*. Kuala Lumpur, Malaysia: Academy of Sciences Malaysia.

Academy of Sciences Malaysia. (2018). *Science outlook 2017: Converging towards progressive Malaysia 2050*. Kuala Lumpur, Malaysia: Academy of Sciences Malaysia.

Balakrishnan, B., & Azman, M. N. A. (2017). Professionals back to school-an engineering outreach programme: A case study in Malaysia. *Journal of Engineering Science and Technology, 12*(10), 2640-2650.

Beatty, P. C., & Willis, G. B. (2007). Research synthesis: The practice of cognitive interviewing. *Public Opinion Quarterly*, *71*(2), 287-311. http://dx.doi.org/10.1093/poq/nfm006

Bonitz, V. S., Larson, L. M., & Armstrong, P. I. (2010). Interests, self-efficacy, and choice goals: An experimental manipulation. *Journal of Vocational Behavior, 76*(2), 223-233. http://dx.doi.org/10.1016/j.jvb.2009.09.003

Halim, L., Soh, T. M. T., & Arsad, N. M. (2018). The effectiveness of STEM mentoring program in promoting interest towards STEM. In *Journal of Physics: Conference Series* (Vol. 1088, No. 1, pp. 012001). IOP Publishing. http://dx.doi.org/10.1088/1742-6596/1088/1/012001

Ministry of Education. (2013). *Malaysia education blueprint 2013-2025*. Putrajaya: Ministry of Education, Malaysia. Retrieved from https://www.moe.gov.my/muat-turun/penerbitan-dan-jurnal/dasar/1207-malaysia-education-blueprint-2013 -2025/file

Ministry of Education. (2016). *Panduan perlaksanaan sains, teknologi, kejuruteraan dan Mmtematik (STEM) dalam pengajaran dan pembelajaran.* Putrajaya: Ministry of Education, Malaysia. Retrieved from https://cms.mrsm.edu.my/cms/index.jsp

Ministry of Science, Technology and Innovation. (2017). *Malaysian Science, Technology and Innovation Indicators Report 2016*. Putrajaya: Malaysian Science & Technology Information Centre, Ministry of Science, Technology and Innovation, Malaysia. Retrieved from https://mastic.mestecc.gov.my/sti-survey-content-spds/malaysian-science-technology-innovation-sti-indica tors-report-2016

Nasa, A. & Anwar, Z. (2016, May 23). Too few STEM students. *New Straits Times.* Retrieved from https://www.nst.com.my/news/2016/05/147260/too-few-stem-students

Haron, H. N., Hussain, N. H., Mohammad, R., Ahmad, N., Talib, H. H. A., Hassan, M. Z., … Sarip, S. (2019). Grooming future scientists and engineers from the root through fun learning concept. In *Journal of Physics Conference Series* (Vol. 1174, No. 1).

Pallant, J. (2013*). SPSS survival manual: A step by step guide to data analysis using IBM SPSS* (5th Edition). Berkshire, UK: Open University Press, McGraw-Hill Education.

Razali, F., Talib, O., Manaf, U. K. A., & Hassan, S. A. (2018). Students attitude towards science, technology, engineering and mathematics in developing career aspiration. *International Journal of Academic Research in Business and Social Sciences, 8*(5), 962–976. http://dx.doi.org/10.6007/IJARBSS/v8-i5/4242

Sadler, P. M., Sonnert, G., Hazari, Z., & Tai, R. (2012). Stability and volatility of STEM career interest in high school: A gender study. *Science education*, *96*(3), 411-427. http://dx.doi.org/10.1002/sce.21007

Shahali, E. H. M., Halim, L., Rasul, M. S., Osman, K., & Zulkifeli, M. A. (2017). STEM learning through engineering design: Impact on middle secondary students' interest towards STEM. *EURASIA Journal of Mathematics, Science & Technology Education*, *13*(5), 1189-1211. https://doi.org/10.12973/eurasia.2017.00667a

Shahali, E. H. M., Ismail, I., & Halim, L. (2017). STEM education in Malaysia: Policy, trajectories and initiatives. *Asian Research Policy, 8*(2), 122–133. Retrieved from http://www.arpjournal.org/usr/browse/list_issues_detail.do?seq=27

Vulperhorst, J. P., Wessels, K. R., Bakker, A., & Akkerman, S. F. (2018). How do STEM-interested students pursue multiple interests in their higher educational choice? *International Journal of Science Education*, *40*(8), 828-846.

Wang, M. T., Ye, F., & Degol, J. L. (2017). Who chooses STEM careers? Using a relative cognitive strength and interest model to predict careers in science, technology, engineering, and mathematics. *Journal of youth and adolescence*, *46*(8), 1805-1820. http://dx.doi.org/10.1007/s10964-016-0618-8

Learning Archaeoastronomy in Temples with STEM-focused Mobile Learning Approach

Jintana WONGTA[a*], Charoenchai WONGWATKIT[b], Chitphon YACHULAWETKUNAKORN[c], Ratthakarn NA PHATTHALUNG[d], Cherdsak SAELEE[e], Mullika TAWONATIWAS[f]

[a,c,d]*Engineering Science Classroom, King Mongkut's University of Technology Thonburi, Thailand.*
[b]*School of Information Technology, Mae Fah Luang University, Thailand.*
[e]*Department of Physics and Materials Science, Faculty of Science, Chiang Mai University, Thailand.*
[f]*Department of Mathematics, Faculty of Science, Chiang Mai University, Thailand.*
*ting_naendoo@hotmail.com

Abstract: Ancient people during prehistorical time constructed their knowledge based on observation and recording then kept it on archaeological site. Young generations are trying to understand the secret of historical site which was called archaeology study. In Thailand, there are many temples and that temple may keep ancient astronomy knowledge. However, there are not many scientists who are interested in archaeoastronomy in our country. Our research focused on mobile learning approach which is proposed to enhance Archaeoastronomy activity with STEM-focused in historical field. The activity was designed based on STEM activity. Science and Math were applied on astronomy topic. Technology was applied on mobile learning and Engineering was applied on drawing and scaling. Additionally, mobile learning was used to support all STEM activities in field because of astronomy mobile applications are widely spread during 21st century. The results showed that students can learn more in field when use mobile supporting in STEM activities and soft skills such as critical thinking, questioning and problem solving were use during this activity. The research could challenge teachers who appreciate STEM education to apply more archaeoastronomy in their historical site around the world.

Keywords: Archaeoastronomy, mobile learning, STEM Education

1. Introduction

Thailand's considered as an enrich multicultural country in Asia. Owing to their location, and territory, they recognized to situate in the central of Southeast Asia, the most important ancient trade's route in Asia. It's considered as the pathway between Western to Eastern. Therefore, Thailand remains a significant civilization in the World history until nowadays. Many historians annually came to Thailand in order to study Eastern civilization history from the historical evidence in the historical site, such as, Sukhothai historical site, Ayutthaya historical site, and others sites in this country. Hence Thai history was not only be significant in the context of domestic Thai history education, but also be significant in the World history education.

Thai history course is a required course in every school in Thailand. According to Ministry of Education, Thai history is a significant course which is be merged as a part of Social studies, Religion, and Culture subject. Students have studied this course since Grade 1st until Grade 12th. Nevertheless, there are some limitations studying history because rote learning is the main method of learning Thai history both in the lecture class, and in the field. In addition, they weren't integrated with others Science. From these limitations, students were rarely trained and develop the critical thinking, creativity skill as expected.

According to the limitation of Thai history education, learning beyond class's considered as a learning method that could improve those limitations. Archaeology is an effective learning approach supporting historical education in the real place. It could collaboratively connect knowledge content in the lecture class to the historical site. Moreover, it could accelerate learning behavior to integrate with others Science, such as, Astrology, Geography, Geology, Geometry, etc. Archaeoastronomy is

one of the integrations between archaeology and astrology from the ancient civilization. Ancient people from prehistoric period may possible connected the monument of Stonehenge with ancient astronomy. The researcher discovered that Stonehenge is aligned in the direction of the sunrise of the summer solstice and the sunset of the winter solstice. In Thailand, Sukhothai Historical Park's considered as a World Heritage Sites by UNESCO. In this World Heritage composed of the city's walls form a rectangle about 2 km (1.2 mi) east-west by 1.6 km (0.99 mi) north-south. There are 193 ruins on 70 km^2 (27 sq. mi.) of land. There is a gate in the center of each wall. Inside are the remains of the royal palace and twenty-six temples, the largest being Wat Mahathat. According to their ancient complete city, it's quietly appropriate for learning many subjects through this ancient city. Students could collaboratively integrate History with Astrology through the city building that connected with Moon orbit, and Earth orbit around the Sun absolutely associated with Temple building.

In field trip, mobile learning is very helpful when the student do not know something then they can search immediately or when they are interesting in something then they can take a photo for recording the evidence which is fascinated by them. Our study designed the STEM activities that related to archeoastronomy and mobile could help supporting the more active learning during in field situation. The more active, the more inquire knowledge may happen. Recently, astronomy mobile apps have developed widely and turns mobile device into a mobile planetarium. It is very easy to our student to find out the relationship of temple construction and sun position which was based on the belief of ancient people.

Therefore, the integration between history, STEM and mobile learning from our research would show some different way of learning history if compare to normal Thai education system. Student's competency may increase due to the enhancing of their soft skills such as critical thinking, creative thinking, questioning and problem solving. The aim of our study is to introduce the new integration pedagogy between STEM activity and history topic using mobile learning approach.

2. Archaeoastronomy and STEM-focused Mobile Learning

Archaeoastronomy is ancient astronomy which explains about the construction of ancient sites based on the observing of regular cycles of the Sun, Moon, planets, and stars in the sky for agriculture including creating a calendar. Archaeoastronomy suggests maybe one of the best means of understanding certain cosmologies of people during ancient civilization. Not only have anthropology and history consistently revealed that celestial phenomena are of "almost universal concern" (Ruggles 1999:83). For example, Thornborough monument complex in Yorkshire's North Riding may have intentionally referenced the midwinter sunrise, Orion's Belt, and other celestial events. These relations might have simulated the seasonal changing of those using the monument complex, thus proposing a close connection between people's skyscape and life cycles during Neolithic period (Harding, Johnson, & Goodrick, 2006). Ancient astronomer from Suvarnabhumi civilization linked the cycles of sun and moon for its association with agriculture especially rice. The Suvarnabhumi people were able to develop a calendar that matched with the seasons by observing and recording natural phenomena surrounding them. Moreover, they can precisely observed the particular angles of sunrise at south solstice (23.5° S), equinox (0°), and north solstice (23.5° N) using their own calendar (Saelee, 2018).

In this current, mobile learning is widely considered by many educational academicians as the blending of mobile computing and e-learning comprising of accessible resources. Students can search for the data anytime and anywhere you are. Baran opined that mobile learning could be an effective accessing learning approach in this period (Baran, 2014). Nevertheless, mobile learning perspectives still based on the traditional learning method which blending with the mobile device. In the present, learning are not only limited to lecture-based learning, but mobile learning could assist the students to collaborating knowledge content by exploring the real world and the virtual world (Shih, Chuang, & Hwang, 2010; Vishwakarma, 2015). According to Chatterjea (2012) created NIEmGeo, the app allows students to geo-tag data like text, photos, and videos onto a shared map for Geography field.

Mobile learning's considered as a necessary learning approach inevitably because nowadays, learning didn't limit not only in classroom (traditional learning), but also appeared in online database. In addition, STEM was also recognized as an effective approach to accelerate learning behavior. Hence there are many study that blending mobile learning in order to support STEM education as follow,

Krishnamarthi founded that mobile learning could accelerate student from underrepresented group to get better learning performance in STEM activity (Krishnamurthi & Richter, 2013). Similar to Ariffin, founded that mobile could developed some skill using the multimedia function of mobile phone (Ariffin, Side, Fadhil, & Mutalib, n.d.). In case of the collaboration skill, Grimus opined that qualified STEM educator had an important role to develop learning approach (Grimus & Ebner, 2016). According to Razak, he founded that lack of motivation, and lack of qualified STEM educator is the main hindrance for STEM education (Razak, Strategy, Through, Usage, & Technology, 2015). Therefore blending mobile learning with STEM education could accelerate learning behavior (Thibaut et al., 2018).

It seems like archaeoastronomy is the STEM education itself so it is challenging for teacher "How to apply this field of study into Thai history learning?" Nowadays, mobile apps are widely spread and very easy to monitor celestial real time in field so if we can apply mobile learning into STEM activity but answer the history questions. Science's students might be focused and concentrated more when studying at historical field. To implement all ideas, teachers designed and mocked up activity first, then use develop lesson plan to test with students in real situation.

3. A Novel Learning Approach and Learning Process

3.1 Research context

The activity is under subjects called "ESC 421 The builder and ESC 422 The Navigator" of Engineering Science Classroom affiliated by King Mongkut's University of Technology Thonburi (ESC-KMUTT) in the 2nd semester of 2018. These 2 subjects are the integrated subject under Story-based learning curriculum. ESC-KMUTT has been used Story-based learning as its curriculum for more than 12 years for nurture the innovator, scientist and engineer. This curriculum is promoting high school students to learn through "stories" by which all learning topics are interwoven and integrated. In addition, thinking skills are taught such as critical thinking, creative thinking, visual thinking and scientific thinking.

3.2 Research Participants

The participants were 10th grade students form 3 classrooms (n=78) of ESC-KMUTT during 2018 academic year. Each group consisted of 6-7 students therefore there were 12 groups in total. All of them were past the first year of high school at ESC-KMUTT and were going to 11st grade in the next semester. The sample consisted of 38 male and 40 female students, at the age between 14-16 years old.

3.3 Methods

This research use Sukhothai historical park for an archaeological site studying during 2 days. Archaeoastronomy activity was designed based on STEM-focused. Science and Math were used in part of astronomy activity. The activities were sun shadow and sun position observation in Sukhothai historical park during 1 day. Engineering and Math were applied on architecture activities which were temple measurement and drawing top view of that temple based on engineering concept. All activities were work in field and use mobile to support learning while they were working or discussing among friends. The important mission was to find the relationship between temple building and celestial phenomena (Figure 1).
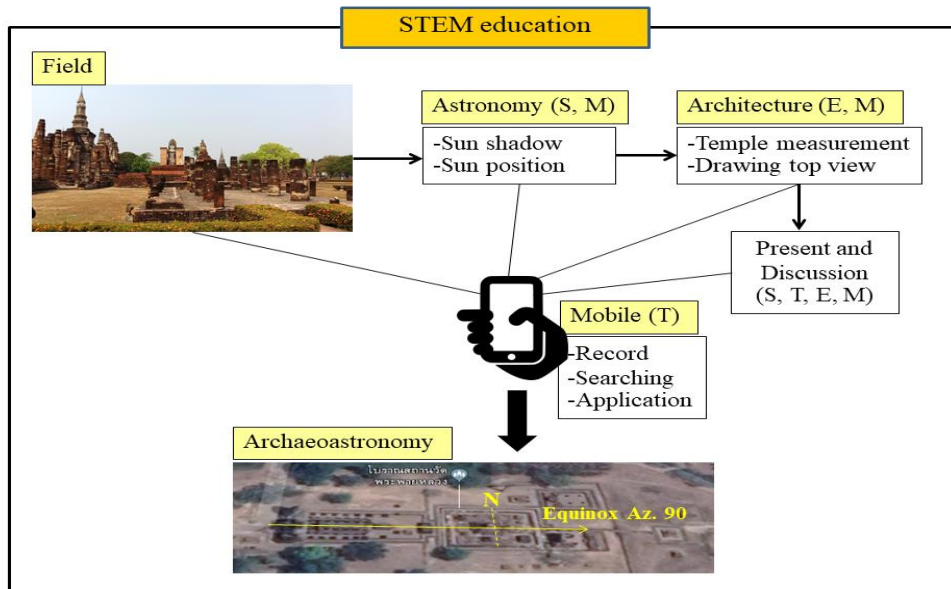
Figure 1. Conceptual framework of Archaeoastronomy activities.

For in field study, there are 3 temples that hypothesized to relate to astronomy observation in Sukhothai historical park. 1) Wat Mahathat, the main temple for Sukhothai empire ceremony which was built following the concept of Mandala, an ancient Hindu symbol representing the universe. 2) Wat Si Sawai, the temple consisted of three prangs which was constructed by the Khmer as a Hindu sanctuary dedicated to Shiva. 3) Wat Phra Phai Luang, the temple was built by the Khmer when the Sukhothai area was an outpost of the Khmer empire. It was the center of town in the pre Sukhothai era and the most important temple of that time (Figure 2). Every temple was measured and drawing its constructs that may relate to sun movement during one year (Table 1).
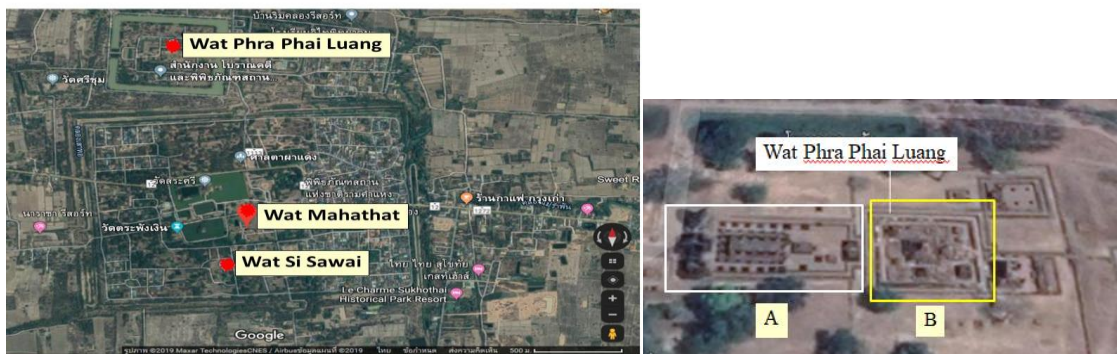
Figure 2. Map of Sukhothai historical park in field trip activity.

Table 1
Learning activity before and during a one-day field trip.

Activity	Description
Introduction (30 min)	1) Students studied the location of 3 temples in Sukhothai historical park by using Google map/ Google earth (10 min). 2) Students watched a video of Equinoxes which made by National Geographic https://www.youtube.com/watch?v=kaG6PTVrFP4 3) Encourage students to ask questions for seeking the relationship between temple building and sun position. Brainstorming and listing the used equipment for 15 min.

Activity	Description
Questioning (15 min)	1) Do students think that people in the past built temple to understand the beam of the sun? 2) What and Why, do ancient people want to know about the relationship between religious building and sun position? 3) How can we understand the knowledge of ancient people from their construction? 4) What do students learn from measuring of the shadow of the sun during 1 day?
Give assignment (15 mins)	1) What do students learn from measuring of the shadow of the sun during 1 day? 2) Students go to the field and measure the sun shadow in 1 day then record the observation. 3) Students measure the temple and draw a top view with scaling. 4) Discover the relationship between temple building and sun position using discussion, mobile application and search engine.
Field trip (9 hrs) A) Wat Mahathat B) Wat Si Sawai C) Wat Phra Phai Luang	1) Students study the 1st temple from 9.30-15.00. Group 1-3 study at Wat Mahathat and Group 4-6 study at Wat Si Sawai. 2) Students study the 2nd temple which is Wat Phra Phai Luang from 16.00-18.30. Group 1-3 site A and Group site B. 3) What time does the sun set at the observing day? 4) Where does the sunset compared to the 3 stupas at Wat Phra Phai Luang? Let's draw the picture.
Present (2 hrs)	Six groups of students present all their works on power point presentation for 10 min and discuss for 10 min.

Students were doing archaeoastronomy activity in field from 9.30-15.30. Firstly, teacher briefed about the activity again and gave them the equipment such as A4 and A3 paper, measuring tape, Scotch tape, plastic rope, compass and water ruler. Then, they were observing the sun position during one day and measuring the size of temple for scaling and drawing (Figure 3).

Students was listening to the history of Sukhothai.

Students was observing the sun position during 1 day.

Students was measuring the size of Wat Mahathat for scaling and drawing.

Figure 3. Field trip activity during 1 day at Sukhothai historical park.

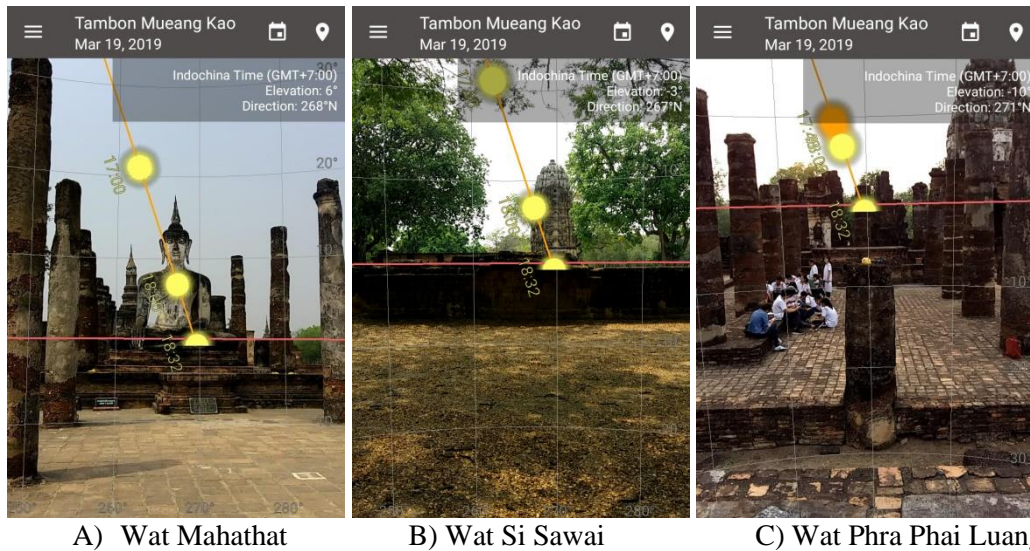A) Wat Mahathat   B) Wat Si Sawai   C) Wat Phra Phai Luang

Figure 4. The photos from Sun Position, Sunrise, and Sunset Demo mobile application.

Mobile applications were used to enhance learning in field situation. For example, Sun Position, Sunrise, and Sunset Demo app is the application for showing sunrise and sunset times, in addition to the solar and lunar path on an augmented reality camera view for any day of the year at our current location. Students used it for monitoring sun movement and sunset in the activity (Figure 4).

4. Experiment and Result

4.1 Experiment

Based on archeoastronomy activity during Sukhothai field trip, a record about student's work were collected and classified into some expected soft skills by teachers.

There were 80 participants from Engineering Science Classroom (ESC) batch number 10. They were divided into 2 main groups. The first group were studied on 19 March 2019 and the second group were studied on 20 March 2019. One main group were divided into six small groups (1-6). Sukhothai historical park group 1-3 were studying at A) Wat Mahathat, group 4-6 were studying at B) Wat Si Sawai during 9.30-15.00 (Fig. 2) after that from 16.00-18.30 they were going to C) Wat Phra Phai Luang. Group 1-3 were studying at zone A and group 4-6 were studying at zone B of Wat Phra Phai Luang (Fig. 2). Finally, everyone were sitting and seeing the sunset at Wat Phra Phai Luang.

The students were assigned to work during one day. All works were collected and present to peer and teachers at night time (20.00-22.00). The assignments are as follows:

1. Measure the angle from reference point to find out the relationship between temple construction and sun position.
2. Measure the size of temple and drawing the temple building.
3. Measure the sun position path in 1 day.

From their works, teachers were classified into STEM education and soft skills such as critical thinking, questioning and problem solving.

4.2 Results

The results were recorded by teachers after archaeoastronomy activity at Sukhothai field trip and characterized all data into STEM and soft skills using. We found that STEM was used in many steps and mobile apps could help monitoring the celestial phenomena real time. At that time, STEM promoted soft skills using. For example, they used critical thinking to figure out why and how ancient people known about astronomy. First, they observed the sun movement during one day every 30 min and plot graph of the shadow of reference stick. Then, they tried to measure temple and relate the temple angle to vernal equinox (E, 90°). From many evidences, most of students were raising the questions when they

were doing their works. Finally, they were still curious that "Is it possible that ancient Sukhothai people use temple to observe the celestial occurrences?"

Table 2
The result of students' works.

Mobile (T)	Measure the angle from reference point. (E,M)
Wat Mahathat Use compass app and measuring tape to measure the angle of interesting point such as temple door, staircase and temple pillar to reference point (Buddha statue). **Questioning**: What is archaeoastronomy? Does Sukhothai civilization has archaeoastronomy?	**E, 90°** Wat Mahathat The drawing of Wat Mahathat after measuring and scaling and the angle between reference point (●) and every pillar inside the temple. Students curious that buddha statue may look at (→).
Mobile (T) Wat Mahathat **Problem solving**: Use mobile sensor to help adjust the problem of tilted floor when they want to study sun position in field.	Sun position path in 1 day (19 or 20 March 2019) (S, M) $$\tan\theta = \frac{x}{d}$$ $$d\tan\theta = x$$ $$d = \frac{x}{\tan\theta} \#$$ **Critical thinking**: Use similarity of triangles and trigonometry to find out the long of shadow and explore how the sun move during one day at Sukhothai historical park. For the time involved in the length of the shadow, we need to find the position of the sun each day by using the point that the sun intersects with the meridian line as a reference point
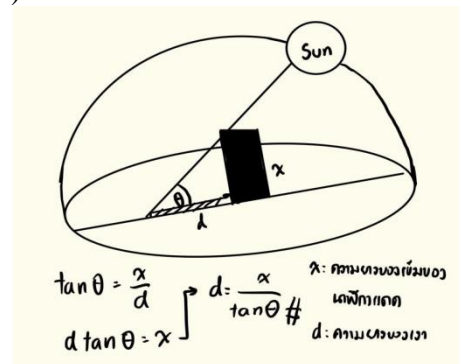
Sun shadow measurement on 19 Mar. 2019 at Wat Mahathat Sukhothai historical park.

Graph showed shadow degree changing during 11.15-14.45.
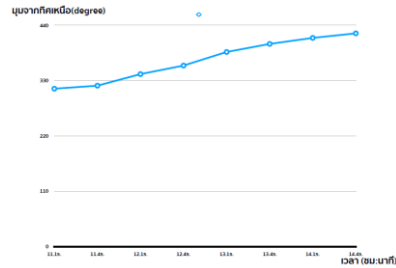
Graph showed the length of shadow changing during 11.15-14.45.
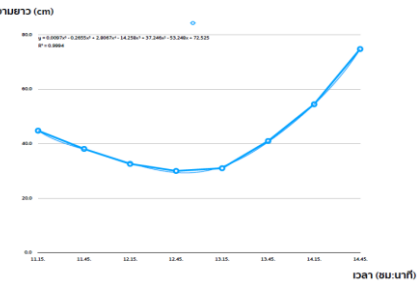
Presentation

Students presented their works to peers and teachers for sharing the observation using power point presentation.

Discussion

Friends and teachers discussed with presenters for the clearly point of view and criticized some interesting points.

4.3 Limitations

This research had limitations because this work only presents a prototype of the method to see the feasibility and proof of concept. There are still lacking empirical evidences to reveal the effectiveness of the proposed STEM-focused mobile learning approach. It is necessary to receive further studies.

5. Discussion and Conclusion

Ancient study did not divide knowledge but integrated many fields of study when students done the archaeoastronomy activity, they had found many critical points from ancient astronomy. Temple in Thai language is called "Wat" and measure in Thai is also called "Wat" too. Students were very fascinated when teacher introduce that today we were going to "wat the wat" or means we were going to measure (wat) the temple (wat). Why temple was called the same as measure? Many curiosities are rising while we are studying archaeoastronomy. Student's works were interesting because they can get the point of STEM and present it very good (Table 2). According to STEM-focused and mobile approach, our research discovered that this pedagogy could enhance student's soft skills such as critical thinking, questioning and problem solving. From teacher observation, student's behavior showed a

positive intention, good teamwork, raising question and active learning even if the weather was very hot at that day. Finally, they admired Sukhothai people to build the meaningful construction like these.

This is the first time for teacher doing these kinds of activities. Sometime, we cannot reach our plan especially time management was still a big problem. In addition, ancient temple will have only ruined construct while students were studying in the area, it took around two to three hours under the sun without shredding from tree. The weather was so hot because the trip was held on March or summer season so next time we are planning to go to the field on December or winter season to avoid heat stroke condition.

Thailand has its own culture for a longtime. There are so many temples in every province. We believe that archaeoastronomy activity can apply in the others schools of Thailand. But it is not all temples that built based on archaeoastronomy therefore teacher need to find the possible temple and mock up the activity before doing it with students. From this research, it still unclear how can students develop their soft skills during our activity. Thus, further study will focus more about soft skills and measure those skills before and after doing the activity.

Acknowledgements

References

Ariffin, S. A., Side, S. F., Fadhil, M., & Mutalib, H. (n.d.). A Preliminary Investigation of Malaysian Student 's Daily Use of Mobile Devices as Potential Tools for STEM in a Local University Context, 80–91.

Baran, E. (2014). A Review of Research on Mobile Learning in Teacher Education: Discovery Service for Universidade de Coimbra. *Journal of Educational Technology & Society*, *17*(4), 17–32.

Chatterjea, K. (2012). Use of Mobile Devices for Spatially- Cognizant and Collaborative Fieldwork in Geography. *Review of International Geographical Education Online*, *2*(3), 303–325.

Grimus, M., & Ebner, M. (2016). Mobile Learning and STEM - First Experiences in a Senior High School in Margarete Grimus Martin Ebner, (January).

Harding, J., Johnson, B., & Goodrick, G. (2006). Neolithic Cosmology and the Monument Complex of Thornborough, North Yorkshire. *Archaeoastronomy*.

Krishnamurthi, M., & Richter, S. (2013). Promoting STEM Education through Mobile, 245–248.

Razak, R. A., Strategy, L., Through, A., Usage, T. H. E., & Technology, O. F. (2015). Mobile learning for teaching and learning Science , Technology , Engineering and Mathematics (STEM): A review of literature, (May).

Ruggles, C. (1999). Astronomy in prehistoric Britain and Ireland. *Astronomy in prehistoric Britain and Ireland/Clive Ruggles. New Haven, Conn.: Yale University Press, c1999. GN 805 R84 1999. DA*.

Saelee, C. (2018). Suvarnabhumi-Gregorian Rule to Determine Whether Thai Lunar Calendar Suvarnabhumi-Gregorian Rule to Determine Whether Thai Lunar Calendar Year 2012 is a Leap-month Year, (September).

Shih, J., Chuang, C., & Hwang, G. (2010). An Inquiry-based Mobile Learning Approach to Enhancing Social Science Learning Effectiveness. *Learning*, *13*(4), 50–62.

Thibaut, L., Ceuppens, S., Loof, H. De, Meester, J. De, Goovaerts, L., & Brussel, V. U. (2018). Integrated STEM Education : A Systematic Review of Instructional Practices in Secondary Education, *3*(1), 1–12.

Vishwakarma, A. (2015). Benefits and Challenges of Mobile Learning in Education. In J. Keengwe (Ed.), *Promoting Active Learning through the Integration of Mobile and Ubiquitous Technologies* (pp. 24–36).

Designing Learning Environment to Encourage the Engineering Design in the setting of FLIPPED Classroom for Design and Technology Courses

Nakarin NIMMA[a], Issara KANJUG[b*]
[a]*Educational Technology Program, Faculty of Education, Khon Kean University, Thailand*
[b]*Department of Educational Technology, Faculty of Education, Khon Kaen University, Thailand*
* issaraka@kku.ac.th

Abstract: This study uses the constructivist learning environment (CLE) as the basis for designing and developing a learning environment including learning management system (LMS) which occurs in pattern of online learning environment called SOCIALClassnet. The objective of this study are designing and developing the LMS to encourage the engineering design in the setting of flipped classroom for first trimester 2019 of Design and technology course. Subjects of this study are 30 students of Mathayom 1 , Nong Waeng Witthaya School, Thailand. The study design is one group pretest-posttest. The results are analyzed as quantitative and qualitative data. The framework of LMS that encouraging the engineering design in the setting of flipped classroom is consists of 1) Problem-based learning 2) Resource of knowledge 3) Cognitive tools 4) Case-related situation 5) Scaffolding 6) Coaching 7) Social support. Verifying efficacy by experts and the evaluation process are 1) Learning environmental design, knowledge content, media and technology and assessment 2) Capability in engineering design 3) Learners' opinions in knowledge content, media and design 4) Learning achivement

Keywords: Constructivism learning environment, flipped classroom, engineering Design

1. Introduction

Using technology to connect the data is more often in 21st century, allowing us to access more information quickly and easily. In the aspect of educational management, social context adaptation is necessary. However, there are some problems occur in the classroom such as teacher-centered learning environment and lack of timing for learning activities due to overtime work. For instance, financial work, supplying, academic e.g. On the other hand, the learners are lack of attention, lack of learning skills and lack of motivation, so the learning achievement is low.

The process of engineering design are consists of these steps 1) Problem identification 2) Data gathering and problem listing 3) Designing the methods of problem solving 4) Testing, evaluation and amendment 5) Presentation. All of these steps could be alternate and work as iterative cycle.

According to problems as above, teachers have to seek for more knowledge and new teaching patterns to encourage self-studying in the setting of flipped classroom. The principle is to change from passive learning to active learning environment that emphasizes self-studying from provided media and technology which based on individual competence (Issara Kanjug, 2013)

The study uses uses the constructivist learning environment (CLE) as the basis for designing and developing a learning environment including learning management system (LMS) called SOCIAL Classnet.

As the importance and necessity of this kind of learning, the researcher is interested in alternating Designing and Technology course into flipped classroom pattern to facilitate capability of engineering design in Mathayom 1 student.

2. Literature Review

2.1 Constructivism Learning Environment Management System

Knowledge is not only derived from passive gain but could be created from a person who understands and gains from experience. If these two principles are applied, the education results will be outspread. (Von Glasersfeld,1991). The learning process is generated from relation or previous understanding which the learners attempt to gather the experiences or situations to form the intellectual model. (Issara Kanchak, 2004) The theory that notices about learning process which establishes relation from self-experiences is so-called Cognitive structure.

2.2 Flipped Classroom Learning Environment

As a result that teaching methods which change from learning in class to dynamic and interactive learning, the teachers have to guide learners to apply their knowledge and motivate them to study. Flipped classroom is a teaching method that facilitate the learners to achieve new knowledge from new tools. They will take time with their learning tools or gadgets and discuss the topic within groups.(Brame,2013) The role of teachers is to help learners to understand the principles not just memorizing and also not just offering information. It was changed from whole class interaction into one-on-one interaction. (Wijarn Panich, 2013)

2.3 Engineering design

Engineering design is a part of education which combines science, technology, engineering and mathematics. It emphasizes on problem solving by using knowledge including the product development which will effects our work and living. Engineering design process is started with identifying problems then analyzing and creating tools to solve that problems.

3. Methodology

3.1 Constructivism Learning Environment Management System to Flipped Classroom Design

Table 1: Component of Constructivism Learning Environment Management System to Flipped Classroom Design

Principles and theories	Design principles	Example of design shot
1) Activating Cognitive Structure and Reading Comprehension	It was illustrated the relationship between theories and the components as follows: cognitive constructivism (Piaget, 1992); cognitive conflict, OLEs(Hannafin,1999),engineering design process has the following 6 steps : Problem identification, Related information search, Solution design, Planning and development, Testing, evaluation and design improvement , Presentation	

2) Supporting Cognitive Equilibrium and Reading Comprehension	It illustrates the relationship between theories and elements: constructivism (Piaget, 1992); OLEs (Hannafin, 1999), CLEs Model (Jonassen, 1999); Cognitive tools. The designing of the components was called Cognitive tools which to support their mission to solve complex problems. And Relate Case was supporting to encourages students personalize the experience to close the case and to expand the view to change the perception; Constructivist Constructivist (Vygotsky, 1978); Zones of similar development This element of design is called a collaboration tool to encourage students to share experiences between students, teachers, and experts in order to expand their perspectives.	
3) Supporting and Enhancement for Reading Comprehension	It was illustrated the relationship between theories and the components as follows: Social Constructivist (Vygotsky, 1978); zone of proximal development, OLEs(Hannafin,1999); conceptual, metacognitive, procedural and strategic scaffolding. The design of that element is called Providing instruction to learners by students to learn according to constructivist theory by emphasizing the teacher to be a coach rather than teaching or entering information for one-sided students Which holds support for the promotion of advice to learners for the mission to be accomplished.	

3.2 The Design Flipped classroom

Table 2: *An example of learning process in Flipped English reading comprehension Learning classroom adapted from Kanjug, I., Na-ngam, C. & Kanjug, P. (2017)*

Components	Description of learning process	Example of learning activity
Learning material : SOCIALClassnet		
Out of Class Knowledge acquisition)1) Problem base (2) Information resource, (3) Scaffolding	• The teacher explained how to use online learning. In SOCIALClassnet format Based on the Constructivism Learning Environment Management System	

Learning material : Teaching reading comprehension as an Active Learning		
In class Knowledge acquisition Knowledge Transfer)1) Problem base Knowledge Construction - Coaching - Collaboration Knowledge Reflection - Reflection	• Students answer questions online in the class. The teacher created the online quiz. In order to achieve the learning process in the classroom in the order of steps. • Students collaborated to learn and exchange ideas with members within the group. At the same time, the teacher will be a coach to provide guidance.	
Out of Class Knowledge sharing - Coaching - Collaboration	• The teacher is the supporter of the guidance while the student is in doubt. • Teacher and students share their knowledge, opinions, questions about problems that arise while carrying out classroom activities through social media such as Facebook, Twitter, SOCIALClassnet,etc.	

3.3 Pilot Study

3.3.1 Participant
• Experts 1)Content experts 2)Media and technology experts 3)Experts in learning environment design
• Target groups of Mathayom Suksa 1 students, Nong Waengwittaya School, Thailand, number 30

3.3.2 Research Instrument

Research tools are consists of

1) Experimental tools : learning environment in the setting of flipped classroom to encourage knowledge of engineering design in Design and Technology course

2) Tools for collecting data :
• Test for assessing learning achievement
• Test for assessing capability of engineering design
• Interviewing form for engineering design
• Learners' opinions survey

3.3.3 Data Collection and Analysis

1. Gathering information about constructivist conceptual framework, flipped classroom and engineering design
2. Synthesize the framework to uses as a basis of creating instructional media
3. Design and developing learning environment in the setting of flipped classroom and then proposed to experts for evaluation
4. Quantitative and qualitative data analysis
- Evaluating efficacy of learning environment using analytical study
- Statistics for assessing capability of engineering design using mean, standard deviation and percentage
- Test for assessing learning achievement using posttest
- Learners' opinions survey

4. Result and Discussion

Pre-test and Post-test of Mathayomsuksa 1 students had an average score of 10.10 points and 22.60 points, respectively. When comparing between before and after learning, it was found that the post-test scores of students were significantly higher than before learning. Statistical at the level of .05

t-test

Paired Samples Statistics

		Mean	N	Std. Deviation
Pair 1	Pre-test	10.10	30	2.06
	Posttest	22.60	30	3.06

Paired Samples Test

		Paired Differences			t	df	Sig.(2-tailed)	Sig.(1-tailed)
		Mean	Std. Deviation	Std. Error Mean				
Pair 1	Posttest - Pretest	12.50	2.81	0.51	24.3376	29	0.0000	0.0000

Figure 1. Result of Learning Achievement Evaluation Pre-test, Post-test and T-Test.

Pre-test and Post-test of Mathayomsuksa 1 students show average scores of 10.10 points and 22.60 points, respectively. Statistical analysis of learning achievement evaluation by using paired T-test shows significantly higher post-test scores with P-value less than 0.05. These results reflect that the students have gained more knowledge from classroom activities which reinforce their thinking process to solve problems.

According to the theory of constructivism, learners acquire knowledge by experiencing and getting through process of developing their wisdom by themselves (Ernst Von Glasersfeld, 1991). Constructivism theory emphasizes the developing of internal knowledge which relates to previous experiences (Kanjug, 2004). Learners should gather their perception together with understanding to create their own cognitive structure (Chaicharoen, 2011).

When combining with flipped classroom model, the environment of studying is changed from passive learning to active learning. The principles of this model is converting the teacher-driven pattern to student-centered learning (Noona et al., 2013) Flipped classroom is one of teaching strategies which stimulate active learning of learners. Teachers may play role in order to guide learners to apply their knowledge and build up their concept for solving problems (Kanjug, 2013). Not only memorizing theories or information, but understanding the concepts or main idea is the principle of flipped classroom (Panich, 2013).

This study introduces good combination of constructivist theory and flipped classroom model. Active learning by using new technologies or multimedia help learners to access to the world of knowledge easily, enhance their experience and finally acquire their intelligence.

5. Conclusion

This study is designed to evaluate the learning environment in the setting of flipped classroom to encourage engineering design in Design and Technology course for Mathayom 1 student. This could be benefit for improving learners capability of identifying problems, analyzing and creating methods for solving problems by themselves and also facilitating self-learning and gaining self-experiences.

References

Day, R., & Bamford, J. (2000). *Extensive reading in the second language classroom.* Cambridge: Cambridge University Press.

Hannafin, M.J., Hill, J.R., and Land, S.M. (1997). *Student centered learning and interactivemultimedia: Status, issues, and implications*. Contemporary Education, 68(2), 94–99.

Institute for the Promotion of Teaching Science and Technology (2017). *Teacher Manual for Science Technology (Design and Technology).* Promotionof Teaching Science and Technology, Ministry of Education,Thailand

Jonassen, D. H. (1999). *Designing constructivist learning environments.* In C.M. Reigeluth (Ed.), Instructional design theories and models:A new paradigm of instructional theory (pp.217- 239).Mahwah, NJ: Lawrence Erlbaum Associates,

Kanjug, I., Na-ngam, C.& Kanjug, P. (2017).*SOCIAL Classnet as an LMS for Online Flipped Learning Environment.* In Proceedings of the 6th IIAI International Congress on Advanced Applied Informatics (AAI 2017), Hamamatsu, Japan on July 9-13, 2017

Kanjug, I., Tijai, N. (2018). *Using Constructivism Learning Environment Management System to Flipped Classroom and Enhance an EFL'S English Reading Comprehension.* In Proceedings of the 26th International Conference on Computers in Education. Philippines : Asia-Pacific Society for Computers in Education.

Wijan Panit. (2012). *21st Century Learning Path for Disciples.* Bangkok. Sodsri – Saritwong   foundation. (in Thai)

An Investigation of Vocational Students' Attitude towards STEM Robotic Activities

Sasithorn CHOOKAEW[a*], Chaiyaporn SILAWATCHANANAI[b], Santi HUTAMARN[c], Supachai HOWIMANPORN[d] , Warin SOOTKANEUNG[e] & Charoenchai WONGWATKIT[f]
[a,b,c,d]*Department of Teacher Training in Mechanical Engineering,*
Faculty of Technical Education,
King Mongkut's University of Technology North Bangkok, Thailand
[e]*Department of Computer Engineering, Faculty of Engineering*
Rajamangala University of Technology Phra Nakhon, Bangkok
[f]*School of Information Technology, Mae Fah Luang, Chiang Rai, Thailand*
*sasithorn.c@fte.kmutnb.ac.th

Abstract: Engineering education is one of the most demanded topics in Thailand. With the traditional instruction, pre-service engineering teachers are not well promoted to learn actively. Based on this point of view, this study developed a series of active learning activities in corresponding to the Robotic based on STEM framework. This aims to help enhance students' understanding on the robotics, functionality, and applications. This study documented perceptions of STEM (science, technology, engineering and mathematics) content and careers for vocational students participating in STEM activities focused on industrial robotics. The analysis of the answers from 578 students in vocational education attended the activities and completed the questionnaires that showed the results showed that student's attitude after the activities were compared across gender groups (men=421, female=157). The finding of this study is not only fruitful for students, especially pre-service engineering teachers, but also shed light of the revolutionized teaching activities for other teachers in different fields. Since this is a very first implementation of the proposed framework, it requires more investigations and improvements in the future.

Keywords: STEM Robotics, vocational education, pre-service engineering teacher, engineering education

1. Introduction

The enhancement of effective vocational students has been a focus within the education system. One approach towards increasing engagement with STEM (science, technology, engineering and mathematics) is through the use of robotics in education. Robotic can acquire a students' imagination like no other learning materials by creating learning process to enjoy activities (Chookaew et al., 2018). Consequently, the students can learn programming via robot's behavior in various sequences and using intuitive, visual programming on a computer screen or other device (Ortiz, Franco, Garau, & Martin, 2016; Witherspoon, Higashi, Schunn, Baehr, & Shoop, 2017). Robotics based learning is considered as a powerful tool for motivating and training students based on STEM curriculum; therefore many studies and experiences that have been developed around the world over recent years (Castro et al., 2018; Spolaôr & Benitti, 2017; Witherspoon et al., 2017). Additionally, many studies proposed robotic to support students' performance with engineering process by industrial need (Vitale, Bonarini, Matteucci, & Bascetta, 2016). However, there is still no study on a robotic based STEM framework for the vocational students, especially their attitudes towards using the industrial robots that may impact the success of learning process.

In response, our activities use active learning to foster a range of important skills across the core STEM subjects. Finally, our study investigated the students' attitude toward STEM Robotic activities. This study was guided by the question:

- How does the STEM robotics activity influence vocational students' attitude?
- What are student learning perceptions on the STEM robotics activities?

2. Related Study

2.1 STEM Robotic

The current research has been interested using robotic for learning in science, technology, engineering, and mathematics (STEM). Many educators approach work with students through STEM robotics activity that provides a very abundance and attractive learning environment and influence on students' motivation about learning science and technology for STEM education (Barak & Assal, 2018), while some study proposed the practical ways to help teachers how to design and implement STEM concept using robotics activity to enhance student learning (Jaipal-Jamani & Angeli, 2017; Kim et al., 2015).

Researchers have attempted to use the benefit of robotic in order to motivate the inspiring vocational students to interest between STEM learning, real life and industry. An articulated robot and mobile robot were used to illustrate the work for vocational students because they are most commonly in use in factories worldwide. Therefore, the vocational students should know and understand related that use in an industrial system.

2.2 Vocational education in Thailand

Thailand education system has been formal vocational and technical education is conducted at three levels: upper secondary, post-secondary (a diploma or vocational associate degree) and university level (degree). The government of Thailand has been endeavoring to enhance vocational students' performance with reforms are currently being implemented to remodel the system towards a Thai vocational qualification based upon industrial practices and needs. There for the big project is the Eastern Economic Corridor (EEC) that focused on improving vocational educational measures to help curb the skilled labor shortages three eastern provinces where the EEC project is located including Rayong, Chonburi, and Chachoengsao (https://www.eeco.or.th/en). Thailand has been using robotics and automation technology and existed large-scale mass production systems. Thus, robotics and automation are important topic to learn for vocational student.
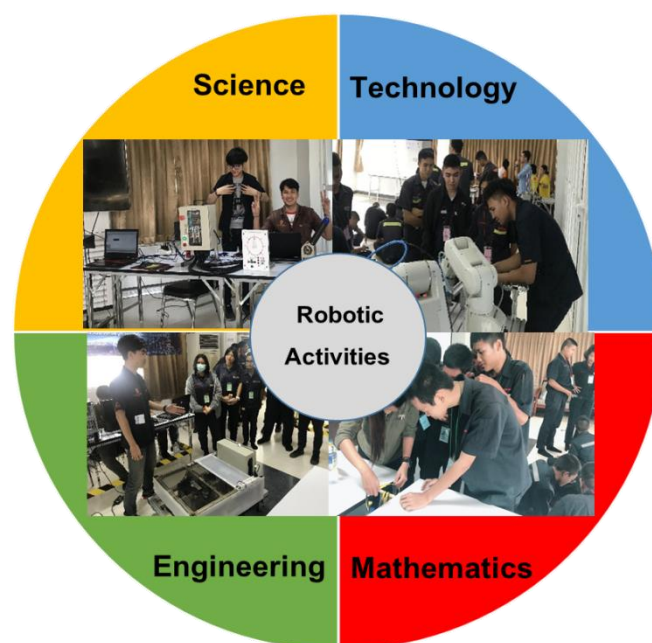

Figure 1. An Overall Structure of STEM robotic activities

3. Methodology

3.1 Participants

Participants in this study were 578 vocational students who were studying diploma program at vocational colleges in three eastern provinces of Thailand where the EEC project is located including Rayong, Chonburi, and Chachoengsao provinces. Among them, 157 vocational students were females and 521 students were males. They ranged in age from 18 to 21. Students attended "Preparing students' performance of STEM robotic toward EEC Project" for one day (7 hours).

3.2 Instrumentation

In this study, we used an online questionnaire to assess students' attitude toward STEM Robotic activities. The questionnaire includes four dimensions (engagement, motivation, awareness, and satisfaction), a total of 12 items. Internal consistency reliabilities for the five scales of the STEM Robotic attitude survey was 0.927.

3.3 Experimental Procedure

In this study we develop the learning activities with Robotic based on STEM framework. The activities focus on promoting students' understanding through active learning consisting of 4 sections:

Section 1 Basic of Robot: This section has explained a servo motor that is a rotary actuator that allows for precise control of angular position, velocity and acceleration in many places such model car robots. This section focusses on students' understanding of how a servo motor works and is applied in the robot. They have described via presentation with concept map, see Figure1 (a).

Section 2 Mobile Robot: Mobile robots have the capability to move and remove belongings. In addition, robot shown the performance of detect and automatically avoid obstacles, see Figure1 (b).

Section 3 Robot Arm: This section has showed an articulated robot system that used in an automotive industry robotics, especially welding robots. This type of robot is the number one imported robot in ASEAN region, see Figure1 (c).

Section 4 STEM Connection: This section has showed the activities for connecting between science and mathematics subject to create technology and engineering work. The proposed activities can help improve students' understanding on the relationship between force, mass, and acceleration, see Figure 1 (d).

(a)

(b)

(c)

(d)

Figure 2. The learning activities each section

4. Results

In order to analyze data how vocational students' attitude towards STEM robotic activities, we have described the gender gap in science, technology, engineering, and math (STEM) engagement is significantly larger in technological fields (Master et al., 2017). Paired sample t-tests was used to analyze the difference vocational students' attitude between men and female that shown in Table 1.

Table 1

The questionnaire

Items	Male = 421 M $\pm$SD	Female = 157 M $\pm$SD	t	p
Motivation				
Q1: I like to engage in STEM robotic activities.	4.22$\pm$0.90	4.04$\pm$0.84	2.07	0.03*
Q2: I am interested to learn related STEM subject more.	4.27$\pm$0.81	4.07$\pm$0.77	2.65	0.00*
Q3: I understand about STEM Robot activities.	4.31$\pm$0.80	4.06$\pm$0.74	3.37	0.00*
Q4: I think STEM Robot activity make your inspiration to study related Science and Engineering.	4.32$\pm$0.82	4.29$\pm$0.76	0.33	0.73
Q5: I want to learn in deep concept related Science, Technology, Engineering and Mathematics more.	4.28$\pm$0.82	4.17$\pm$0.77	1.53	0.12
Awareness				
Q6: I would like to be scientist or engineer in the future.	4.12$\pm$0.89	4.01$\pm$0.90	1.26	0.20
Q7: I think that everything is Science, Technology, Engineering and Mathematics.	4.26$\pm$0.82	4.17$\pm$0.84	1.12	0.25
Q8: I can connect the Science Mathematics subject to create Technology and Engineering.	4.11$\pm$0.89	3.91$\pm$0.88	2.41	0.01*
Q9: I aware that Science, Technology, Engineering and Mathematics are the part of important daily routine.	4.24$\pm$0.81	4.07$\pm$0.79	2.25	0.02
Satisfaction				
Q10: I enjoy learning Science, Technology, Engineering and Mathematics.	4.28$\pm$0.85	4.15$\pm$0.86	1.53	0.12
Q11: I am satisfied with STEM robotic activities.	4.38$\pm$0.79	4.25$\pm$0.82	1.64	0.10
Q12: I would like to participate another STEM robotic activities.	4.36$\pm$0.81	4.24$\pm$0.81	1.64	0.09

*$p<0.05$

Based on this result, it can be implied that the proposed STEM robotic activities for vocational students.

5. Conclusion

With the drawbacks of traditional engineering education, this study developed a series of active learning activities to help promote pre-service engineering teachers' understanding by incorporating with Robotic based on STEM framework. This is to help students be readier and more comprehensive of how the robotics work and how they can be applied in the real industries. After experiencing four sections of the proposed learning activities, students both male and female have revealed positive attitudes toward the proposed learning framework on different dimensions, including learning motivation, awareness, and satisfaction.

However, based on this very first implementation of the proposed Robotic based on STEM framework, it still remains some limitations that can be further improved in the future, also requires more investigations. For example, the activities can be provided differently to different groups of learners based on their learning performance or learning interest. Besides, there should be a guideline for the teachers to follow as a learning facilitator. This can significantly boost the learning environment

more fruitful and lively; in the meantime, they can naturally understand the learning phenomena both positive and negative in order to improve later. Regarding the finding of this study, it has a generalization issue due to the implementation on the certain group of samples. In the future, a comparison study between groups of samples, experiments or interventions can enhance the impact of this finding. Several recommendations for applying robotic activity are presented. The teachers are required to put more teaching effort on engaging students in the hands-on activity that can increase their attention and learning experiences; furthermore, these tasks can help enhance positive attitude for all students.

References

Barak, M., & Assal, M. (2018). Robotics and STEM learning: Students' achievements in assignments according to the P3 Task Taxonomy—practice, problem solving, and projects. International Journal of Technology and Design Education, 28(1), 121-144.

Castro, E., Cecchi, F., Salvini, P., Valente, M., Buselli, E., Menichetti, L., & Dario, P. (2018). Design and impact of a teacher training course, and attitude change concerning educational robotics. International Journal of Social Robotics, 1-17.

Chookaew, S., Howimanporn, S., Pratumsuwan, P., Hutamarn, S., Sootkaneung, W., & Wongwatkit, C. (2018). Enhancing High-School Students' Computational Thinking with Educational Robotics Learning. Paper presented at the 2018 7th International Congress on Advanced Applied Informatics (IIAI-AAI).

Jaipal-Jamani, K., & Angeli, C. (2017). Effect of robotics on elementary preservice teachers' self-efficacy, science learning, and computational thinking. Journal of Science Education and Technology, 26(2), 175-192.

Kim, C., Kim, D., Yuan, J., Hill, R. B., Doshi, P., & Thai, C. N. (2015). Robotics to promote elementary education pre-service teachers' STEM engagement, learning, and teaching. Computers & Education, 91, 14-31.

Master, A., Cheryan, S., Moscatelli, A., & Meltzoff, A. N. (2017). Programming experience promotes higher STEM motivation among first-grade girls. Journal of experimental child psychology, 160, 92-106.

Ortiz, O. O., Franco, J. A. P., Garau, P. M. A., & Martin, R. H. (2016). Innovative mobile robot method: improving the learning of programming languages in engineering degrees. IEEE Transactions on Education, 60(2), 143-148.

Spolaôr, N., & Benitti, F. B. V. (2017). Robotics applications grounded in learning theories on tertiary education: A systematic review. Computers & Education, 112, 97-107.

Vitale, G., Bonarini, A., Matteucci, M., & Bascetta, L. (2016). Toward Vocational Robotics: An Experience in Post-Secondary School Education and Job Training Through Robotics. IEEE Robotics & Automation Magazine, 23(4), 73-81.

Witherspoon, E. B., Higashi, R. M., Schunn, C. D., Baehr, E. C., & Shoop, R. (2017). Developing computational thinking through a virtual robotics programming curriculum. ACM Transactions on Computing Education (TOCE), 18(1), 4.

An Online Personalized Learning System with Ongoing Learning Experience Adaptation: A Prototype System for STEM Discipline

Charoenchai WONGWATKIT[a,b]*, Patcharin PANJABUREE[c] & Sasithorn CHOOKAEW[d]
[a]*School of Information Technology, Mae Fah Luang University, Thailand*
[b]*Innovation for Quality of Life Development with Information Technology Research Group, Mae Fah Luang University, Thailand*
[c]*Institute for Innovative Learning, Mahidol University, Thailand*
[d]*Department of Teacher Training in Mechanical Engineering, Faculty of Technical Education, King Mongkut's University of Technology North Bangkok, Thailand*
*wongwatkit.c@gmail.com

Abstract: In personalized learning systems, personal information and learning information are usually analyzed for providing proper instruction for individuals. On the other hand, scholars have indicated the challenge of proposing models owing the lack of taking various data types into account. Several previous studies have indicated that without properly incorporating learning behavior into the personalized learning systems might fail to help students learn with proper learning process. To address this issue, this study proposes a model for analyzing ongoing learning data and adapting personalized learning experience. Besides, this study presents an overall structure of a personalized learning system that can work with the proposed mechanism. In comparison with other models, the proposed model performed the best with high accuracy; consequently, it can be deployed in the presented learning system. The findings of this study not only address the significance of ongoing learning experience in the personalized learning system but also enable a practical example to increase learning motivation in the online learning world, in particular STEM-related courses.

Keywords: Educational data mining, artificial intelligence in education, applications for STEM education

1. Introduction

Learning experience is recognized by scholars as a significance component of learning. In online learning environment, ongoing learning experience plays a crucial role in learning success. Not only the students have strong determination and learning discipline, but also the systems must respond to their learning capability in order to drive learning motivation continuously and give them positive in learning attitude (Fonseca, Martí, Redondo, Navarro, & Sánchez, 2014; Rosenberg, 2001). To avoid dropout rate in online learning, scholars have suggested preparing learning experience in order to respond with dynamic change of individual's capability (Panjaburee, Triampo, Hwang, Chuedoung, & Triampo, 2013; Chookaew, Wanichsan, Hwang, & Panjaburee, 2015; Srisawasdi & Panjaburee, 2015; Kuo, Tsai, & Wang, 2017; Wongwatkit, Srisawasdi, Hwang, & Panjaburee, 2017). Even though the existing personalized learning systems have an adaptive feature, the analysis of students characteristics is performed before actual learning as well as learning recommendation system (Hung, Chang, & Lin, 2016; Hwang, Chu, & Yin, 2017). This has some limitations in taking ongoing learning data and students' capability into account of making learning adaptation because there are a large amount of data and different data in the different learning units.

To address these shortcomings, this study proposes a mechanism for adapting ongoing learning experience based on educational data mining technique. The proposed mechanism can take the learning data to learn and eventually to develop an algorithm to be deployed in the personalized learning environment. The results of this study shed light of enhancing the learning experience and quality of

students, and research advancement in the personalized learning environment, in particular an application of this system on STEM-related courses. This study was directed with two objectives: 1) to propose a mechanism for ongoing learning experience adaptation, and 2) to present an overall structure of the personalized learning system that can work with the proposed mechanism.

2. Related Study

2.1 Educational Data Mining and Methodology

Educational Data Mining (EDM) is a method to find insights of data in different perspectives of education, including policy, operation, and learning (Dutt, Ismail, & Herawan, 2017). Regarding policy, EDM can help analyze data from different departments/functions in institutions for amending policy or strategy in responding with current need or situation. In operation, EDM can take data of personnel, students, and classrooms in providing the trend or reducing the process. Moreover, in learning, EDM can use data generated during the learning process to analyze and segment students by their performance or to predict a trend of students who are likely to fail (Calvet Liñán & Juan Pérez, 2015; Guruler & Istanbullu, 2014). It is certain that data mining is very beneficial in various perspectives of education.

One of the well-known techniques in EDM is machine learning. It is the learning of machine or computer by learning from the historical data to analyze and find the pattern, trend or association, and explain the phenomena, or predict the possibility of the new data. Machine learning can be categorized in three groups. 1) clustering: it can cluster or segment data by similar characteristic (unsupervised learning), e.g., K-Means clustering, EM Clustering, Affinity Propagation, 2) classification: it can learn from a big data with identified class/answer (supervised learning) and develop a model/algorithm to predict the answer of unknown data, e.g., kNN, Naïve Bayes, SVM, Decision Tree, Random Forest, Deep Learning, and 3) association: it can analyze for the relationship among data that meet the condition set. However, different techniques have different process of preparing data and the results can be different. It is necessary to evaluate their performance with suggested metrics (Baradwaj & Pal, 2012; Jamal et al., 2016; Vaessen et al., 2014).

In the past ten years, many studies have applied EDM in different domains: 1) students' performance prediction. For example, evaluating students' performance from end-semester examination in university (Baradwaj & Pal, 2012), predicting academic achievement at the end of program (Asif, Merceron, Ali, & Haider, 2017), and final performance prediction based on participation (Xing, Guo, Petakovic, & Goggins, 2015), 2) Early prediction of academic failure, e.g., detect failure in computer course (Costa, Fonseca, Santana, de Araújo, & Rego, 2017), and 3) completion rate, e.g., predicting completion rate from discussion forum in language course on MOOCs (Crossley et al., 2015). Moreover, many researches applied EDM in adaptive and interactive learning platforms (Colchester, Hagras, Alghazzawi, & Aldabbagh, 2017; Bannert, Molenar, Azevedo, Järvelä, & Gašević, 2017; Udupi, Sharma, & Jha, 2016). In this study, EDM process is used as a method in developing a classification model for analyzing the learning experience.

2.2 Personalized Learning System and Ongoing Learning Experience

Personalized learning system is the online learning system that consider the students' data into analysis for adapting and recommending the learning activities for individual students. This system can help improve learning motivation, which plays an important role in better learning performance (Nedungadi & Raman, 2012). There are three types of students' data used in the system. 1) Personal data, e.g., gender, age, personality, 2) learning background, e.g., pre-test score, exercise results, and 3) learning preference, e.g., learning style, learning format, learning feedback. Some systems integrate this data for enhancement, called learning profile (Hwang, Sung, Hung, & Huang, 2013). Besides, the learning strategy behind this system can be different, e.g., formative assessment, inquiry learning, collaborative learning or game-based learning, which can be applied in different learning topics that require more learning motivation (Srisawasdi & Panjaburee, 2015).

In the past years, learning data generated while learning is considered important for personalized learning system since each student can have different learning experience (Wongwatkit &

Prommool, 2018) and different patterns. Learning intention can consider from duration of learning, doing exercises, taking exams. Learning performance or capability is widely used as it is easy to assess and calculate (Fonseca et al., 2014). Next is the learning sequence, which can be used as learning behavior. More importantly, learning interaction is quite difficult in storing as it has more complexity for analysis, and different in formats, e.g., scrolling the mouse, pinching on the mobile, eye blinking (Wongta et al., 2016). To say, such data is very beneficial in making learning more meaningful, since they are the real learning experience of the students.

In the past decade, there is a range of research studies related to adaptive/personalized learning. For example, many studies on taking students' scores or students' characteristics, e.g., gender, age to analyze and present learning recommendation (Sasithorn Chookaew, Panjaburee, Wanichsan, & Laosinchai, 2014; Wongwatkit, Chookaew, Chaturarat, & Khrutthaka, 2017). Findings show that personalized learning system can enhance students' learning motivation, learning attitudes (Wang & Liao, 2011). Also, several studies considered learning behavior during the learning process by adopting learning analytics (G.-J. Hwang, Kuo, Yin, & Chuang, 2010; G. J. Hwang et al., 2017).

3. Overview of Online Personalized Learning System

In this section, the overview of an online personalized learning system is presented hereinafter called OPLS. This system is designed to work with the proposed mechanism (to be presented in the next section) to analyze and adapt the ongoing learning experience for individual students based on their learning behavior and capability during the learning process. In other words, the system can monitor and adapt the treatment upon the ongoing results. Moreover, the system gives personalized guideline and learning feedback to students.

The overall structure of OPLS is shown in Figure 1. The student firstly received the pre-learning diagnostics and recommended learning chapters with Learning Diagnostics and Recommendation Module. After that, the student enters the learning chapters from Learning Module. Note that the solid square is recommended chapter, while the square with a regular line is open to learning. In each chapter, there are several learning units, as shown in circles, associated with learning objectives. The learning unit requires the student to think, relate the experience, and give responses via Prompt & Feedback. The student can select any unit to learn. Based on learning experience in the learned unit, the Learning Experience Adaptation (LEA) Module will analyze and present the appropriate learning experience for the units remained (the solid circle is recommended). For example, if the student learned U_j as a first unit after LEA analyzed, U_i and U_k may have a different learning experience, but still, keep learning smooth and connected with the previously learned units. To say, the ongoing learning experience has been personally adapted.
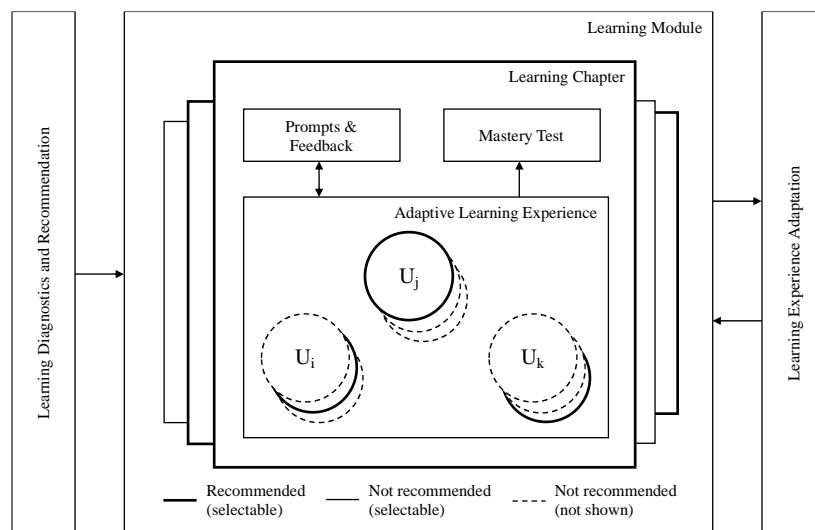

Figure 1. Overall system structure.

The topic implemented in this study is the secondary school's digital literacy, following the standard curriculum of the country. It emphasizes a variety of threats on computer and internet, how to

protect and solve the problems that occurred. Also, media and information literacy are highlighted as they are related to different platforms, ranging from social media, game, web, and mobile application. In addition, cyberbullying is included. The students can learn these lessons interactively, while the materials and activities were designed with experiential learning storytelling, visual/motion graphic representations, in concerning mobile responsive UI and UX concepts. The highlights of this system are that the students not only get the recommendation and experience adapted for them but also have the freedom to learn, via mobile devices without any installation.

4. Ongoing Learning Experience Adaptation

In this section, a mechanism of LEA module in OPLS and its development following data mining process are discussed. The result of this mechanism development is a classification model for analyzing and adapting ongoing learning experience.

As illustrated in Figure 2, the LEA mechanism starts from considering ongoing learning experience of individual students, from interactive learning media and materials with storytelling, questions and prompts during the learning process, and constructive feedback. Such data generated during the learning process, including learning duration, learning capability, interaction with feedback, is stored as input data for the developed classification model (algorithm), while the output is the recommendation to adjust the ongoing learning experience of the following learning units.
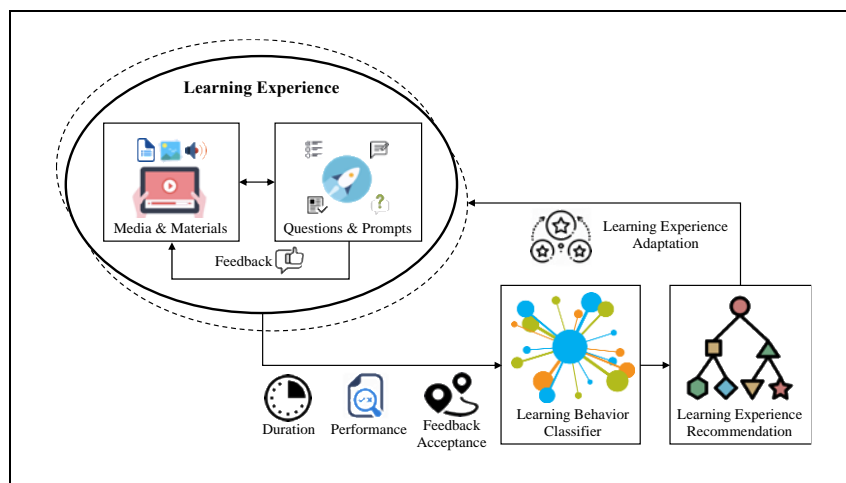

Figure 2. Overview of learning experience adaptation.

In the following topics, the classification model (algorithm) used in LEA will be developed following the data mining process.

4.1 Problem Definition and Data Acquisition

In this very first step, it needs to define the purpose/problem for the mining; moreover, it needs to determine what and how data can be acquired. The reasons to conduct this process are that there are many variables (attributes) that affect the analysis of learning experience, e.g., the duration used in each learning page, the responses given to the prompts, and the interactions with the presented feedback. Such data is different and significant in amount, which makes it challenging to analyze.

In addition to that, the data used in this mining is from the learning logs of students during three weeks from the OPLS prototype version. The total 253 data records are stored in JSON via real-time NoSQL database, as shown in Figure 3, while the students' profiles are variety in gender, age, mobile experience, and digital literacy, as summarized in Table 1. The target data consists of 25 attributes from one learning unit and one attribute from the literacy test.
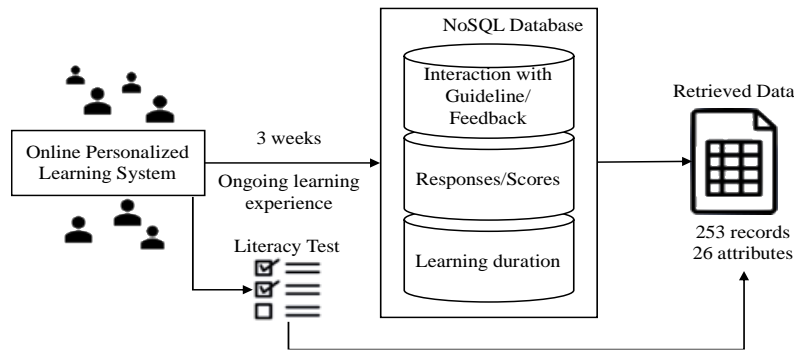
Figure 3. Data acquisition process.

Table 1

Statistical Data of Students' Profile

Variables	Male (N = 119)				Female (N = 134)			
	Min	Max	Mean	SD	Min	Max	Mean	SD
Age (years)	10.42	15.59	12.79	0.77	10.19	15.10	12.32	1.35
Mobile experience (years)	1.00	7.12	4.35	1.45	0.70	6.96	3.74	0.71
Literacy test (score = 10)	2.00	10.00	3.98	1.76	0.00	8.00	3.16	1.45

4.2 Data Preparation and Transformation

Once data was acquired, the next two steps are essential in preparing data, including data preprocessing and data transformation. This was operated on Jupyter Notebook in Anaconda Navigator environment with Python language and Pandas, Seaborn and Scikit-learn libraries.

This first step is to improve quality of data with data cleansing. Some data records were found duplicated, e.g. records from the same student. Hence, they were deleted. Some data values were missing, e.g., no responses from some prompts. Mean replacement was then used. Some attributes were categorical data, e.g., true-false questions, yes-no feedback acceptance. Therefore, such data was encoded to be numerical with One-HOT Encoding technique.

Here comes to the second step, after the data has been preprocessed. Data values in each attribute have different scales, which affect the weight for developing classifier; therefore, it is necessary to rescale into the same range (0-1) with normalization method. This transformed data is formatted as CSV, which can be used later.

4.3 Data Modelling and Evaluation

In this project, a classification model was developed with Rapid Miner Educational Edition by splitting 253 data records for 70% training data and 30% testing data with the stratified sampling method. At this point, all attributes were labeled features (total = 25 features), and one attribute (digital literacy level) was labeled as a class. This class was categorized from the score as follows: 0.00-5.59: low (3), 6.00-7.99: med (2), 8.00-10.00: high (1). The classification models developed in this paper consists of Naïve Bayes, Decision Tree, Deep Learning, Random Forest, while the performance of each model is evaluated and presented in the next section.

Based on the developed models (algorithms), the evaluation results are concluded in Table 2. It was found that Deep Learning algorithm has the best Precision, F Measure, and Accuracy, while Decision Tree gains the highest Recall.

Table 2

Result of Classification Models

Models	Precision	Recall	F Measure	Accuracy
Naïve Bayes	87.4	41.7	55.4	65.2
Deep Learning	91.5	69.8	81.4	83.6
Decision Tree	62.5	82.1	68.8	62.4
Random Forest	83.5	68.2	76.5	17.4

The selected algorithm, Deep Learning, from this study can be deployed in the proposed ongoing learning experience adaptation for analyzing the ongoing learning data generated by individual students, including duration, learning capability, and interaction. The mechanism can eventually adapt the individual students' ongoing learning experience.

5. Discussion and Conclusion

This research study aims at proposing the mechanism for analyzing a large amount of learning data generated while learning process from individual students on the online personalized learning system, and adapting the ongoing learning experience accordingly. The classification model developed for the proposed mechanism was performed following the data mining process. The result shows that Deep Learning algorithm gives the best result in terms of accuracy and precision. It was optimal to be deployed in the system later. Besides that, this paper presented an overall structure of the online personalized learning system that works with the proposed mechanism.

Furthermore, the methodology used in this study was in the positive agreement with educational data mining process as it can help enhance the possibility and performance of online learning (Dutt et al., 2017). Moreover, it can find insights from the big data and develop a model to making decision or prediction for the benefits of learning. In the meantime, the performance of Deep Learning algorithm was the best among other models, which was also aligned with many studies owing to the fact that Decision Tree has a limitation in dealing with irrelevant features, Naïve Bayes is suitable for handling multiple classes, whereas Random Forest spends more runtime (Ahmad, Farman, & Jan, 2019; Tan, Steinbach, & Kumar, 2006).

However, this research study remains several limitations. The validation process of the fixed data of training data and testing data should be avoided, where the k-fold cross-validation technique can be used to address this point (Wong, 2015). The performance of the system environment should be examined when the model has been deployed, including speed/time/performance. Moreover, the algorithm developed in this project cannot be used with other learning lessons since it was trained and tested with the data acquired from that lesson. Different lessons can give different learning experience to the students. This project needs more works and investigations to be done in the future. It is interested in extending the capability of the developed model by considering more valid/possible features. More algorithms are needed for other different lessons. The model should be implemented into the learning system, where making API service can be considered for other subjects/platforms. Also, more investigations on the effects of learning motivation, attitudes, and learning performance are necessary.

In addition to that, the proposed system can be applied in STEM-related courses (Özyurt & Özyurt, 2015; Srisawasdi & Panjaburee, 2015). For example, the system can support learning sciences to provide more meaningful activities in a wide range of topics, e.g., chemical reaction, human anatomy, force, and gravity (Srisawasdi & Panjaburee, 2019). The applications of this system can cover those in computer and technology topics, such as basic programming, digital literacy and game development, by automatically tracking the learning and provide relevant learning experience (Wongwatkit et al., 2017). Moreover, this system can be more beneficial when applied with the topics in engineering and mathematics through the active learning process, inquiry-based learning, or experiential learning (Panjaburee & Srisawasdi, 2016; Srisawasdi & Panjaburee, 2014). Having the students learn by experiment and improve upon, the proposed system can facilitate the corresponding adaptive experience.

Acknowledgements

References

Ahmad, J., Farman, H., & Jan, Z. (2019). Deep learning methods and applications. In Deep Learning: Convergence to Big Data Analytics (pp. 31-42). Springer, Singapore.

Asif, R., Merceron, A., Ali, S. A., & Haider, N. G. (2017). Analyzing undergraduate students' performance using educational data mining. *Computers & Education*, *113*, 177–194.

Bannert, M., Molenar, I., Azevedo, R., Järvelä, S., & Gašević, D. (2017). Relevance of learning analytics to measure and support students' learning in adaptive educational technologies. In *Proceedings of the Seventh International Learning Analytics & Knowledge Conference on - LAK '17* (pp. 568–569). New York, New York, USA: ACM Press.

Baradwaj, B. K., & Pal, S. (2012). Mining Educational Data to Analyze Students' Performance.

Liñán, L. C., & Pérez, Á. A. J. (2015). Educational Data Mining and Learning Analytics: differences, similarities, and time evolution. *International Journal of Educational Technology in Higher Education, 12*(3), 98-112.

Castro R., L. F., Espitia P., E., & Montilla, A. F. (2018). Applying CRISP-DM in a KDD Process for the Analysis of Student Attrition (pp. 386–401). Springer, Cham.

Chookaew, S., Panjaburee, P., Wanichsan, D., & Laosinchai, P. (2014). A Personalized E-Learning Environment to Promote Student's Conceptual Learning on Basic Computer Programming. *Procedia - Social and Behavioral Sciences*, *116*, 815–819.

Chookaew, S., Wanichsan, D., Hwang, G. J., & Panjaburee, P. (2015). Effects of a personalised ubiquitous learning support system on university students' learning performance and attitudes in computer-programming courses. *International Journal of Mobile Learning and Organisation*, *9*(3), 240–257.

Colchester, K., Hagras, H., Alghazzawi, D., & Aldabbagh, G. (2017). A Survey of Artificial Intelligence Techniques Employed for Adaptive Educational Systems within E-Learning Platforms, *Journal of Artificial Intelligence and Soft Computing Research, 7*(1), 47-64.

Costa, E. B., Fonseca, B., Santana, M. A., de Araújo, F. F., & Rego, J. (2017). Evaluating the effectiveness of educational data mining techniques for early prediction of students' academic failure in introductory programming courses. *Computers in Human Behavior*, *73*, 247–256.

Crossley, S., McNamara, D. S., Baker, R., Wang, Y., Paquette, L., Barnes, T., & Bergner, Y. (2015). Language to Completion: Success in an Educational Data Mining Massive Open Online Class. *International Educational Data Mining Society*.

Data Mining | Occupant Behavior Research at LBNL BTUS. (n.d.). Retrieved May 20, 2019, from https://behavior.lbl.gov/?q=node/11

Dutt, A., Ismail, M. A., & Herawan, T. (2017). A Systematic Review on Educational Data Mining. *IEEE Access*, *5*, 15991–16005.

Fonseca, D., Martí, N., Redondo, E., Navarro, I., & Sánchez, A. (2014). Relationship between student profile, tool use, participation, and academic performance with the use of Augmented Reality technology for visualized architecture models. *Computers in Human Behavior*, *31*(1), 434–445.

Guruler, H., & Istanbullu, A. (2014). Educational Data Mining. *Studies in Computational Intelligence*, *524*(February 2016), 105–124.

Hung, Y. H., Chang, R. I., & Lin, C. F. (2016). Hybrid learning style identification and developing adaptive problem-solving learning activities. *Computers in Human Behavior*, *55*, *Part A*, 552–561.

Hwang, G. J., Chu, H. C., & Yin, C. (2017). Objectives, methodologies and research issues of learning analytics. *Interactive Learning Environments*, *25*(2), 143–146.

Hwang, G.-J., Kuo, F.-R., Yin, P.-Y., & Chuang, K.-H. (2010). A Heuristic Algorithm for planning personalized learning paths for context-aware ubiquitous learning. *Computers & Education*, *54*(2), 404–415.

Hwang, G., Sung, H., Hung, C., & Huang, I. (2013). A learning style perspective to investigate the necessity of developing adaptive learning systems. *Educational Technology and Society*, *16*(2), 188–197.

Kuo, T. M. L., Tsai, C. C., & Wang, J. C. (2017). Why Learners Fail in MOOCs? Investigating the Interplay of Online Academic Hardiness and Learning Engagement among MOOCs Learners. *25th International Conference on Computers in Education*, 216–221.

Nedungadi, P., & Raman, R. (2012). A new approach to personalization: integrating e-learning and m-learning. *Educational Technology Research and Development, 60*(4), 659-678.

Osei-Bryson, K. M., & Barclay, C. (Eds.). (2015). *Knowledge Discovery Process and Methods to Enhance Organizational Performance*. CRC Press.

Özyurt, Ö., & Özyurt, H. (2015). Learning style based individualized adaptive e-learning environments: Content analysis of the articles published from 2005 to 2014. *Computers in Human Behavior*, *52*, 349–358.

Panjaburee, P., & Srisawasdi, N. (2016). An integrated learning styles and scientific investigation-based personalized web approach: a result on conceptual learning achievements and perceptions of high school students. *Journal of Computers in Education, 3*(3), 253-272.

Panjaburee, P., Triampo, W., Hwang, G.-J., Chuedoung, M., & Triampo, D. (2013). Development of a diagnostic and remedial learning system based on an enhanced concept–effect model. *Innovations in Education and Teaching International*, *50*(1), 72–84.

Rosenberg, M. J. (2001). *E-learning: Strategies for delivering knowledge in the digital age* (Vol. 9). McGraw-Hill New York.

Srisawasdi, N., & Panjaburee, P. (2014). Technology-enhanced Learning in Science, Technology, and Mathematics Education: Results on Supporting Student Learning. *Procedia - Social and Behavioral Sciences*, *116*, 946–950.

Srisawasdi, N., & Panjaburee, P. (2015). Exploring effectiveness of simulation-based inquiry learning in science with integration of formative assessment. *Journal of Computers in Education*, *2*(3), 323–352.

Srisawasdi, N., & Panjaburee, P. (2019). Implementation of Game-transformed Inquiry-based Learning to Promote the Understanding of and Motivation to Learn Chemistry. *Journal of Science Education and Technology, 28*(2), 152-164.

Tan, P. N., Steinbach, M., & Kumar, V. (2006). Classification: basic concepts, decision trees, and model evaluation. *Introduction to data mining, 1*, 145-205.

Udupi, P. K., Sharma, N., & Jha, S. K. (2016). Educational data mining and big data framework for e-learning environment. In *2016 5th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO)* (pp. 258–261). IEEE.

Wang, Y.-H., & Liao, H.-C. (2011). Adaptive learning for ESL based on computation. *British Journal of Educational Technology*, *42*(1), 66–87.

Wong, T. T. (2015). Performance evaluation of classification algorithms by k-fold and leave-one-out cross validation. *Pattern Recognition, 48*(9), 2839-2846.

Wongta, J., Wongwatkit, C., Boonkerd, J., Chaikajornwat, R., Maeprasart, V., & Khrutthaka, C. (2016). Enhancing Course Timetable Management in Science Classrooms with User-oriented Mobile Application : Analysis and Prototype Development on KMUTT-ESC Case Study. In *The 24th International Conference on Computers in Education* (pp. 325–334). Mumbai, India: Asia-Pacific Society for Computers in Education.

Wongwatkit, C., & Prommool, P. (2018). Analysing Ongoing Learning Experience with Educational Data Mining for Interactive Learning Environments. In *The 6th Global Wireless Summit*. Chiang Rai, Thailand.

Wongwatkit, C., Che-leah, M., Chookaew, S., Wongta, J., Yachulawetkunakorn, C., & Na Phatthalung, R. (2017). Sufficiency Economy Philosophy-Based Interactive Mobile Game Application to Promoting Sustainability Understanding based on Inquiry Learning with Everyday Life Activities. In *The 25th International Conference on Computers in Education* (pp. 774–783). Christchurch, New Zealand: Asia-Pacific Society for Computers in Education.

Wongwatkit, C., Chookaew, S., Chaturarat, K., & Khrutthaka, C. (2017). An Interactive Story-based Mobile Game Application to Diagnosing Learning Style and Learning Suggestion based on ILS: Development and Evaluation of The AdventureHero Game. In *2017 6th IIAI International Congress on Advanced Applied Informatics* (pp. 785-790). Hamamatsu, Japan.

Wongwatkit, C., Srisawasdi, N., Hwang, G., & Panjaburee, P. (2017). Influence of an integrated learning diagnosis and formative assessment-based personalized web learning approach on students learning performances and perceptions. *Interactive Learning Environments*, *25*(7), 889–903.

Xing, W., Guo, R., Petakovic, E., & Goggins, S. (2015). Participation-based student final performance prediction model through interpretable Genetic Programming: Integrating learning analytics, educational data mining and theory. *Computers in Human Behavior*, *47*, 168–181.

Probing Digital Game-Based Science Learning Experience through Eye-Tracking

Bo-Yuan CHENG[a], Hung-Yuan WANG[b], Chung-Yuan HSU[a*], Guo-Li CHIOU[c] &
Meng-Jung TSAI[c]
[a]*Department of Child Care, National Pingtung University of Science and Technology, Taiwan*
[b]*Kaohsiung Municipal Fushan Elementary School, Taiwan*
[c]*Program of Learning Sciences, National Taiwan Normal University, Taiwan*
*jackohio@mail.npust.edu.tw

Abstract: This study aimed to investigate the role the students' prior knowledge in their visual attention and behavioral patterns while playing a digital game. The participants were 39 fourth graders from an elementary school in the southern part of Taiwan. The Tobii 4C Eye Tracker (with a sampling rate of 90Hz) was utilized to track the students' visual attention while they were playing the game. In addition, the lag sequential analyses were conducted to examine the visual transitional patterns of the participants with different levels of prior knowledge. The results of this study showed that students with the lower level of prior knowledge tended to put more mental effort on the trivial information of the game. In contrast, the participants with the higher level of prior knowledge were more likely to employ more effective gameplaying strategies (e.g., evaluation).

Keywords: Science learning, game-based learning, eye-tracking, prior knowledge

1. Introduction

Game-based science learning has been receiving a growing attention since the last decade. Many researchers suggested that learning science by playing digital games might not only effectively promote students' knowledge acquisition (Papastergiou, 2009), but also enhance their problem-solving skills. Particularly, although many scientific concepts are abstract, invisible, and difficult to grasp, they can be easily illustrated in the virtual world of the digital games (Cheng, She, & Annetta, 2015). In addition, previous studies indicated that students' prior knowledge played an essential role in playing games and could be used to predict their gameplaying performance (Lee & Chen, 2009). Although a large amount of studies have been conducted to examine the effectiveness of game-based learning, little has been known about how players process visual information and make decision while playing games. Therefore, this study aimed to explore whether students with different levels of prior knowledge have different patterns of visual attention while playing a digital game.

2. Methodology

2.1 Participants

The participants were 39 fourth graders (18 girls and 21 boys) in this study. They were categorized into two groups based on their pretest scores. The participants whose scores were on the top 40% were assigned into the high prior knowledge group (H-PK), whereas those whose scores were on the bottom 40% were assigned into the low prior knowledge group (L-PK). As a result, there were 18 participants in the H-PK (5 girls and 13 boys) and 15 participants in the L-PK (10 girls and 5 boys).

2.2 Materials and Apparatus

A game, "Saving the princess", was used in the present study. The learning objective of the game was to understand the relationship between the height of a light source and the length of a shadow produced by the light source. In this game, players should control the location of the shadow of the avatar's head to keep it within a zigzag path by changing the height of the light source. If players failed to maintain the avatar's shadow within the zigzag path, the game would stop immediately. In addition, if the players failed three times, the game would be over. Moreover, a self-explanation prompt would appear each time the player failed. The prompt was designed to help players reflect on the cause of their failure. The Tobii 4C Eye Tracker (with a sampling rate of 90Hz) was utilized to track the students' visual attention while they were playing the game. In addition, we developed a fixation identification program (Hsu, Tsai, & Chiou, 2016) for identifying fixations and calculating a series of eye-movement indices.

In addition, we developed a pre-test and a post-test to assess the participants' understanding of basic optics. Both tests included 10 multiple-choice questions and were carefully examined and validated by two science educators.

2.3 Procedure

Before playing the game, each participant took the pretest and then went through an eye-tracking calibration. Afterward, each participant started to play the game, and the Tobii 4C was used to record her/his eye movements throughout the gameplaying. The participants were requested to use a chin holder during the gameplaying to ensure the stability of the eye movement data. When the participant passed the game or had played the game for 10 minutes, the game would be automatically terminated and the Tobii 4C would stop recoding. After the gameplaying, the participants took the posttest.

2.4 Data analysis

To analyze the eye-tracking data, we defined a total of 15 areas of interest (AOIs) as shown in Figure 1 and 2. The detailed description of each AOI was shown in Table 1. For each AOI, a set of eye-movement indices were computed to determine each participant's visual attention distribution, including Total time spent in zone, Total fixation duration in zone, Total fixation count in zone, Percentage of time spent in zone, Percentage of Fixation Duration in Zone, and Percentage of Fixation Count in Zone. Moreover, we conducted a series of independent t tests to examine the difference between the H-PK and L-PK groups in previous eye-movement indices. In addition, the lag sequential analyses (LSA, Bakeman & Gottman, 1997; Tsai et al., 2016) were conducted to establish the visual transitional patterns of the two groups.

Table 1
Description of the AOIs.

AOI	Description
Up_Arrow	Representing the control button whose function was to lift up the flashlight
Down_Arrow	Representing the control button whose function was to lower down the flashlight
Light	Representing the flashlight in the game
Shadow	Representing the region of the avatar's shadow
Path_shadow	Representing the region of the avatar's current head shadow
Path_passed	Representing the region where the avatar's head shadow had passed
Path_next	Representing the region ahead of the avatar's head shadow
Live	Representing the remaining lives of the avatar
Countdown	Representing the remaining time of the game
Avatar	Representing the avatar that the player manipulated in the game environment
Red_point	Representing the region that the avatar's head shadow transcended the red path
Question	Representing the region of the self-explain prompt
Answer	Representing the region of the participants' responses to the self-explain prompt
Out	Representing the area outside of the previous 13 AOIs

Figure 1. The AOIs in the game

3. Results

3.1 The differences in the eye-movement indices between the two groups

Table 1 shows the results of independent *t* tests that were conducted to examine the differences in the eye-movement indices between the H-PK and the L-PK groups. As shown in Table 1, some significant differences could be identified in the Light AOI, including the *Total time spent in zone* ($t = 2.78$, $p < .05$), *Total fixation duration in zone* ($t = 2.47$, $p < .05$), and *Total fixation count in zone* ($t = 2.30$, $p < .05$). In other words, in the Light AOI, the L-PK group tended to have higher TTS ($M = .46$, $SD = .52$), TFD ($M = .34$, $SD = .44$), and TFC ($M = .87$, $SD = 1.13$). In addition, some significant differences were found in the Path_shadow AOI, including the *Percentage of time spent in zone* ($t = 2.66$, $p < .05$), *Percentage of fixation duration in zone* ($t = 2.88$, $p < .01$), and *Percentage of fixation count in zone* ($t = 3.19$, $p < .01$). In the Path_shadow AOI, the L-PKgroup were more likely to have higher PTS ($M = 35.25$, $SD = 10.55$), PFD ($M = 49.16$, $SD = 11.26$), and PFC ($M = 43.87$, $SD = 9.36$).

Table 1

Results of the t-tests that examined the differences in the eye-movements between the two groups

AOI	Indices	H-PK	L-PK	*t*
		Mean(SD)	*Mean(SD)*	
Light	Total time spent in zone (TTS)	.08(.16)	.46(.52)	2.78*
	Total fixation duration in zone (TFD)	.05(.12)	.34(.44)	2.47*
	Total fixation count in zone (TFC)	.17(.38)	.87(1.13)	2.30*
Path_shadow	Percentage of time spent in zone (PTS)	25.52(10.40)	35.25(10.55)	2.66*
	Percentage of fixation duration in zone (PFD)	37.50(11.81)	49.16(11.26)	2.88**
	Percentage of fixation count in zone (PFC)	33.03(10.00)	43.87(9.36)	3.19**

Note: * $p < .05$; **$p < .01$

3.2 Patterns of the visual transitions of the two groups

We conducted lag sequential analyses to examine the significant visual transitions among the AOIs of the H-PK and L-PK groups. The significant visual transitions were illustrated in Figure 2. Both groups would look up the red point when they failed to keep the avatar's head shadow within the path (Red point→Answer). However, the major differences were, first, the L-PK group were likely to focus on the trivial information (Light →Avatar, Avatar→Light). Second, instead of focusing on the path the avatar's head shadow located, the H-PK group would further evaluate the path in the front (See Path_shadow→ Path_shadow, Path_next→Path_shadow in Figure 2).
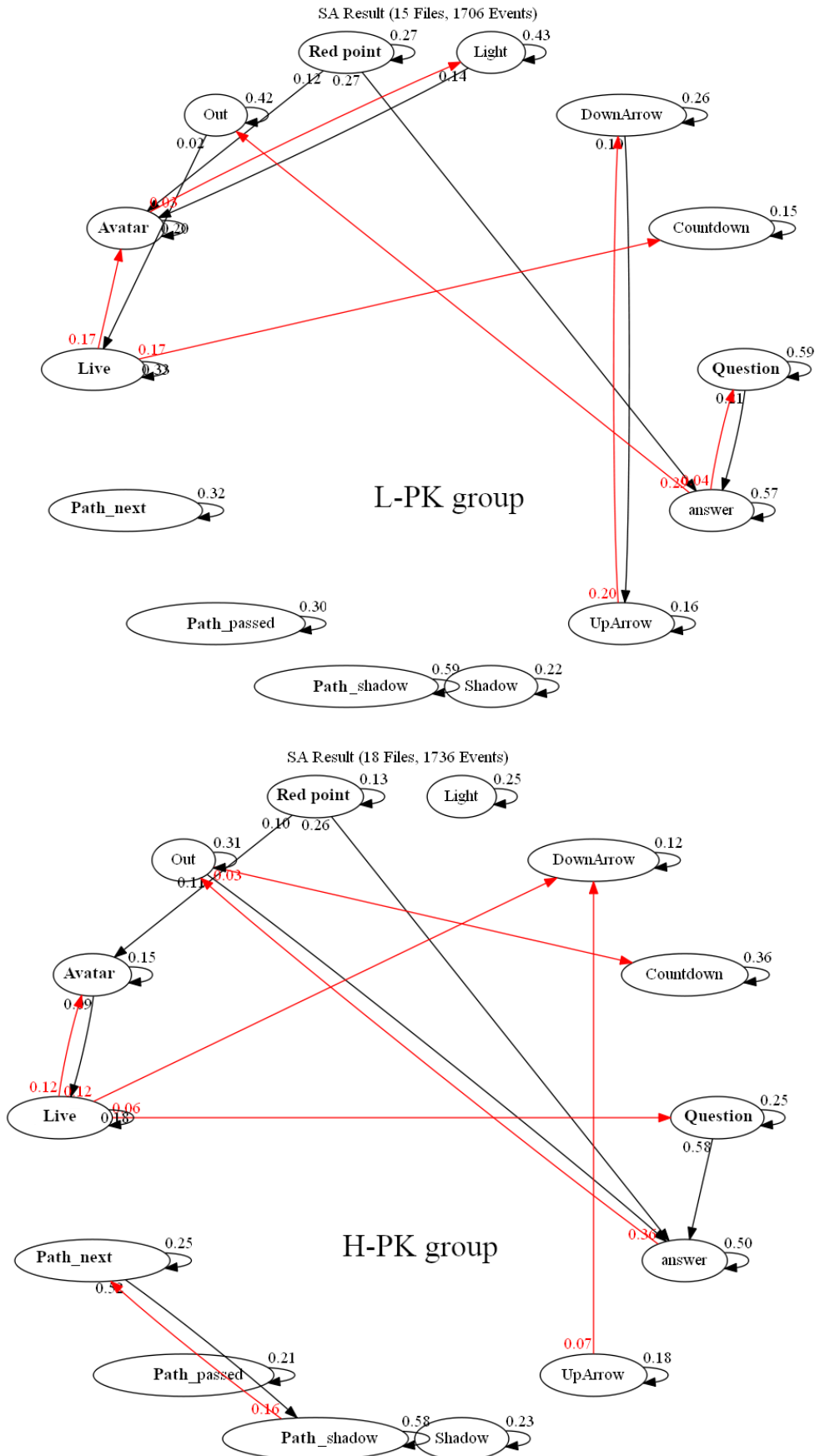
Figure 2. Significant visual transitions of the H-PK group and the L-PK group

4. Discussion

This study aimed to investigate the role the students' prior knowledge in the distributions of their visual attention and visual patterns while playing a digital game. The findings showed that the L-PK group tended to put more mental effort on the Light AOI than the H-PK group. This difference in visual attention might be explained by the difference in the levels of prior knowledge of the two groups. In other words, without insufficient prior knowledge, the L-PK group might need to look at the position of the flashlight to learn the relationship between the height of a flashlight and the length of the shadow. In addition, given that paying attention to the Path_shadow AOI was the most essential key to succeed in the game, the H-PK group could not only appropriately allocate their visual attention to this AOI, but also move from the Path_shadow to the Path_next AOI. The visual transition from the Path_shadow to the Paht_next AOI might denote an effective strategy to pass the game. That is, the players needed to check back and for the current and the future locations of the avatar's head shadow in order to immediately adjust the height of the flashlight for successfully passing the game. In sum, the results of this study agree with previous findings that students' levels of prior knowledge played an essential role in game-based learning. Moreover, through eye-movement analyses, we provide fresh evidence to account for how prior knowledge affected gameplaying behaviors in terms of visual attention and visual transitions.

Acknowledgements

References

Bakeman, R., & Gottman, J. M. (1997). *Observing interaction: An introduction to sequential analysis* (2nd ed.). UK: Cambridge University Press.

Cheng, M. T., She, H. C., & Annetta, L. A. (2015). Game immersion experience: its hierarchical structure and impact on game-based science learning. *Journal of Computer Assisted Learning, 31*(3), 232-253. doi:10.1111/jcal.12066

Hsu, C.-Y., Chiou, G.-L., & Tsai, M.-J. (2019). Visual behavior and self-efficacy of game playing: An eye movement analysis. *Interactive Learning Environments*, *27*, 942-952. doi:10.1080/10494820.2018.1504309

Hsu, C.-Y., Tsai, C.-C., & Wang, H.-Y. (2016). Exploring the effects of integrating self-explanation into a multi-user game on the acquisition of scientific concepts. *Interactive Learning Environments*, *24*, 844-858. doi:10.1080/10494820.2014.926276.

Hsu, C.-Y., Tsai, M.-J., & Chiou, G.-L. (2016). A pilot study on developing and validating a fixation-based scaffolding learning system. Paper presented at 2016 International Conference of East-Asian Association for Science Education (EASE 2016), Tokyo, Japan.

Just, M. A., & Carpenter, P. A. (1980). A theory of reading: From eye fixations to comprehension. Psychological Review, 87(4), 329–354. doi:10.1037/0033-295X.87.4.329

Lee, C.-Y., & Chen, M.-P. (2009). A computer game as a context for non-routine mathematical problem solving: The effects of type of question prompt and level of prior knowledge. *Computers & Education, 52*(3), 530-542. doi: 10.1016/j.compedu.2008.10.008

Papastergiou, M. (2009). Digital game-based learning in high school computer science education: Impact on educational effectiveness and student motivation. *Computers & Education, 52*(1), 1-12. doi:10.1016/j.compedu.2008.06.004

Park, S. I., Lee, G., & Kim, M. (2009). Do students benefit equally from interactive computer simulations regardless of prior knowledge levels? *Computers & Education, 52*(3), 649-655. doi:10.1016/j.compedu.2008.11.014

WORKSHOP 5 - The 4th International Workshop on the Theory and Practice of Interest-driven Creators (IDC)

Designing an Interest-Driven Challenge-Based Learning and Alternative Assessment Method for an Educational Technology Undergraduate Course

Mas Nida MD KHAMBARI
[a]*Faculty of Educational Studies, Universiti Putra Malaysia, Malaysia*
*khamasnida@upm.edu.my

Abstract: This paper centers on illustrating the design process of a challenge-based learning and alternative assessment used in the Educational Technology course at undergraduate level at Universiti Putra Malaysia. The learning and alternative assessment design of this course was framed by the two anchoring loops of the Interest-Driven Creator Theory, namely the Interest Loop and the Creation Loop. Each loop was utilized at a different point and time of the course, spreading throughout 14 weeks of the semester. The Interest Loop was implemented in the first half of the semester, overlapping with the Creation Loop which was implemented in the second half of the semester. Several nudges were creatively designed as a mean to stimulate and scaffold learners throughout the course. Every week during class, the learning activities started by applying the Interest Loop. This was done by inviting learners to participate in the challenges, at the same time making sure that the learners can extend the input from the activities to their final project. The objective of such design was to let students learn by doing or completing the weekly challenges given to them during class. Then, the students were guided to complete their final project through a series of workshops and personal group consultation with the course instructor. By designing the course using the Interest-Driven Creator Theory, it was found that the Interest Loop was specifically useful in designing the learning activities at the micro level of the Educational Technology course, while the Creation Loop was specifically useful in designing the alternative assessment at the macro level.

Keywords: Alternative Assessment, Interest-Driven Creator Theory, Challenge-Based Learning, Scholarship of Teaching and Learning

1. Introduction

I believe many 21st Century education enthusiasts and academics around the world are trying their best, and always looking for ways, to improve their teaching approach. Until today, several new methods centering on learners (rather than teachers) have emerged and are being introduced by scholars. For instance – authentic learning, discovery learning, problem based learning, service based learning, community based learning, passion based learning, and challenge based learning – to name a few, are methods that have gained interest among educators. These methods, if necessary, can be viewed as the 'bait' to 'lure' learners to enjoy learning through meaningful experiences, and consequently, gained some desired social skills and score well in examinations.

As an educator, I partake on the same journey as other education enthusiast and academics. Being an academician at the Faculty of Educational Studies, I have benefited a lot being around colleagues who are experts in the learning sciences. Among others, I learned that a good educator must have a theoretical grounding on his/her knowledge that were to be imparted to his/her learners. I specifically benefited from the Technological, Pedagogical, Content Knowledge (TPACK) Framework introduced by Mishra and Koehler (2006). This framework suggest that:

> …thoughtful pedagogical uses of technology require the development of a complex, situated form of knowledge that we call Technological Pedagogical Content

Knowledge (TPCK). In doing so, we posit the complex roles of, and interplay among, three main components of learning environments: content, pedagogy, and technology.

(Mishra & Koehler, 2006, p. 1017)

The TPACK framework is as illustrated in Figure 1. A teacher knowledge consists of three main components, namely Content Knowledge (CK), Pedagogical Knowledge (PK) and Technological Knowledge (TK). The overlapping of the three components lead to four types of interrelated knowledge, namely Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge and finally, the Technological Pedagogical Content Knowledge (TPACK) emerged from the interplay among the three preceding interrelated knowledge.
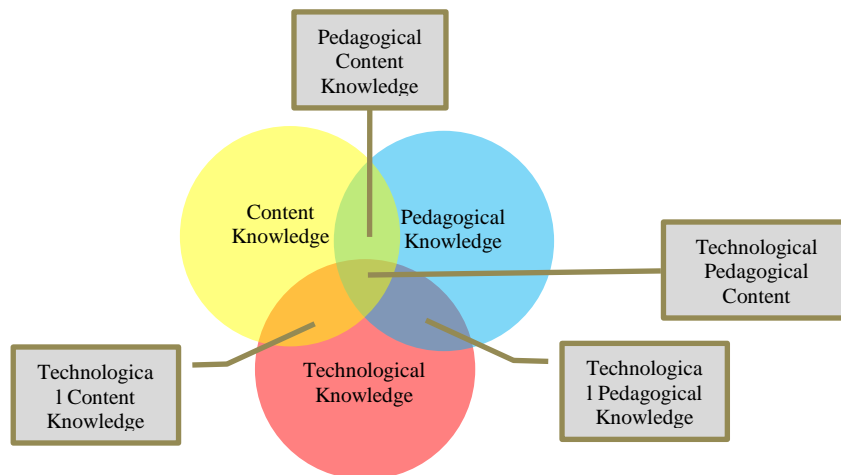

Figure 1. The Technological Pedagogical Content Knowledge Framework
(adapted from Mishra & Koehler, 2006, p. 1025).

In my five years of teaching undergraduate courses at the university, I found that the Challenge-Based Learning method echoes my teaching philosophy. After attending a number of intellectual discourses about the Interest-Driven Creator Theory at the International Conference on Computers in Education organized by the Asia Pacific Society for Computers in Education (APSCE) for the past three years, I felt that this theory complements my methods of Challenge-Based Learning. This paper therefore illustrates my three years of teaching experience with Interest-Driven Challenge Based Learning Framework. Reflecting on the TPACK Framework, I arrived to my own version of TPACK (Figure 2) that resonates my teaching philosophy. However, I must warn that this TPACK is only applicable to my own journey of scholarship of teaching and learning. Nevertheless, it *might* resonate to other academics and therefore *might* be transferrable or adaptable to them.

Figure 2 illustrates how I positioned the Interest-Driven Creator Theory onto my TPACK framework. Note that a fourth knowledge component is added, which is the Interest-Driven Creator Theory, and the pedagogical knowledge is now Challenge-Based Learning method. The overlapping of these four components contribute to the emergence of a *theoretically informed TPACK*, or Interest-Driven TPACK. The inclusion of Interest-Driven Creator Theory into my own TPACK solidifies my learning design as it gives meaning to every challenge that is implemented into the learning process.
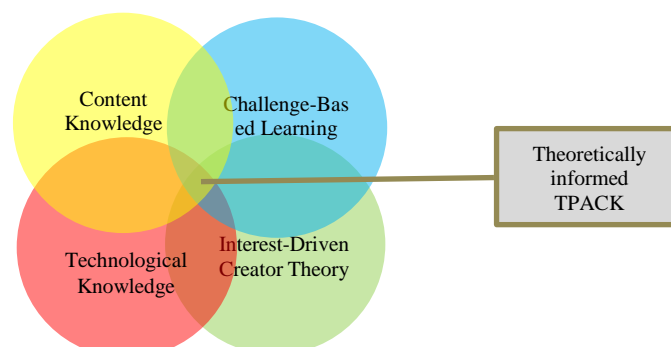

Figure 2. Positioning the Interest-Driven Creator Theory on the TPACK Framework

154

By having a theoretically informed TPACK, I felt that it has become easier for me to practice my learning design onto the courses that I am teaching and this gave rise to my pedagogical stance. Hence, the design of Interest-Driven Challenge Based Learning and Alternative Assessment ensues.

2. The Learning Issue and Objectives of the Design

Learners today have instant access to technologies and the web, thus instructors play a vital role to augment students' learning experience by leveraging technologies they use commonly in their daily lives. As most of my learners are pre-service teachers, I always asked them, "What kind of a teacher do you want to become?" and "How do you want to be remembered as a teacher?" These two questions are essential to prepare them for this course and concretize their self-efficacy as future teachers. Thus, pedagogical paradigm ensues and this warrants for a change in the instructional design for 21st century learners. This Interest-Driven Challenge Based Learning and Alternative Assessment Design aims (i) to let learners be autonomous life-long learners and have ownership on their learning through intentional guided events and workshops to trigger their interest and creation ability, and fill their knowledge gaps, (ii) build resiliency and future competencies among learners, and (iii) ultimately to achieve the course outcome and beyond. Based on the challenge-based learning framework and the Interest-Driven Creator Theory that foregrounds the instructional design of this course, I believe that learners can optimize their innate ability better and enjoy learning, thus have an imprinted effect on their memory retention, and consequently perform better in examinations.

3. The Design of Interest-Driven Challenge Based Learning and Alternative Assessment

Challenge-based learning encourages learners to be actively engaged in learning through collaborative hands on activities, by leveraging common technologies they use in their daily lives to solve real-world problems (Apple Inc., 2010). These are meant to augment learners to develop deeper knowledge of the subjects understudy and extend it to a larger crowd. The Challenge-Based Learning Framework, as developed by Apple Inc., is as follows (Figure 3). This framework can be understood by its five stages of implementation (Apple Inc., 2010), namely:

Big Idea		
Essential Question		
The Challenge		
Guiding Questions	Guiding Activities	Guiding Resources
Solution: Implementation		
Assessment		
Publishing Student Samples	Publishing Student Observations	

Figure 3. The Challenge Based Learning Framework (adapted from Apple Inc., 2010)

Stage 1: From big idea to the challenge. Learners are given a premise of current issues related to them, that they can help solve. The teacher should give questions that would guide them in finding solutions to the problem. At the same time, learners are encouraged to leverage commonly used technology in their tasks to solve the problem.

Stage 2: Setting the foundation. At this stage, learners formulate questions that can help them solve the issue. This step works best with learners working in groups and collaborate. The

instructor should remind the learners that they have the options to use multi resources to devise their plan for activities and resources.

Stage 3: Identifying a solution. The learners should arrive at a solution plan by now and have a solid foundation to begin prototyping or experimenting with their solutions. Several research and documentation are done at this stage.

Stage 4: Implementation and evaluation. Learners have implemented their solution plan and assess what worked or what didn't work from the plan. At this point, learners will have to decide what they want to assess and determine whether they had progressed in addressing the challenge.

Stage 5: Publishing results and reflections. Throughout the whole project planning and implementation, learners document their work in the form of audio visuals and share their work in a public domain, highlighting on the process done, how it was implemented and their own reflections. The institution is encouraged to organize a public event as an avenue for learners to share and celebrate their efforts.

I have been teaching the Educational Technology course for undergraduates for the past five years, and every semester, the course design was updated to ensure that this course keeps abreast with the current and emerging trends in educational technology. Moreover, the Educational Technology course is a compulsory course for all undergraduate students at the Faculty of Educational Studies.

The learning and alternative assessment design of the Educational Technology course was developed with the spirit of Challenge-Based Learning, and framed by the Interest-Driven Creator Theory, anchoring on its first two concepts namely Interest and Creation Loop, to infuse teaching spirit to the learners (pre-service teachers).

An original design was produced through this mesh-up that combines workshops, events, gamification and role-plays as guide and nudges (and as "hoarding boards") to lead learners (and curb from mistakes) to progress and complete their final projects. The instructor's role shirts as facilitator and project manager, overlooking learner's progress and providing relevant resources to them. This approach was meant to reduce cognitive load but at the same time, provide meaningful learning experience, enhance memory retention, and celebrate learners' heterogeneity.

This was done by applying the Interest Loop at the micro level of learning design, which is by inviting learners to participate in bite-sized challenges through role-play and gamification approach while making sure that students can extend the input from the activities to their final project. The objective of such design was to let students learn by doing. Borrowing the concepts of Challenge-Based Learning, these activities leverage on technologies that are already available to the learners (Apple Inc, 2010), namely their own smartphones.

Next, the instructor takes role as the project manager to help students complete the coursework and the final challenge (project) by applying the Creation Loop. The Creation Loop is specifically helpful in macro designing the course as it is more applicable for long-term assessments at the time this paper was written. Students were guided through a series of workshops and events, and personal group consultations with the instructor. The design of alternative assessment is also specifically useful in revoking learners' passivity in classroom activities and replace it with learners' initiative, self-discipline and choice (Janisch & Akrofi, 2007).

Figure 4 provides the complete Interest-Driven Challenge Based Learning and Alternative Assessment framework I developed for the Educational Technology course, together with lineup of activities that are meant to provide learners with meaningful experience and immerse them in the learning process. Note that the Interest Loop is implemented at the first half of the Challenge-Based Learning Framework (from the Big Idea to The Challenge). The lineup of Lecture Activities for the Challenge-Based Learning method are all designed to help *trigger* learners to look for more information, *immerse* them into the learning process, and allow them to *extend* their newly constructed knowledge to the daily ordinaries (Chan et al., 2018). These bite-sized challenges are given to learners mostly throughout the first half of the semester, allowing learners to see themselves and set their minds

as teachers (they are currently pre-service teachers undergoing training at undergraduate level). The challenges act as nudges to help learners progress with their coursework and final project. As learners go through this Interest Loop, they became more invested into their own courseworks and final projects.

In the second half of the semester, learners have shifted to the second half of the Challenge-Based Learning Framework (from Solution and Implementation to Assessment). The Creation Loop occurs at this stage, anchoring the macro design of the course and helping learners finish up their coursework and final project. At this stage, learners are already able to *imitate* readily available projects or come up with ideas that are built on their newly constructed knowledge at the micro level. Learners start to *combine* their knowledge, tools and media to create a prototype of a project that they have chosen to do. Finally, a special event is conducted at the end of the semester to let learners *stage* their projects by demonstrating them to the public. Learners are also required to write an ePortfolio on any free online platform, reflecting on their learning experience throughout the semester as a mean to understand their thinking process and experience, and whether they synchronize with the desired learning outcomes; as well as determine the effectiveness of the Interest-Driven Challenge Based Learning and Alternative Assessment Framework.

4. Conclusion

I have been practicing Interest-Driven Challenge-Based Learning and Alternative Assessment method for the past three years for the Educational Technology course. Each semester, similar activities were carried out, and it just became better every semester as new methods and activities emerged and woven into the learning and alternative assessment design. As I develop the design, I intended for the methods to be transferable to other courses that I teach, and implemented at a larger scale. Furthermore, this approach leverages materials, tools and technologies (like smartphones and free mobile apps) that are common and easily accessible to many of us. However, I must emphasize again that it is only specific to the instructional design for the Educational Technology course that I found the Interest Loop is helpful in designing the course at a micro level, and the Creation Loop is beneficial in designing the course at a macro level. Therefore, this shall not be generalized to other courses' designs and any situations.

Applying the Interest-Driven Challenge-Based Learning and Alternative Assessment method has resulted in swift and systematic implementation for activities that promotes challenge-based learning, and adaptable to other instructors if they wanted to adopt this method. Following this method has allowed me to scaffold my learners at the beginning of the semester by giving appropriate nudges and assesments, and it also allows me to remove the scaffold towards the end of the semester and watch the learners blossom cognitively and affectively, and take flight into their own learning. I believe that continuous assessments are lenient ways of guiding learners (and not punishing in nature) and play a vital role in developing learners' knowledge, competencies and skills.
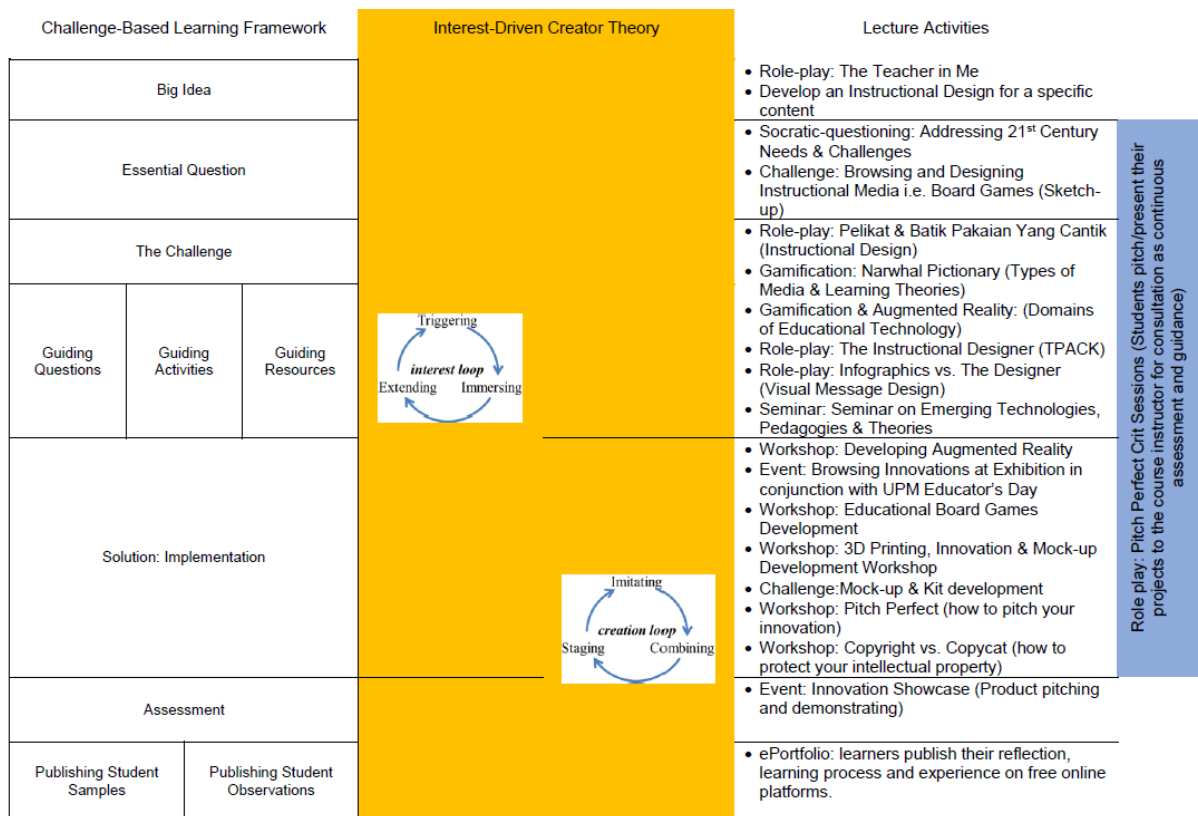
Figure 4. Interest-Driven Challenge Based Learning and Alternative Assessment framework
for Educational Technology Course for Undergraduates

References

Apple Inc. (2010). Challenge based learning: a classroom guide. Retrieved from
https://images.apple.com/education/docs/CBL_Classroom_Guide_Jan_2011.pdf

Chan, T. W., Looi, C. K., Chen, W., Wong, L. H., Chang, B. Liao, C. C. Y, Cheng, H., Chen, Z., Liu, C. C., Kong, S. C. Jeong, H., Mason, J., So, H. J., Murthy, S., Yu, F. Y., Wong, S. L., King, R. B., Gu, X., Wang, M., Wu, L, Huang, R., Lam, R., & Ogata, H. (2018). Interest-driven creator theory: towards a theory of learning design for Asia in the twenty-first century. Journal of Computers in Education, 5(4), 435-461.

Janisch, C., Liu, X., & Akrofi, A. (2007). Implementing alternative assessment: Opportunities and obstacles. Educational Forum, 71(3), 221–230. https://doi.org/10.1080/00131720709335007

Mishra, P. & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College,108*(6), 1017–1054

Enhancing students' writing quality and interest through story creation: From the perspective of the interest-driven creator (IDC) theory

Wen-Yi LIU*& Zhi-Hong CHEN

Graduate Institute of Information and Computer Education, National Taiwan Normal University, Taiwan

*898080048@ntnu.edu.tw

Abstract: There have been numerous empirical studies argue that if the students become intrinsically interested in certain specific subject, their learning performance may be facilitated. In other words, in the process of learning, interest potentially acts a crucial role and have direct impact on the learning outcomes. In addition to cognitive aspects, however, the affective aspects are also necessary to take into consideration. Therefore, how to cultivate students' interest has increasingly become a research issue recently. The objective of the present study is to propose the prototype of the six-stage story structure (4S) approach designed based on interest-driven creator (IDC) theory and expect to enhance students' learning of Chinese writing at the stage of elementary education. To this end, a series of learning activities for the 4S approach have been developed in accordance with the conceptual framework of interest and creation loop in IDC theory. To further examine the effectiveness on students' learning performance and interest, the evaluating rubrics for writing quality and interest questionnaire are developed with reference to prior literatures. Moreover, the relevant descriptions of the 4S approach are described in detail, and the future works are also discussed.

Keywords: story structure, story creation, writing quality, learning interest

1. Introduction

In daily lives, interest is one of common and significant emotional component. For instance, people have different interest in various recreation at their leisure time, such as reading, watching television, taking specific exercise, and so forth. When speaking of learning, a well-known Chinese proverb says that interest is the best instructor at initial phase of knowledge acquisition. Some Asian researchers also state that the interest is even the "mother" of learning (Wong et al., 2016). Particularly, in the viewpoint of the academic goal, interest is a crucial factor that probably influences the learning outcomes. A meta-analysis, conducted by Schiefele, Krapp, and Winteler (1992), evidently reported that learners' performance was positively correlated to their interest. Therefore, the "interest" itself is inherently related to learning and actually acts an important role in educational filed.

The interest development is essential for students in school settings; because promoting interest can help students not only become stimulated and actively engaged, but also accumulate their learning experiences (Harackiewicz, Smith, & Priniski, 2016). When a student becomes intrinsically interested in certain specific subject, he/she will be willing to pay better attention and continue to concentrate on the learning content. Furthermore, cultivating interest may contribute to students' information processing more efficiently, and therefore improve their performance. Hidi and Renninger (2006) supplementary designated that the development of interest involves learners' knowledge, positive emotion, and personal value. That is to say, the development of interest has been a research issue in the educational practices.

The construct of interest comprises situational interest and individual interest (Hidi & Renninger, 2006). How to transfer situational to individual interest have drawn educators' attentions over the two decades. For instance, the four-phase model proposed by Hidi and Renninger (2006) consist of triggering and maintenance of situational interest, and emerging and well-developing of individual interest. The research findings of Harackiewicz, Smith, and Priniski (2016), further asserted

that four categories of interventions were found to be potentially useful to progressively develop students' interest: settings of getting attention, problem-oriented learning context, arousing preceding individual interest, and enhancing of utility value.

The interest-driven creator (IDC) theory (Chen, Chi, Ciou, 2017; Wong et. al., 2015), which are developed by a group of Asian researchers, advocated a theoretical model in a macro-view. The model comprises three anchored loops, namely, interest, creation, and habit loop (Chan et al., 2018). First, the interest loop consisted of triggering of interest, immersing of interest, and extending of interest (Wong et. al., 2015). Second, the creation loop consisted imitating, combining, and staging (Chan, Looi, & Chang, 2015). Third, the habit loop consisted cueing environment, routine, and satisfaction (Chen, et al., 2015).

Recently, the IDC theory has been implanted in various subject domains. An increasing number of empirical studies put the IDC theory into educational practices and instructional design with the integral support of emerging technology. For example, underpinned by the interest loop, Chen, Chi, and Ciou (2017) designed a digital game-based learning system (called Character Monster) for pupils' Chinese character learning through the design strategies including arouse curiosity, learning by feeding, and collecting albums of Character Monsters. In addition, supported by the creation loop, Chang, Shih, and Huang (2017) constructed a social network platform (CoCoing.info) as an effective tool for the understanding of concept map. Correspondingly, Kong and Li (2016) attempted to apply the creation loop in coding education to nurture students as the creators.

Specifically, in language learning, writing is often regarded as a challenge for less skilled novices (Lee, 2016), and getting students to be less-interested possibly eventually bring about negative impact on their performance. Yet, previous studies focused on the effectiveness of writing instruction on learners' academic goal in cognition, but few research further investigated the learners' attribute in affection such as perception and interest (Graham, McKeown, Kiuhara, & Harris, 2012).

Narrative story is one kind of text genres, which is widespread in the general readings and course textbooks. The scenes or storylines in the well-organized stories often follow an underlying structure, and similarly the writing production also often logistically obey certain rules. Therefore, guiding students to organize the stories in a structured way would probably be a suitable learning strategy from story creation to writing task, and interest can also be reserved simultaneously. In line with the aforementioned consideration, how to arouse and retain students' interest and engage them in both story creation process and writing tasks would turn into the highlight of the current research.

Referring to the theoretical framework of interest loop and creation loop, this study intended to propose a blended method, called the six-stage story structure (4S) approach, based on the learning content/guidelines of writing and story creation at elementary school level. The purpose of the 4S approach is to enhance student's interest by creating an attractive and meaningful blended learning environment where students are capable to verify what they are learning through "learning by creating". It is expected that students' writing quality and their learning interest can be simultaneously enhanced through the support of the 4S approach.

2. Conceptual Model and Activity Design

2.1 Six-Stage Story Structure

The proposed approach, designed based on "six-stage story structure", was called "4S" approach in which the acronym represented the four initial s-letter. Table 1 listed the story structure (the key components of the storyline in a well-organized story) used in the 4S approach. The six-stage story structure comprised "Setting", "Theme", "Attempt", "Consequence", "Climax", and "Resolution" which were referenced to the literatures (e.g., Keating, 2011; Ukrainetz, 2006; Watanabe & Hall-Kenyon, 2011).

In order to promote the interest of the students in story writing, the clear learning supports were needed in the process. As shown in Table 1, the provided six-stage story structure potentially offered the students explicit guidelines to gradually reduce the metal loads and difficulties in writing. By following the prompts underlying the story structures step by step, the students could create their own storylines more definitely. While the students gained a sense of achievement, they would be willing to engage themselves in producing the stories and become more interested in the follow-up story creation.

Table 1

Six-stage story structure in the 4S approach

Stage	Story structure	Stage	Story structure
1	Setting	4	Consequence
2	Theme	5	Climax
3	Attempt	6	Resolution

2.2 Story Structure-Based Model for Writing

Figure 1 demonstrated the conceptual framework of the story structure-based model for Chinese writing learning. It should be noted that the story structure-based model, applied in the 4S approach and learning activities, was strengthened by the interest loop (i.e., triggering interest, immersing interest, and extending interest) and creation loop (i.e., imitating, combining, and staging).

In terms of triggering interest, the students' interest was evoked by manipulating the appealing story objects in storybooks with six-stage story structure. Regarding the immersing interest, students will engage in producing stories by themselves after their interest is evoked. In this phase, the creation loop was embedded in immersing interest. In terms of imitating, the students initially acquire the underlying story structure in the storyline. Regarding the combining, the students are encouraged to combine the information and apply the story structure in their story production. Lastly, in the staging, the students will gradually write a well-structured story and share with peers. As for the extending interest, the students may actively promote more elaborative story creation. After the interest of students increased, they would be further nurtured as a creator (i.e., story-maker or younger writer).
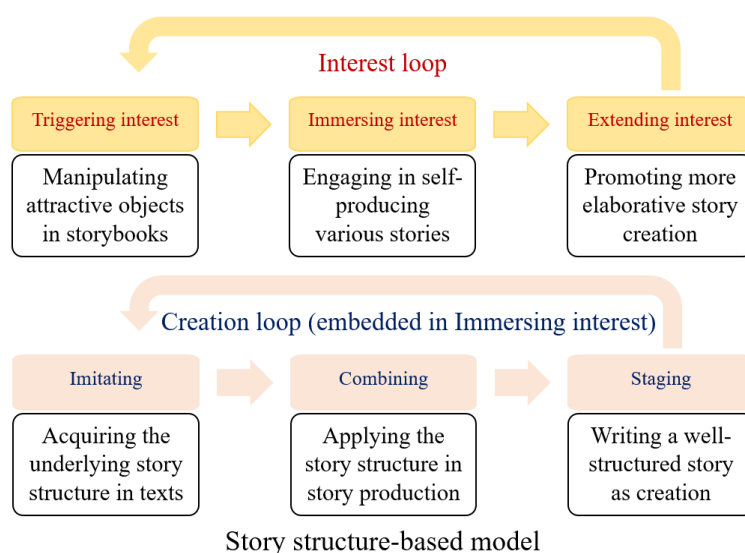

Figure 1. Interest with embedded creation loop and story structure-based model.

2.3 Prototype of Learning Activity in the 4S Approach

Figure 2 showed the blended learning activities designed in the 4S approach. All of the content in the paper-based and digital storybook used in the learning activity have been re-written in a structured way. Three storybooks in total are used in the process of learning activity, and their interfaces are designed in the same style. On the top of the storybook are the story structure and its meaning which is denoted by the question-form (i.e., using the sentence opener leading by where, who, what, when and how).

On the middle is the content of story, and on the bottom are the provided story objects which the students can select and add (by drag or slot) into the storylines. Following the underlying structure in each story, the students are guided to act as a story-teller or story-maker to modify the storyline and produce a new story on their own. In other words, the 4S approach would be one of the ways by evoking students' interest and immersive cultivating themselves into the creators.
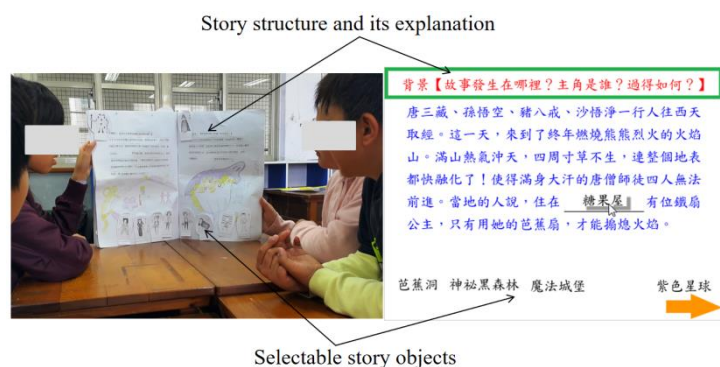
Figure 2. Learning activity designed based on the interest and creation loop.

3. Methodology

3.1 Materials: Storybooks

The learning activities will be implemented in pupils' Chinese course, and the materials adopted in the activities are three selected storybooks. The "Cinderella" (adopted from Grimm's Fairy Tales) is a well-known tale which most students are familiar with, so it is arrange as the first storybook. In terms of the difficulties of the texts, the storylines in both the second storybook, "Fight the Evil Dragon" (adopted from Taiwanese indigenous folk legend), and the third storybooks, "Monkey Borrows the Plantain Fan" (Chinese classic novel) become more complicated and their length of story is longer. As the students have understood the underlying story structure in the "Cinderella", they can further apply them into the latter storybooks for helping better comprehension.

3.2 Measuring Instruments

Since the dependent variables are writing quality and learning interest, the performance test and interest questionnaire are used to evaluate students learning outcomes. All the students are requested to write a story with the topic "a fantastic adventure journey" in the pre-/post- test of the performance test. Two experienced Chinese teachers co-constructed the rubrics and evaluated the writing works of the students with the 9-point full marks. The quality of their writing comprises three dimensions: organization, coherence, and richness. In addition, the interest questionnaire, a 5-point Likert scale which was developed by authors based on the interest loop in IDC theory, comprises three dimensions: triggering interest (arouse curiosity), immersing interest (flow state), and extending interest (sustain to re-engage).

4. Future Works

The present study focused on the application of the interest loop (i.e., triggering, immersing, and extending) and creation loop (i.e., imitating, combining, and staging). The blended six-stage story structure (4S) approach was further designed according to the above two loops in the IDC theory. After several times of adjustment and discussion with the first-line Chinese teachers at elementary schools. The 4S approach worked because it enables student to make a direct connection between their story creation and writing quality. However, the effectiveness of the 4S approach is required to be evidently examined.

The future works are planning to conduct an experiment in two fifth-grade classes at an elementary school, and the proposed 4S approach will be applied in the writing tasks of Chinese course to compare with the conventional approach. Because the three-stage story structure (i.e., setup, confrontation, and resolution) was widely introduced in Chinese textbook in conventional approach, hence, the learning outcome by conventional approach would be a baseline for the comparison with respect to the 4S approach. We hope the upcoming experiment can help understand the improvement of writing quality and interest of students in detail.

Acknowledgements

We would like to thank the reviewers who gave insightful suggestion on our work.

References

Chan, T. W., Looi, C. K., & Chang, B. (2015). The IDC theory: Creation and the creation loop. In T. Kojiri, T. Supnithi, Y. Wang, Y. T. Wu, H. Ogata, W. Chen, S. C. Kong, & F. Qiu (Eds.), *Workshop Proceedings of the 23rd International Conference on Computers in Education* (pp. 814-820). Hangzhou, China: Asia-Pacific Society for Computers in Education.

Chan, T. W., Looi, C. K., Chen, W., Wong, L. H., Chang, B., Liao, C. C., ... & Jeong, H. (2018). Interest-driven creator theory: towards a theory of learning design for Asia in the twenty-first century. *Journal of Computers in Education*, *5*(4), 435-461.

Chang, B., Shih, Y. A., & Huang, T. C. (2017). Creation loop example of IDC theory: CoCoing.info. In Y. Hayashi, T. Supnithi, M. Mathews, S. L. Wong, A. F. Mohd Ayub, A. Mitrovic, W. Chen, ... J. C. Yang (Eds.), *Workshop Proceedings of the 25th International Conference on Computers in Education* (pp. 359-364). New Zealand: Asia-Pacific Society for Computers in Education.

Chen, W., Chan, T. W., Liao, C. C. Y., Cheng, H. N. H., So, H. J., Gu, X. (2015). The IDC theory: Habit and the habit loop. In T. Kojiri, T. Supnithi, Y. Wang, Y. T. Wu, H. Ogata, W. Chen, S. C. Kong, & F. Qiu (Eds.), *Workshop Proceedings of the 23rd International Conference on Computers in Education* (pp. 821-828). Hangzhou, China: Asia-Pacific Society for Computers in Education.

Chen, Z. H., Chi, P. Y., & Ciou, H. J. (2017). Applying interest loop to develop game-based model for Chinese character learning. In Y. Hayashi, T. Supnithi, M. Mathews, S. L. Wong, A. F. Mohd Ayub, A. Mitrovic, W. Chen, ... J. C. Yang (Eds.), *Workshop Proceedings of the 25th International Conference on Computers in Education* (pp. 372-375). New Zealand: Asia-Pacific Society for Computers in Education.

Graham, S., McKeown, D., Kiuhara, S., & Harris, K. R. (2012). A meta-analysis of writing instruction for students in the elementary grades. *Journal of Educational Psychology*, *104*(4), 879-896.

Harackiewicz, J. M., Smith, J. L., & Priniski, S. J. (2016). Interest matters: The importance of promoting interest in education. *Policy Insights from the Behavioral and Brain Sciences*, *3*, 220-227.

Hidi, S. & Renninger, K. A. (2006). The four-phase model of interest development. *Educational psychologist*, *41*(2), 111-127.

Keating, P. (2011). The plot point, the darkest moment, and the answered question: Three ways of modelling the three-quarter-point. *Journal of Screenwriting*, *2*(1), 85-98.

Kong, S. C., & Li, P. (2016). The interest-driven creator theory and coding education. In D. Gao, Y. T. Wu, T. W. Chan, S. C. Kong, M. H. Lee, J. C. Yang, J. L. Shih, J. C. Hong, J. Shang, K. H. Cheng, & S. Y. Chen (Eds.), *Workshop Proceedings of the 20th Global Chinese Conference on Computers in Education* (pp. 116-119). Hong Kong: The Hong Kong Institute of Education.

Lee, J. F. K. (2016). Enriching short stories through processes– A functional approach. *System*, *58*, 112-126.

Schiefele, U., Krapp, A., & Winteler, A. (1992). Interest as a predictor of academic achievement: a meta-analysis of research. In K. A. Renninger, S. Hidi, & A. Krapp (Eds.), *The role of interest in learning and development* (pp. 183-212). Hillsdale, N. J.: Erlbaum.

Ukrainetz, T. (2006). *Contextualized language intervention: Scaffolding PreK-12 literacy achievement* (pp. 196–246). Eau Claire, WI: Thinking Publications.

Watanabe, L. M., & Hall-Kenyon, K. M. (2011). Improving young children's writing: The influence of story structure on kindergartners' writing complexity. *Literacy Research and Instruction*, *50*(4), 272–293.

Wong, L. H., Chan, T. W., Chen, Z. H., King, R. B., & Wong, S. L. (2015). The IDC theory: Interest and the interest Loop. In T. Kojiri, T. Supnithi, Y. Wang, Y. T. Wu, H. Ogata, W. Chen, S. C. Kong, & F. Qiu (Eds.), *Workshop Proceedings of the 23rd International Conference on Computers in Education* (pp. 804-813). Hangzhou, China: Asia-Pacific Society for Computers in Education.

Wong, L. H., Chan, T. W., Chen, Z. H., & Liao, C. C. Y. (2016). The IDC theory: Curiosity, flow and meaningfulness for interest development. In D. Gao, Y. T. Wu, T. W. Chan, S. C. Kong, M. H. Lee, J. C. Yang, J. L. Shih, J. C. Hong, J. Shang, K. H. Cheng, & S. Y. Chen (Eds.), *Workshop Proceedings of the 20th Global Chinese Conference on Computers in Education* (pp. 76-83). Hong Kong: The Hong Kong Institute of Education.

How the Habits of Self-regulated Academic Writers are Behaviorally Facilitated?

Hercy N. H. CHENG[ab]*, & Xiaotong ZHANG[b]

[a] *National Engineering Laboratory for Educational Big Data, Central China Normal University, China*
[b] *National Engineering Research Center for E-Learning, Central China Normal University, China*
*hercycheng.tw@gmail.com

Abstract: In this paper, the authors demonstrated online academic writing behaviors as an example to illustrate a habit loop in Interest-driven Creator (IDC) theory. A habit loop describes that the habitual routine of creation should be triggered by a cueing environment, and provide a sense of harmony. Furthermore, instead of using the theory as a design framework, the authors proposed that the IDC theory could also be used as an analysis framework. In this study, the authors aimed to explore how the habits of self-regulated academic writing were behaviorally facilitated. For this purpose, the authors collected behavioral data of graduate students in an online academic writing system for two months. The students were divided into high and low self-regulated learners. Their behavioral patterns were then computed separately with hidden Markov models. The results showed that the model of the high self-regulated learners included a small version of a creation loop and a habit loop, in which the academic writing were triggered by the behaviors of literature reading, self-monitoring, and co-authoring. Besides, after writing, the high self-regulated learners tended to go back to read more literature and monitor their progress. Conversely, in the model of the low self-regulated learners, all behaviors likely transited to writing without any evident loops, implying that the low self-regulated learners might be performance goal oriented.

Keywords: Habits, self-regulated learning, academic writing, hidden Markov models

1. Introduction

When entering graduate schools, students start to conduct individual research for their very first time. Even with the scaffolding of their advisors, the process of research is basically self-regulated. In other words, unlike undergraduate education, graduate education involves more uncertainty and complexity in field knowledge, research direction, and methodology. When graduate students overcome these issues and finish a study somehow, they still have to figure out how to write their own theses. International graduate students reported that their difficulties in academic writing included literature review, methods, and analysis (Singh, 2015). Because academic writing is a big challenge for most graduate students, they are usually encouraged to submit conference papers in advance. As an example of creation, writing academic papers or theses is not a one-time job. Any professors would tell their graduate students to keep writing as a habit in order to improve the writing quality.

Recently, Asian scholars proposed an Interest-Driven Creator (IDC) theory (Chan, *et al.*, 2018), which emphasizes the importance of interest, creation, and habits in a form of loops. In the habit loop, there are three component concepts: a cueing environment, routine, and harmony. A cueing environment is a habit trigger that psychologically and behaviorally prepares students to do the habitual routine, that is, creation in the theory. A cueing environment could be anything or anyone that could trigger one to create works, for example, a certain setting of learning spaces, fixed learning timetables, or important people (e.g. teachers, parents, and/or peers). Some researchers have proposed portfolio visualization as a cueing environment to trigger students to start writing a new composition (Liao, Chang, Cheng, & Chan, 2017). After the habitual routine, students should feel the sense of satisfaction, achievement, or even harmony. These positive feelings may become a motivated cueing (Wood, & Neal, 2007) or a cached motive (Daw, Niv, & Dayan, 2005), so that students would be willing to do the routine again.

Even though the IDC theory is still young, more and more researchers used the theory as a design framework to develop learning systems (*e.g.* Chang, Shih, & Huang, 2017; Chen, Chi, & Ciou, 2017; Liao, Chang, Cheng, & Chan, 2017). In this paper, the authors would like to further use the theory as an analysis framework to examine how the habits of academic writing were triggered. Furthermore, the authors collected graduate students' behavioral data, in which the students used an online academic writing system to prepare their own papers for two months. In the system, the students were allowed to build literature lists, take reading notes, write manuscripts, provide/receive comments from co-authors, and monitor progress. Ideally, students with good writing habits should work like self-regulated learners. In other words, they should set personal goals, devise strategic plans, monitor their own progress, and regulate their behaviors if necessary (see Zimmerman, 2002). Therefore, their behavioral patterns might have not only cognitive but also metacognitive information. More importantly, studying their behavioral patterns may help us understand the habit loop in the theory.

In this study, we aimed to explore the students' habitual behaviors of self-regulated academic writing by hidden Markov models (HMMs), a machine learning technique that describes a statistical model of Markov process with unobservable variables. Many previous researchers have adopted the machine learning technique to understand self-regulated learning behaviors. For example, Biswas et al. (2010) used hidden Markov models to explore how learning modes might affect students' self-regulated learning behaviors. In their study, it was assumed that the unobservable variables in hidden Markov models could be regarded as metacognitive strategies. Their results demonstrated that a hidden Markov model was a promising technique for modeling self-regulated learning behaviors. In our study, hidden Markov models were used to examine the differences in the behavioral patterns of academic writing between high and low self-regulated learners.

2. Method

2.1 Participants

The participants were 92 first-year graduate students, including 38 male and 54 female students. Their ages ranged from 21 to 25 years old in the spring semester of 2019. Their majors included computer sciences, software engineering, and educational technology. They took a course on the academic reading and writing, in which the students were required to prepare their manuscripts with any topics of their choices in the online academic writing system. They were also required to invite several classmates as their coauthors, who had to providing comments for the first authors during the process of writing. The whole process took a semester, but due to the time limitation, the analysis in this paper only included the data in two months, *i.e.*, April and May 2019.

2.2 Instrument

In the end of the semester, the students were asked to fill out a self-regulated learning questionnaire (Kizilcec, Pérez-Sanagustín, & Maldonado, 2017), which contains 24 questions with six dimensions: goal setting, strategic planning, task strategy, elaboration, self-evaluation and help seeking. The questionnaire was a 5-point Likert scale with options from 1 point (strongly disagree) to 5 points (strongly agree) for each statement. The questionnaire was used to group students as high and low self-regulated learners.

2.3 Online Academic Writing System

During the course, the students were required to use the online academic writing system as a platform to submit their weekly assignments, which included writing one note for an academic paper, writing about 10% of their own manuscripts, and give 3 comments to co-authored manuscripts. The teacher would not really check their progresses every week. Instead, he checked them in the end of the semester, so that the students could demonstrate their behaviors of self-regulate learning in their writing behaviors.

The system was designed to scaffold graduate students to prepare their papers. For this reason, the system served for the following functions: surveying literature, reading literature, goal-setting &

planning, writing papers, self-monitoring, and peer commenting (detailed actions are described in Table 1). For example, in the chapter plan page, as shown in Figure 1(a), students were allowed to monitor the status of all chapters in their manuscripts, including the current word numbers, the target word numbers, and the self-evaluated scores. If they would like to write the manuscripts, they may click a chapter name and write the chapter. In the writing page, as shown in Figure 1(b), their own notes taken for literature were displayed on the right, so that they could reorganize the manuscripts.

(a) The chapter plans

(b) The chapter writing with notes

Figure 1. The online academic writing system.

Table 1

Actions in the Online Academic Writing System

Categories	Codes	Descriptions of Actions
Surveying	KW-ADD	Adding keywords in order to build a personal keyword list
	RS-CHK	Checking a personal researcher list
	LT-ADD	Adding literature in a shared literature list
	LT-CHK	Checking the literature list
Reading	NT-WRT	Taking a note after reading literature
	NT-CHK	Reading notes
Goal-setting & Planning	PL-ADD	Adding a chapter plan, including target word numbers and deadline
	PL-RVS	Revising a chapter plan
Self-monitoring	PL-CHK	Checking all chapter plans in a page (see Figure 1(a))
	CH-EVL	Evaluating the perceived quality of a chapter
Writing	CH-WRT	Writing a chapter with the supports of notes (see Figure 1(b))
	CH-RVS	Revising a chapter with the supports of peer comments
Peer commenting	CM-ADD	Adding comments for co-authored papers
	CM-MNG	Managing comments from co-authors, including full accepting, partial accepting, or rejecting

2.4 Data collection

The behavioral data of students' academic writing activities was collected from 2019/4/1 to 2019/5/31. The data was then coded as shown in Table 1. In the end of the semester, according to the self-regulated learning questionnaire (*M*=3.69, *SD*=0.33), the students were divided into a high SRL group (higher than the average, *N*=49) and a low SRL group (lower than the average, *N*=43). After the process of data collection, there were 5,120 actions for high SRL students and 10,709 actions for low SRL students.

2.5 Data analysis

The data was analyzed by hidden Markov models, in which there are several unobservable states generating observable outputs. Each model was consisted of the sets of transition probabilities (the likelihood of students changing states), emission probabilities (the likelihood of students' actions in every state) and initial probabilities (the likelihood of a state as a starting one). In this study, the observable outputs were the students' actions as given variables, while the hidden states were assumed as the students' cognitive and/or metacognitive strategies. In other words, the hidden states of the models were summarized according to the probability distribution of the actions. The models for the high and low SRL groups were computed separately. In order to determine the optimal numbers of states, Bayesian Information Criteria (BIC) was adopted (see Biswas, *et al.*, 2010). The BIC may consider the better fittingness and conciseness of a model. In the end, there were five states for the high SRL group, and four states for the low SRL groups. It was expected that hidden Markov models could help us understand the behavioral patterns in the online academic writing system.

3. Results

3.1 High Self-regulated Learners

In Table 2, the emission probabilities in the hidden Markov model of the high self-regulated learners are shown. For better readability, the probabilities higher than 5% are highlighted. According to the emission probabilities, the five hidden states were named as literature survey & reading, progress planning, progress monitoring, individual paper writing, and paper co-authoring.

- **Literature surveying & reading**: the state was mainly consisted of the actions in getting prepared to explore research status by searching literature, reading papers, and taking notes. This state could be regarded as the component of imitation in creation loops, because the students in this state learnt knowledge from literature and summarize them as reading notes.
- **Progress planning**: the state was consisted of the actions of adding and revising the plans for each chapter. In this state, the students were planning how to compose the article. This state could be regarded as a part of cueing environments in habit loops, because the students in this state prepared how to write their manuscripts before writing.
- **Progress monitoring**: the state was dominated by the actions of checking the plans for chapters. This state could be regarded as another part of cueing environments and harmony in habit loops, because self-monitoring may serve as a behavior facilitator before writing and an achievement accumulator after writing.
- **Individual paper writing**: the state was dominated by the actions of writing papers with self-evaluation. It was noted that this state rarely involved actions related to peers. This state could be regarded as combination in creation loops, because the students in this state composed their own papers by reorganizing or extending their reading notes.
- **Paper co-authoring**: the state was mainly consisted of the actions of providing and receiving comments with minor probabilities of writing papers. This state could be regarded as staging in creation loops, because the students in this state collaboratively composed papers.

Table 2

The Emission Probabilities of the High Self-regulated Learners (%)

States	Surveying				Reading		Goal-setting & Planning		Self-monitoring		Writing		Peer commenting	
	KW-ADD	RS-CHK	LT-ADD	LT-CHK	NT-WRT	NT-CHK	PL-ADD	PL-RVS	PL-CHK	CH-EVL	CH-WRT	CH-RVS	CM-ADD	CM-MNG
Literature surveying & reading	14.38	3.84	10.38	44.26	10.68	10.97	0.00	0.00	2.24	0.42	1.82	0.00	0.30	0.71
Progress planning	0.00	0.00	0.00	1.05	0.00	0.00	21.83	75.04	1.11	0.00	0.00	0.35	0.23	0.38
Progress Monitoring	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	97.85	0.62	0.00	0.39	0.59	0.36
Individual paper writing	0.38	0.04	0.00	0.19	0.00	0.00	0.00	0.00	0.00	8.41	90.11	0.04	0.29	0.54
Paper Co-authoring	0.65	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.28	6.72	9.81	59.51	22.43

The hidden Markov model of high self-regulated learners was illustrated in Figure 2. For better readability, only the transitions with probabilities higher than 5% were shown. In this figure, individual writing and monitoring progress were the two centered states, linked with almost all states, suggesting their importance in the context of self-regulated academic writing.

From the perspective of the IDC theory, the three states about reading and writing could be regarded as the three components in a creation loop, which involved imitation (*i.e.* surveying, reading, and note-taking), combination (*i.e.* individual writing by reorganizing notes and developing arguments), and staging (*i.e.* co-authoring by peer commenting). Basically, the three states were self-transition, revealing that the common nature of reading and writing was immersion. In other words, the students were able to keep in the reading and writing states. Besides, there was a small creation loop between reading literature and writing papers, suggesting that academic reading and writing were not phase-based, but closely connected with each other. Furthermore, self-regulated learners more likely continued writing parts of papers just after reviewing literatures. In the same way, they were also likely back to looking for new literatures when they get stuck in writing papers.

However, although the states of co-authoring might also trigger the states of individual writing, the probability of the reverse transition was lower than 5%. The results implied that the students normally did not want to share their works with others until they were ready. Yet, if they were asked to participate in any forms of staging, the experience could invoke higher willingness to do creation. Additionally, the probabilities of transitions between reading and co-authoring were both lower than 5%. Therefore, although a small creation loop between reading and writing was found, there were not sufficient evidences to identify the complete creation loop in this study.
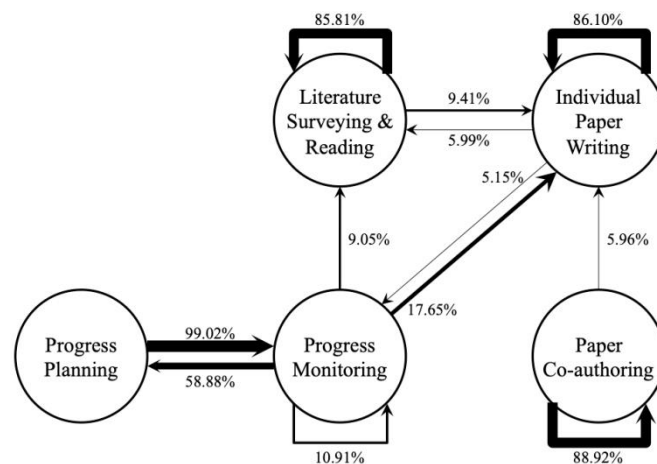

Figure 2. The hidden Markov model of the high self-regulated learners.

On the other hand, if reading and writing were regarded as the routines in a habit loop, then the cueing environment should be self-monitoring evidently in this study. As shown in Figure 2, after monitoring progress, the students had the probability of 17.63% to trigger writing papers, and 9.05% to

trigger surveying and reading more papers. The results could be explained by open learning models (Bull, & Kay, 2007), which explicitly showed learners their working progress and portfolios. In this study, the system displayed their writing progress and self-evaluation in the page of chapter plans (Figure 1(a)). Such an open learner model may not only point out students' efforts and achievements, but also highlight their missing parts, which may further lead them back to reflect themselves and regulate their writing behaviors.

Besides, in the habit loop, after the routine of creation, learners were supposed to feel the sense of harmony or satisfaction. In this study, it was found that the students had probability of 5.15% to go back to the state of progress monitoring after individual writing. The results implied that self-regulated learners tended to reflect how well they just created works in the self-monitoring page. Additionally, the states of monitoring and planning progress were not self-transition, but intertwined. The strong transitions between the two states suggested the dynamics between planning and self-monitoring in self-regulated learning. Furthermore, if self-regulated learners were required to plan their creation, self-monitoring would naturally happen. On the other hand, if self-regulated learners found that their plans were too hard to catch up, they might likely either regulate their learning behaviors or change the plans.

3.2 Low Self-regulated Learners

In Table 3, the emission probabilities in the hidden Markov model of the low self-regulated learners are shown. According to the emission probabilities, the four hidden states were named as literature surveying and reading, progress managing & survey enhancing, paper writing with peers, and peer commenting.

- **Literature surveying & reading**: the state was distributed very similarly with that of high self-regulated learners, so it was named as the same way. The similarity demonstrated that all graduate students, regardless of their self-regulated learning abilities, searched and read papers in the same way.
- **Progress managing & survey enhancing**: the state was mixed of progress planning, progress monitoring and keyword adding. The result implied that the low self-regulated learners might not be able to distinguish their metacognitive strategies in their minds.
- **Paper writing with peers**: the state was consisted of paper writing, evaluation, and receiving comments from co-authors. Unlike those high self-regulated learners' individual writing, the low self-regulated learners tended to modify papers according to co-authors' comments. The reason perhaps was that low self-regulated learners usually had low confidence and thus looked for suggestions when writing.
- **Peer commenting**: the state was majorly consisted of providing comments for and receiving comments from co-authors. This was a state where the learners treated peer commenting as a task, without any connections to writing in their minds.

Table 3

The Emission Probabilities of the Low Self-regulated Learners (%)

States	Surveying				Reading		Goal-setting & Planning		Self-monitoring		Writing		Peer commenting	
	KW-ADD	RS-CHK	LT-ADD	LT-CHK	NT-WRT	NT-CHK	PL-ADD	PL-RVS	PL-CHK	CH-EVL	CH-WRT	CH-RVS	CM-ADD	CM-MNG
Literature surveying & reading	4.24	3.34	10.87	51.01	12.00	14.83	0.00	0.00	1.13	0.07	1.13	0.00	0.90	0.48
Progress managing & survey enhancing	26.73	0.93	0.00	0.91	0.00	0.00	7.82	19.20	42.95	0.14	0.71	0.11	0.50	0.00
Paper writing with peers	0.84	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.75	12.65	74.21	4.86	1.22	5.18
Peer commenting	0.13	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.06	0.35	0.94	0.99	91.26	5.96

The hidden Markov model of the low self-regulated learners was illustrated in Figure 2. Despite the fact that the meanings of the states were slightly different from those of high self-regulated learners, the model of low self-regulated learners was basically a subset of that of high self-regulated learners. However, there were no evident loops like those in the model of high self-regulated learners. In Figure 2, it was noticed that the state of paper writing (with peers) was triggered by the other three states. In a sense, these low self-regulated learners might be performance goal oriented instead of mastery goal oriented in terms of achievement goal orientation theory (see Elliot, & McGregor, 2001). Performance goal oriented learners tended to get motivated by the perceived performance and to strive for outperforming others, while mastery goal oriented learners tended to develop their abilities. In other words, in this study, the low self-regulated learners likely read literature, monitor progress and providing comments just for writing papers. The behaviors of self-regulation did not seem evident in the model of the low self-regulated learners.

Figure 3. The hidden Markov model of the low self-regulated learners.

4. Concluding Remarks

In this paper, we built two hidden Markov models of academic writing behaviors for graduate students with high and low self-regulated learning strategies. The two models shared a common hidden state named literature surveying & reading, suggesting that they all gathered information from academic papers in the same way. The two models also demonstrated that the states of literature surveying & reading, paper writing, and peer comments were all self-transition with high probabilities. We believed that the models captured the students' immersions in the three behaviors, which could be regarded as the three components (*i.e.* imitating, combining, staging) in a creation loop from the perspective of the IDC theory. In other words, if students were engaged in these activities of creation, they would naturally keep doing it.

Except these commonalities, the two models had the following dissimilarities, suggesting the characteristics of self-regulated learners in the context of academic writing. First, the high self-regulated learners tended to writing papers alone, while the low self-regulated learners preferred writing papers with others' comments. Second, when doing peer commenting, the high self-regulated learners tended to relate peer commenting with their writing, while the low self-regulated learners preferred treating peer commenting as an independent task. Third, when self-monitoring, the high self-regulated learners had two separate but intertwined mental states, *i.e.* progress monitoring and progress planning, while the low self-regulated learners mixed monitoring, planning, and survey enhancing together in their minds. Fourth, there was a small version of a creation loop between literature reading and writing in the model of the high self-regulated learners, while there was no evident creation loop in the model of the low self-regulated learners. Fifth, there was also a habit loop between progress monitoring and paper writing in the model of the high self-regulated learners, while no habit loop was found in the model of the low self-regulated learners. Therefore, we may conclude that the high self-regulated learners might be mastery goal oriented, while the low self-regulated learners seemed performance goal oriented.

From the perspective of the IDC theory, although we might have identified several behavioral evidences of loops, such as immersing in an interest loop, imitating and combining in a creation loop, as

well as a cueing environment and routine in a habit loop, there were still missing parts in this study. First, about the anchored concept of interest, the current activity of academic writing lacked the explicit design of a whole interest loop. In this study, these graduate students were required to submit their manuscripts with necessary preparation every week. Though, they were allowed to decide the topics of their papers. Second, about the anchored concept of creation, although we found that peer commenting as a component of staging could lead to writing, there were no evident transitions from writing to peer commenting and then from peer commenting to reading like in an ideal creation loop. Therefore, because the loop would not happen itself, educational designers should make the process more visible. For example, students should be required to provide and receive comments after writing, and to go back to survey and read papers after participating in bigger staging. By doing so, a virtuous cycle would naturally happen. Third, about the anchored concept of habit, we found that self-monitoring could facilitate the routines of reading, writing, and planning. We also found that writing could facilitate self-monitoring. Although a habit loop seemed existed, it was still hard to prove the third component of harmony in the habit loop. We did not yet know whether the students had a sense of satisfaction, achievement or even harmony after writing. Perhaps we should operationalize the concept of harmony first, so that we could start to evaluate students' minds when they finished the routine of creation.

Acknowledgements

References

Biswas, G., Jeong, H., Kinnebrew, J. S., Sulcer, B., & Roscoe, R. D. (2010). Measuring self-regulated learning skills through social interactions in a teachable agent environment. *Research and Practice in Technology Enhanced Learning*, *5*(2), 123-152.

Bull, S., & Kay, J. (2007). Student models that invite the learner in: The SMILI: Open learner modelling framework. *International Journal of Artificial Intelligence in Education*, *17*(2), 89-120.

Chan, T. W., Looi, C. K., Chen, W., Wong, L. H., Chang, B., Liao, C. C. Y., *et al.* (2018). Interest-driven creator theory: towards a theory of learning design for Asia in the twenty-first century. *Journal of Computers in Education*, *5*(4), 435-461. https://doi.org/10.1007/s40692-018-0122-0

Chang, B., Shih, Y. A., & Huang, T. C. (2017). Creation loop example of IDC theory: CoCoing.info. In Y. Hayashi, *et al.*, (Eds), *Workshop Proceedings of 25th International Conference on Computers in Education: Technology and Innovation: Computer-Based Educational Systems for the 21st Century, ICCE 2017* (pp. 381-386). Asia-Pacific Society for Computers in Education.

Chen, Z. H., Chi, P. Y., & Ciou, H. J. (2017). Applying interest loop to develop game-based model for Chinese character learning. In Y. Hayashi, *et al.*, (Eds), *Workshop Proceedings of 25th International Conference on Computers in Education: Technology and Innovation: Computer-Based Educational Systems for the 21st Century, ICCE 2017* (pp. 372-375). Asia-Pacific Society for Computers in Education.

Daw, N. D., Niv, Y., & Dayan, P. (2005). Uncertainty based competition between prefrontal and dorsolateral striatal systems for behavioral control. *Nature Neuroscience, 8*, 1704-1711.

Elliot, A. J., & McGregor, H. (2001). A 2 × 2 achievement goal framework. *Journal of Personality and Social Psychology*, *80*, 501-509.

Kizilcec, R. F., Pérez-Sanagustín, M., & Maldonado, J. J. (2017). Self-regulated learning strategies predict learner behavior and goal attainment in Massive Open Online Courses. *Computers & Education*, *104*, 18-33.

Liao, C. C. Y., Chang, W. C., Cheng, H. N. H., & Chan, T. W. (2017). Cultivating students' writing habit in a game-based learning environment. In Y. Hayashi, *et al.*, (Eds), *Workshop Proceedings of 25th International Conference on Computers in Education: Technology and Innovation: Computer-Based Educational Systems for the 21st Century, ICCE 2017* (pp. 376-380). Asia-Pacific Society for Computers in Education.

Singh, M. K. M. (2015). International Graduate Students' Academic Writing Practices in Malaysia: Challenges and Solutions. *Journal of International Students*, *5*(1), 12-22.

Wood, W., & Neal, D. T. (2007). A new look at habits and the habit-goal interface. *Psychological Review, 114*(4), 843-863.

Zimmerman, B. J. (2002). Becoming a self-regulated learner: an overview. *Theory into Practice*, *41*(2), 64-70.

Developing digital game-based learning system for the acquisition of Chinese characters in primary education: An interest-driven creator (IDC) theory perspective

Wen-Yi LIU[*] & Zhi-Hong CHEN

Graduate Institute of Information and Computer Education, National Taiwan Normal University, Taiwan

*898080048@ntnu.edu.tw

Abstract: Due to the vast amount of and the complexity of Chinese characters, practice by handwriting is a common and effective strategy in the primary stage of literacy education. Nevertheless, students regard the practice as tedium or labor work, and this mental load leads them to lost interest in practicing to copy and write the characters in the assignments. To further promote students acquisition of Chinese characters, sustaining their interest of practicing acts an important role in the learning process. Therefore, the aim of the current study is to develop a game-based learning system to support students practice by handwriting in a joyful rather than uninterested manner. Under the perspective of interest-driven creator (IDC) theory, the proposed game, called character monster, was designed according to one of three anchored loops: interest loop. The corresponding features with respect to three elements (i.e., triggering interest, immersing interest, and extending interest) are presented in detail. In addition, to examine the effects of the learning system, the experimental design is also identified.

Keywords: Chinese character, game-based learning, interest-driven

1. Introduction

Chinese is the main subject in both primary and secondary educational system in Mandarin-speaking areas, and the acquisition of the characters is the essential foundation of mastering the other language skills of Chinese. Due to the vast amount of and the complexity of Chinese characters, there are some commonly used strategies, such as writing in air with an index finger, copying with a pen, and pronouncing their sounds, when students begin learning to write Chinese characters (Hao et al., 2010). Prior studies (e.g., Longcamp, Boucard, Gilhodes, & Velay, 2006) indicated that handwriting would be a sort of perceptual-motor skill and this motor activity could beneficially contribute to memory retention. Because every characters comprised individual shape, pronunciation, and explanation, students are requested to memorize relevant information embedded in the target characters (Shen, 2005). Therefore, sustaining practice is necessary for mastery of Chinese characters handwriting and supportive to word recognition.

However, students regarded such repeated practices as tedious and laborious works, and this situation often tackled them and resulted in counter-effect such as having no intention or interest to do (Zahradníková, 2016). In addition to cognitive aspect, the factors in affective aspect are also imperative for teaching and learning. Previous evidence-based empirical studies revealed that there exists a positive correlation between school achievement and subject-specific interest (Jansen, Lüdtke, & Schroeders, 2016). If a learner lost interest in the learning of specific subject matter, he/she would be less willing to engage in the learning tasks corresponding to such subject. In other words, the development of interest would be taken into account for school curriculum, since interest may directly involve students' concentration, engagement, and experiences (Harackiewicz, Smith, & Priniski, 2016).

It is noted that interest promotes deeper learning. Hidi and Renninger (2006) further pointed out that interest can be conceptualized into two categories involving situational and individual interest. Yet, there had been certain theoretical perspectives to interpret how to cultivate individual interest (stable

state of personal preference) from situational interest (temporary state of environmental factors). More recently, a group of Asian scholars put forth an interest-driven creator (IDC) theory (Chan et al., 2018; Wong et al., 2015) and implemented into practical domains under the affordance of technology such as the learning of mind-mapping (Chang, Shih, & Huang, 2017) and programming education (Kong & Li, 2016).

With the progressive advancement of emergent technology, game-based technology is one of energetic tools for boosting active participation and immersive engagement (Jabbar, Azita, & Felicia, 2015). That is to say, the game-based learning environment probably draws students' concentration and further facilitates learners' task engagement. Therefore, integrating game-based technology into the context potentially become a promising approach to support the learning of Chinese characters. Designed by the viewpoint of the IDC theory, this study aimed at both improving performance and sustaining interest through incorporating game-based learning system into the process of Chinese characters learning.

2. Development of game system: Character Monster

2.1 Radical-Oriented Design Approach

The Chinese characters are well-known for the logographic properties of their components and structures. The stroke is the basic unit of the Chinese character, since each character is structurally assembled by various kinds of strokes into a square-block space. Every character comprises three components: shape, pronunciation, and meaning. In terms of the functional contributions, the radical, central component of certain character, comprise semantic and phonetic part which represents the underlying meaning and the pronunciation guidance respectively. Over 80% of characters are phono-semantic compound characters, hence knowing the radical information would help understand a group of similar characters (Chen et al., 2013). While students are gradually taught how a character was combined and to develop the structural awareness of a character, they can probably memorize Chinese characters in a systematized way (Shen, 2004).

One of the effective way of introducing characters is to focus on the radical structure initially, and make connections between the radicals and characters (Taft & Chung, 1999). Different from the tradition method, the radical-oriented approach was utilized to design the character monster (a virtual role) and relevant deriving characters are the food of these monsters. Table 1 summarized three examples of character monsters with regard to corresponding radicals and their deriving characters (with the same radical) as well as the attributes in common. It is worth noting that each character monster is designed according to its radical knowledge and related attributes. This design approach affords intuitive information about the radical, and helps evoke the students' curiosity directly.

Table 1

Character monster, corresponding radical, and deriving characters

Monster	Radical	Deriving characters			Attribute in common
Gold-radical	金(gold)	釘(nail)	銀(silver)	錢(money)	mental material
Rain-radical	雨(rain)	雷(thunder)	霜(frost)	霧(fog)	weather phenomenon
Clothes-radical	衣(clothes)	衫(shirt)	袖(sleeve)	褲(pants)	made of cloth

2.2 Conceptual Framework and Game-Based Model

Prior research results have revealed that games could enhance subject learning, since games offered learners with visual-audio effects and immersive experience, but the design of educational game should take the suitable learning content into account (Jabbar, Azita, & Felicia, 2015). In the current study, we attempted to purposely develop a digital game by implanting "monster-feeding equals to characters-writing" notion as the part of game scenarios to support students in promoting language learning outcomes in both cognitive (e.g., achievement performance) and affective (e.g., attitude and interest) aspects. Specifically, the proposed game system was developed according to one specific anchored loop — interest loop — in IDC theory.

Figure 1 illustrated the interest loop (the referred conceptual framework) and game-based model. The interest loop comprises three elements, namely triggering interest, immersing interest, and extending interest (Chan et al., 2018; Wong et al., 2015). In terms of the triggering interest, the students' interest is aroused by character monster's appearance. The student can hold a monster and accompany him/herself in gaming context. Since every character monster is designed individually in accordance with their radical knowledge and relevant features, and each one is appealing with different outer shape so that these monsters could attract students' attention and evoke their curiosity initially.

In terms of the immersing interest, the learning tasks involve mainly in writing characters on behalf of feeding character monsters. In other words, these written-produced character by handwriting (belong to certain radical) would become the food of one radical-specific character monster within the game scenario. At this time, the students would become more willing to engage themselves in writing characters so as to strengthen the ability of the character monsters by feeding food (i.e., accomplishing the handwriting tasks).

In terms of extending interest, the students can continue readily to collect and further feed the other character monsters. After sufficiently attending the game levels, the students can choose to enter the arenas. The arenas offer three-stage modules, namely single, collaborative, and challenge. The reward mechanism designed in the game scenario also supportively holds the joyfulness and inspires the students keep on partaking the game-play. The activities, designed in accordance with interest loop, are cyclically implemented, and enhance students learning of Chinese characters.
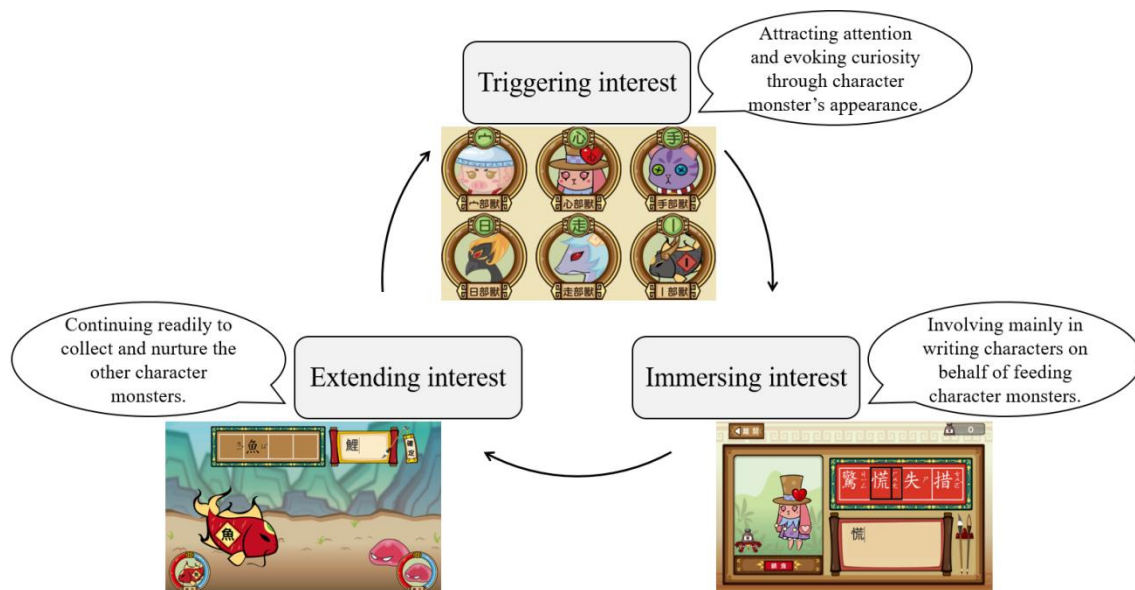

Figure 1. Interest loop and game-based model.

3. Experimental design

3.1 Participants and Settings

The participants in this study are fifty fifth graders (native speakers of Chinese) at an elementary school. Two intact classes are randomly assigned as the experimental group (n = 25) and control group (n = 25). The students in experimental group receive the digital game-based learning system (Character Monster), and every student is equipped with a mobile device (i.e., tablet PC) to afford learning engagement, while those in control group receive the conventional instructions.

The target characters are adopted from the Chinese textbook used at the chosen elementary school. To examine the effectiveness of the game-based learning system, the long-term intervention is needed. The duration of the experimental procedure will last for eight weeks, and the frequency of the intervention is two periods per week and each period is around forty minutes.

3.2 Research Instruments

The dependent variables we concerned are performance and interest, so the achievement test and interest questionnaire are developed by authors to act as research instruments.

The achievement test consisted of three section with full mark 60 points. The sections involve identification of radical, orthography of character, and semantic meaning of radical-related characters. The orthography of character is finished by handwriting with pen, while the other two sections are measured in the form of multiple choices.

The interest questionnaire is designed based on the three dimensions of interest loop in IDC theory. Nine items in total are included in the survey with a 5-point Likert's scale, and every dimension involves three items. The triggering interest refers to the evoking of curiosity, while immersing interest is similar to the state of flow experience, and extending interest means the willingness to re-partake. The item examples of the interest questionnaire are shown in Table 2.

Table 2

Item Example of Interest Questionnaire

Dimension	Description of item
Triggering interest	Using the learning system can arouse my curiosity towards the knowledge of radical and character.
Immersing interest	Compared to general case, when using the learning system to write characters, time passes faster than I think it does.
Extending interest	If given another opportunity, I am willing to spend more time in how to write characters by using the learning system.

4. Conclusions and future works

This study presented a conceptual framework and game-based model on the basis of interest-drive creator (IDC) theory, and incorporated the attributes of tablet PC technology for handwriting and the characteristics of Chinese characters. In the developed game-based learning system, it is expected that the students are able to practice handwriting and learn the Chinese characters in a joyful manner. Additionally, more practical experiments are required to examine the proposed framework and model in the future.

Acknowledgements

References

Chan, T. W., Looi, C. K., Chen, W., Wong, L. H., Chang, B., Liao, C. C., ... & Jeong, H. (2018). Interest-driven creator theory: towards a theory of learning design for Asia in the twenty-first century. *Journal of Computers in Education*, *5*(4), 435-461.

Chang, B., Shih, Y. A., & Huang, T. C. (2017). Creation loop example of IDC theory: CoCoing.info. In Y. Hayashi, T. Supnithi, M. Mathews, S. L. Wong, A. F. Mohd Ayub, A. Mitrovic, W. Chen, ... J. C. Yang (Eds.), *Workshop Proceedings of the 25th International Conference on Computers in Education* (pp. 359-364). New Zealand: Asia-Pacific Society for Computers in Education.

Chen, H. C., Hsu, C. C., Chang, L. Y., Lin, Y. C., Chang, K. E., & Sung, Y. T. (2013). Using a radical-derived character e-learning platform to increase learner knowledge of Chinese characters. *Language Learning & Technology*, *17*(1), 89-106.

Hao, Y., Hong, J. C., Jong, J. T., Hwang, M. Y., Su, C. Y., & Yang, J. S. (2010). Non-native Chinese language learners' attitudes towards online vision-based motion games. *British Journal of Educational Technology*, *41*(6), 1043-1053.

Harackiewicz, J. M., Smith, J. L., & Priniski, S. J. (2016). Interest matters: The importance of promoting interest in education. *Policy Insights from the Behavioral and Brain Sciences*, *3*, 220-227.

Hidi, S. & Renninger, K. A. (2006). The four-phase model of interest development. *Educational psychologist*, *41*(2), 111-127.

Jabbar, A., Azita, I., & Felicia, P. (2015). Gameplay engagement and learning in game-based learning: A systematic review. *Review of Educational Research*, 85(4), 740-779.

Jansen, M., Lüdtke, O., & Schroeders, U. (2016). Evidence for a positive relation between interest and achievement: Examining between-person and within-person variation in five domains. *Contemporary Educational Psychology*, *46*, 116-127.

Kong, S. C., & Li, P. (2016). The interest-driven creator theory and coding education. In D. Gao, Y. T. Wu, T. W. Chan, S. C. Kong, M. H. Lee, J. C. Yang, J. L. Shih, J. C. Hong, J. Shang, K. H. Cheng, & S. Y. Chen (Eds.), *Workshop Proceedings of the 20th Global Chinese Conference on Computers in Education* (pp. 116-119). Hong Kong: The Hong Kong Institute of Education.

Longcamp, M., Boucard, C., Gilhodes, J. C., & Velay, J. L. (2006). Remembering the orientation of newly learned characters depends on the associated writing knowledge: A comparison between handwriting and typing. Human Movement Science, 25, 646-656.

Shen, H. H. (2004). Level of cognitive processing: Effects on character learning among non-native learners of Chinese as a foreign language. *Language and Education*, *18*, 167-182.

Shen, H. H. (2005). An investigation of Chinese-character learning strategies among non-native speakers of Chinese. *System*, *33*, 49-68.

Taft, M., & Chung, K. (1999). Using radicals in teaching Chinese characters to second language learners. *Psychologia*, *42*, 243-251.

Wong, L. H., Chan, T. W., Chen, Z. H., King, R. B., & Wong, S. L. (2015). The IDC theory: Interest and the interest Loop. In T. Kojiri, T. Supnithi, Y. Wang, Y. T. Wu, H. Ogata, W. Chen, S. C. Kong, & F. Qiu (Eds.), *Workshop Proceedings of the 23rd International Conference on Computers in Education* (pp. 804-813). Hangzhou, China: Asia-Pacific Society for Computers in Education.

Zahradníková, M. (2016). A qualitative inquiry of character learning strategies by Chinese L2 beginners. *Chinese as a Second Language*, *51*(2), 117-137.

WORKSHOP 6 - The 10th International Workshop on Innovative Designs for Mobile and Ubiquitous Learning: 1:1 and Beyond

A System for Finding and Improving the Relevant Contents of Digital Textbooks based on Quizzes' Contents

Lingyu LI[a]*, Noriko UOSAKI[b], Kousuke Mouri [c], Chengjiu YIN [a]
[a]*Kobe University, Japan*
[b]*Osaka University, Japan*
[c]*Tokyo University of Agriculture and Technology, Japan*
*lilingyu0311@gmail.com

Abstract: In this paper, we developed a digital textbook content improvement system, which can help teachers to find and improve the relevant content of digital textbook objectively based on the contents of quizzes. Based on the DITeL system, we have designed two modules of the system configuration. The first part includes the functions such as registration, modifications and deletions of the contents of questions, optional items and students' answers, and the calculation and display of average grades ratio about questions which have been answered by students. The second part is based on the question and the correct answer, automatically to search relevant page about the digital textbook. We aim to use the system that students can take quizzes in every lesson to test the level of mastery of their knowledge. And teachers can find which questions that students got lower scores, and which the contents of relevant page about the digital textbook need to be improved.

Keywords: digital textbooks, quizzes, educational data mining, system configuration

1. Introduction

In recent years, with the development of e-publishing technologies for communications and learning, many educational institutions have been investigating and implementing e-learning systems. So more and more traditional textbooks have been replaced by digital ones (Rainie, et al., 2012, Yin et al., 2014). By 2020, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) is scheduled to change all the traditional textbooks for elementary, middle, and high schools into digital textbooks in Japan (Yin et al., 2015).

In the past decades, various studies have been conducted to investigate the effectiveness of learning with digital textbooks (Hezroni, 2004; Reinking, 1997; Snyder, 2002; Yin et al., 2017). In previous studies, a digital textbook system has been developed to collect textbook reading data such as "turning to next/previous page", "memo", "zoom in/out", "adding marker". The system is named as digital textbook for improving teaching and learning (DITeL). Teachers and students can use the system and read the digital textbook by using mobile devices such as iPad, iPhone, and Android (Yin et al., 2017, Yin & Yamada et al., 2018).

It is very convenient to use digital textbooks to learn by using mobile devices (Yin et al., 2010). However, many of these digital textbooks were created based on the authors' experience in a subjective manner. Therefore, the problem is how the contents of digital textbooks can be evaluated and improved (Yin & Hwang et al., 2018). Digital textbooks have become a potentially effective pedagogic tool for supporting teaching, learning and scholarship. Therefore, how to measure the quality of digital textbooks, and how to evaluate and improve the content of digital textbooks become very important issues (Yin et al., 2016).

In this paper, based on the DITeL system, we developed a new system, which can help teachers to improve their teaching contents in a much more objective manner based on the students' test scores, and the relevant contents to the questions which can be searched automatically. We named the system as DITeL2. According to the modules of the system configuration, we have designed two parts. The first part is the registration, modifications and deletions of the contents of questions,

optional items and students' answers. And the calculation and display of average grades ratio about questions which have been answered by students. The second part is automatic search for the relevant pages of the digital textbook based on the questions and the correct answers.

The students can take quizzes in every lesson to grasp their comprehension level by using our system. And teachers can grasp which parts of their teaching materials were difficult for their students by their test scores. If the average score of a question is very low, through the data mining technology, the DITeL2 can find the relevant learning contents from the digital textbooks, and feedback the learning contents to the teachers. The teachers can review whether the relevant learning content of the digital textbooks needs improvement. If they consider that the relevant learning contents were not explained well, then the teachers can improve the contents themselves.

2. Literature Review

Data analysis is an internal step in the process of data collection (Yin, Hirokawa, et al., 2013; Yin, Sung, et al., 2013). Our system collects data automatically while the learner is using the system.

2.1 Previous Studies of Data Collection Research on Digital textbooks

There have been some studies on distribution systems of digital learning materials where questionnaire surveys were conducted on their usability (Siegenthaler et al., 2010). There are also some researches conducted which examined the efficacy of digital textbooks compared with traditional paper-based textbooks in terms of the improvement of their reading skills, reading comprehensions, and reading strategies (Daniel et al, 2013; Anton et al., 2013; Nelson & O'Neil, 2001) as well as some researches on technological literacy concerning reading and writing skills (Ihmeideh et al, 2014).

There have been very few researches conducted so far to improve digital textbook by using massive learning data (Yin et al., 2016). Although, there are a few researches were conducted to improve digital textbook by using learning data. For example, Bakia and Güvelib (2008) proposed to improve a web-based mathematics teaching materials by collecting data such as attitude scale, interviews, field observations. But, the sample data is very small. And these qualitative and quantitative data were collected from the sample, consisting of eighteen teachers and eighty students.

2.2 Previous Studies of the Digital Textbook System

In the previous study, we proposed and designed the Quizzes based system to measure the contents of digital textbooks (Yin et al., 2016), we have already confirmed that by using our algorithm, the relevant learning contents of quizzes can be found.

In this paper, by using the algorithm and based on DITeL system, we developed a new system DITeL2. The DITeL2 can find the relevant learning contents from the digital textbooks, and feedback the learning contents to the teachers.

3. System Configuration

On the basis of the web-based digital textbook system using the e-pub format (Yin et al., 2017), we added some new functions that they can help teachers to improve the digital textbook in a much more objective manner based on the students' test scores.

As shown in Figure 1, this system configuration, there are two modules: one is for finding which questions that students got the lower scores, another is for searching relevant contents automatically (Yin et al., 2016).
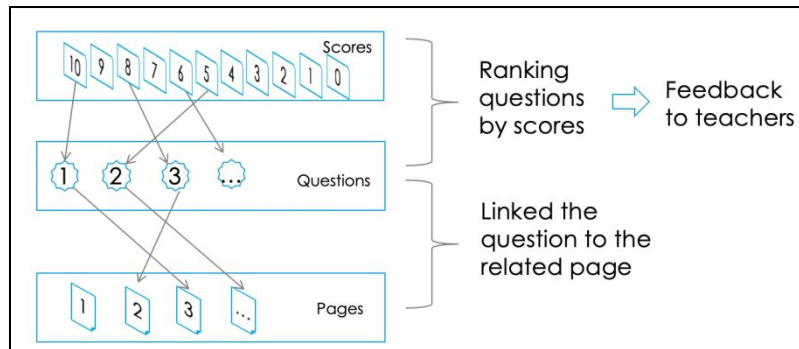
Figure 1. System Configuration

3.1 Question Scores Ratio Ranking Module

This module is used to find which question's average score ratio is lower. The average score ratio will be calculated for each question by using the following formula.

   QASR (Question's Average Score Ratio) means the average score ratio of one question.
   SCQ (Sum of the Scores of Question) means the summary of all the students' scores of the question.
   CS (Counter of Students) means the count of all the students who have answered.

$$QASR = (SCQ/ CS)*100$$

3.2 Searching Content Module

The "lucene-gosen" was used to analyze what is relevant content to the digital textbook based on the questions of quiz. The "lucene-gosen" is a Japanese morphological analyzer. It creates index files based on the pages of the digital textbook, and then creates a search engine. In our study, the content of every question and correct options in a quiz, are seen as a search query. Using the search engine, we can find the relevant pages of a question. Then we link the question to the relevant pages in the digital textbook.

4. System Implementation

Figure 2 shows the main interface of DITeL2 for teachers. There are two new features in the DITeL2: one is for creating quizzes, another one is for automatic searching for the relevant pages of the digital textbook based on the questions of quiz.
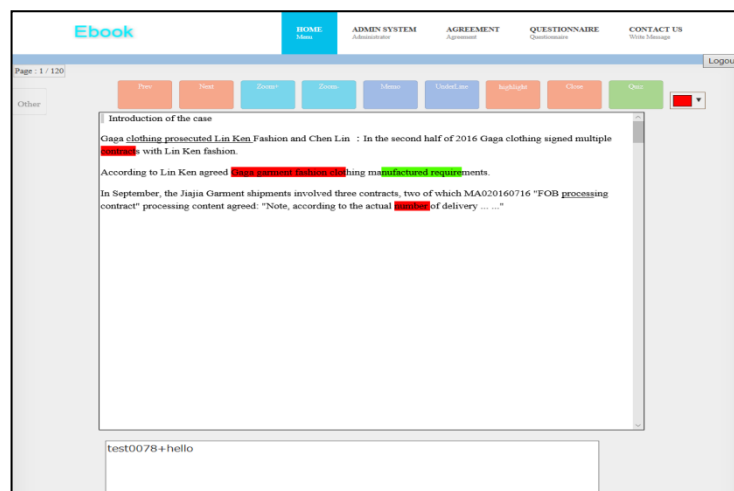

Figure 2. Teacher interface of DITeL2

4.1 The Interface for Creating Quizzes

In the first part, we designed three functions to register the contents and options of the quizzes, and the student's answers. So, teachers can design and build quizzes consisting of various types of questions, including single choice and true-false questions. And students can take quizzes in every lesson. These questions, options and answers are kept in separate tables on the database. The records of the answers are used to calculate the quiz scores, which are the percentage of average grades.

4.1.1 The Teachers' Interface for Creating Quizzes

In this function, teachers can insert the contents of questions and the IDs of correct answers to the questions, and the registered contents also include course IDs, textbook IDs (Figure 3). So that students can find the quiz they need to answer based on them. We can also modify and delete the questions that have already been registered. If somebody answers the question, the quiz scores ratio of the question will also be displayed.

Figure 3. The list of questions

Teachers can insert the optional items of the questions, and these optional items can be used in different quizzes. We can also modify and delete the optional items that have already been registered.

4.1.2 The Students' Interface for Answering the Questions

In this function, students can find the quizzes they need to answer based on the course IDs and digital textbook IDs. Every time the students answer the quizzes, their scores are calculated and registered into the grade table of the students (Figure 4). They can also check the correct answers of the quizzes they took.

Figure 4. Questions that students need to answer

4.2 The Interface for Finding Relevant Contents by using Questions

In this part, according to the method described in the second module of the system, this function is designed to show the relevant pages. When you click on the "Page Correlation" button of every question on the questions list (Fig. 5).

Figure 5. The relevant Pages

Then, the teacher can view which pages of the digital textbook the question is related to, and based on the student's quiz scores, the digital textbook can also be objectively modified.

5. Conclusion and future work

In the previous study, we designed an algorithm for finding the related digital textbook's pages to the quizzes. In this paper, based on the algorithm (Yin et al., 2016), we have developed a system DITeL2 to find the related pages of digital textbook to the questions of quizzes. The system has two new features: creating quizzes and finding the relevant contends of the quizzes from the digital textbooks.

Through the system, the teachers can create quizzes, and students can take a quiz in every lesson to test the level of mastery of their knowledge. According to the contents of the question of the quizzes, DITeL2 can find which contents have relevant with the question. If the grades ratio of the question is lower, the system can feedback the relevant learning contents to the teachers, and teachers can go to the relevant learning contents and revise the contents.

There are still many areas to be improved in our system. In the future, we will improve the system and apply it to the classroom to evaluate the effectiveness of the system.

Acknowledgements

References

Anton, C., Camarero, C., and Rodriguez, J. (2013). Usefulness, Enjoyment, and Self-Image Congruence: The Adoption of e-Book Readers, Psychology and Marketing, vol. 30, no. 4, pp.372–384.

Bakia,A., Güvelib, E.(2008). Evaluation of a web based mathematics teaching material on the subject of functions, Computers & Education, vol.51, no.2, pp.854–863.

Daniel, D. B., et al. (2013). E-textbooks at what cost? Performance and use of electronic v. print texts, Computers & Education, 62, pp. 18–23.

Hezroni, O. E. (2004). Literacy and assistive technology for children with special needs. Script, 7-8, 195–218, (Hebrew).

Hwang, G.J., Yang, T.C., Tsai, C.C., Yang, S. J.H. (2009). A context-aware ubiquitous learning environment for conducting complex science experiments, Computers & Education, 53, pp.402-413.

Ihmeideh, F. M. (2014). The effect of electronic books on enhancing emergent literacy skills of pre-school children. Computers & Education, 79, pp. 40–48.

Li, L.Y., Uosaki, N., Ogata, H., Mouri, K., and Yin, C. (2018). Analysis of Behavior Sequences of Students by Using Learning Logs of Digital Books. Proc. of 26th International Conference on Computers in Education 2018, Manila, Philippines, Nov. 26–30, pp. 367–376.

Nelson, L., & O'Neil, F. (2001). Electronic monographs in the academic library: an implementation story. LASIE, 32, pp.13–20.

Rainie, Lee, Kathryn Zickuhr, Kristen Purcell, Mary Madden, and Johanna Brenner (2012). The rise of e-reading. Washington D.C: Pew Research Center's Internet & American Life Project. http://libraries.pewinternet.org/2012/04/04/the-rise-of-e-reading/

Ren, Z., Uosaki, N., Kumamoto, E., Liu, G.Z. and Yin, C. (2017). Improving teaching materials through digital book reading log, Proc. of the International Conference on Advanced Technologies Enhancing Education, Qingdao, China, pp.90-96.

Reinking, D. (1997). Me and my hypertext: a multiple digression analysis of technology and literacy (sic). The Reading Teacher, 50, 626–643.

Siegenthaler, E., et al., Improving the usability of e-book readers. Journal of Usability Studies,6(1), pp.25–38, 2010.

Snyder, I. (2002). Silicon literacies: Communication, innovation and education in the electronic age. London: Routledge.

Yin, C., Ogata, H., Tabata, Y. and Yano, Y. (2010). Supporting the acquisition of Japanese polite expressions in context-aware ubiquitous learning, Int. J. Mobile Learning and Organisation, Vol. 4, No. 2, pp.214–234.

Yin, C., Okubo, F., Shimada, A., Kentaro, K., Yamada, M., Ogata, H., Fujimura,N.(2014). Smart phone based data collecting system for analyzing learning behaviors, Proc. of International Conference of Computers on Education, Nara, Japan, pp. 575–577.

Yin, C., Okubo, F., Shimada, A., Oi, M., Hirokawa, S., Yamada, M., Ogata, H. (2015). Identifying and analyzing the learning behaviors of students using e-books. In: Ogata, H. et al. (Eds.) *Proc. of 23rd International Conference on Computers in Education.* Hangzhou, China: Asia-Pacific Society for Computers in Education, pp. 118–120.

Yin, C., Hirokawa, S., Yau, J., Nakatoh, T., Hashimoto, K. & Tabata, Y. (2013). Analyzing research trends with cross tabulation search engine. Int. Journal of Distance Education Technologies, vol. 11. no.1, pp. 31-44.

Yin, C., & Hwang, G. J. (2018). Roles and strategies of learning analytics in the e-publication era. *Knowledge Management & E-Learning*, *10*(4), pp. 455–468.

Yin, C., Sung, H.Y., Hwang, G.J., Hirokawa, S., Chu, H.C., Flanagan, B., & Tabata, Y. (2013). Learning by searching: a learning approach that provides searching and analysis facilities to support research trend surveys, Journal of Educational Technology & Society, vol. 16, no. 3, pp. 286–300.

Yin, C., Uosaki, N., Chu, H., Hwang, G., Hwang, J., Hatono, I. et al. (2017). Learning Behavioral Pattern Analysis based on Students' Logs in Reading Digital Books. Proc. of 25th International Conference on Computers in Education 2017, Christchurch, New Zealand, Dec. 4–8, 549–557.

Yin, C., Yau J.Y.-K., Uosaki, N., Hirokawa, S., & Kumamoto, E. (2016). Measuring & evaluating digital textbooks through quizzes. Proc. of the 24th International Conference on Computers in Education, Mumbai, India, 374–379.

Yin, C., Yamada, M., Oi, M., Shimada, A., Okubo, F., Kojima, K., & Ogata, H. (2018). Exploring the relationships between reading behavior patterns and learning outcomes based on log data from e-books: A human Factor Approach. *International Journal of Human–Computer Interaction*, *35*(4–5), 313–322. DOI: 10.1080/10447318.2018.1543077

Supporting Japanese Language Learners with an Onomatopoeia Learning Site

Noriko UOSAKI [1], Pengcheng DAI[2], Hye Rin KONG[3], Jacky Chun Kit LAM, and Mehrasa ALIZADEH[1]

[1] Osaka University, Osaka, Japan
[2] Peking University, Beijing, China
[3] Hanyang University, Seoul, Korea
[4] Delft University of Technology, Delft, Netherlands
n.uosaki@gmail.com

Abstract: This paper describes our study where we aim to support onomatopoeia learning for Japanese language learners using our developed website called SLL Ono (To See, to Listen, to Learn onomatopoeia). The lack of English proficiency of Japanese people has been pointed out for a long time. Therefore it is a must for foreigners to have a Japanese language skill to survive in Japan. The focus in our study is onomatopoeia learning since there are more than 4,500 onomatopoeia words in Japanese. The result of our pilot evaluation shows that there was no statistically significant difference between our system and the blogger site. However the mean score increased more when they learned with SLL Ono and 15 out of 16 participants preferred our system. It was found that our automatically generated quiz function did not work effectively enough and that the refinement of the learning contents was necessary. It is among our future works to improve our quiz system and add more contents in order to improve quiz efficiency and to enrich its contents.

Keywords: Onomatopoeia learning support, Japanese language learning, blogger

1. Introduction

According to Ministry of Health Labour and Welfare, there are 1,460,463 foreign workers working in Japan as of October 31, 2018 (https://www.mhlw.go.jp/stf/newpage_03337.html). In addition, JASSO (Japan Student Services Organization) announced that 298,980 international students are studying in Japan as of May 1, 2018 (https://www.jasso.go.jp/about/statistics/intl_student_e/2018/index.html).

Japanese language skill is a necessity in order to live in Japan because of the low English proficiency of Japanese people. EF English Proficiency Index (2018) indicates that Japan is categorized the countries with low English proficiency (https://www.ef.com/ca/epi/). In fact, many foreign students in Japan reported the inability of Japanese local people to communicate in English as one of their biggest culture shocks. According to the questionnaire conducted in one of the authors' class held in a university in western Japan, 14 out of 15 reported that local people in Japan did not understand their English when they talked to them in English. One student reported she had never talked to local people in English. Therefore, Japanese language ability is a must in order to survive in Japan. One of the characteristics of Japanese language is that it is rich in onomatopoeia, especially when it is spoken. According to the "Japanese Onomatopoeia Dictionary" (Ono, 2007), there are more than 4,500 onomatopoeia words in Japanese. It indicates how commonly they are used by Japanese speakers in their daily lives.

2. Motivation

There are mainly two types of onomatopoeia in Japanese: 'giongo' (phonetic expressions that imitate real sounds such as 'wan-wan', the sound of a dog similar to bow-wow in English) and 'gitaigo' (mimetic expressions of states in which no sounds are produced such as 'waku-waku' meaning being

excited). The latter one is occasionally translated into English as 'mimicry', but in this paper, we define 'Japanese onomatopoeia' as Japanese 'giongo' and 'gitaigo' with the following reasons:
(1) there is no actual equivalence of 'gitaigo' in English,
(2) 'onomatope'(オノマトペ), the phonetic translation of the English word 'onomatopoeia', includes both 'giongo'and 'gitaigo',
(3) 'giongo' and 'gitaigo' are closely related in terms of usage, structure, morphology, and syntax, and in fact, it is sometimes too difficult to categorize them,
(4) 'giongo' and 'gitaigo' are usually regarded as a set.

Learning Japanese onomatopoeia is a big challenge for learners of Japanese as a second language because of the following reasons (Inose, 2007; Asaga, Mukarramah & Watanabe, 2008).
(1) Difficult to explain: Many onomatopoeia words represent some feelings that people feel in various situations. There are some terms which represent some feelings of human beings in other languages such as "happy" or "sad" in English, Japanese onomatopoeia contains more complexed feelings.
(2) Difficult to translate: There is no equivalence in other languages since some languages do not have rich varieties of onomatopoeia.
(3) Difficult to understand: Japanese onomatopoeia words are written in hiragana or katakana (Japanese phonograms), Unlike kanji (Chinese characters), which are ideograms, it is difficult to understand the meanings.
(4) Difficult to listen: Japanese onomatopoeia words usually consist of repetitions of the same CV (consonant-vowel) clusters. It is difficult to judge whether it is one word or the repetition of the two words.
(5) Difficult to grasp the difference: There are many synonyms and much assonance in Japanese onomatopoeia words. For example, both "pyuh pyuh", and "byuh byuh" represent the sound of wind, but there is a slight difference.
(6) Difficult to grasp the situation: Some Japanese onomatopoeia words are used only in a specific situation. For example, the meaning of "jime jime" is muggy, dump and humid in dictionary, but it implies a specific rainy season (June to early July) in Japan.

In fact, a questionnaire survey conducted by Uosaki et al. (2015) revealed that there were only 9% of foreigners who felt no difficulty in learning onomatopoeia. Therefore there is a high necessity to develop some system in order to support their onomatopoeia learning.

The objective in this study is to propose an effective system to support Japanese onomatopoeia learning. Our research question is: (1) whether or not our system contributes to the facilitation of Japanese onomatopoeia learning. The rest of this paper is followed by the sections which describes related researches to clearly identifying the difference between related works and our research, the design of SLL Ono, its evaluation and the conclusions.

3. Related Researches: Japanese Onomatopoeia Learning Support

There are few researches so far where they developed a system to support Japanese onomatopoeia learning (Ochi & Kawasaki,1997; Ochi et al. 1997; Asaga et al.,2008; Ogata et al., 2006; Hou et al.,2010; Kaneko & Miyakoda, 2013). Asaga et al. (2008) developed Onomatopoeia Online Example Dictionary System called ONOMATOPEDIA extracting from data on the web. They reported the system had a problem with accurateness of the image search. Hou et al. (2010) developed Japanese mimicry and onomatopoeia learning assistant system called JAMIOLAS using wearable sensors and sensor network to support learning Japanese onomatopoeia. Their limitation is that the number of the onomatopoeia words which can be learned through their system was limited to the terms only related to temperature and humidity. Therefore we have created a new website called SSL Ono in order to facilitate Japanese language learners' onomatopoeia learning.

4. SLL Ono

SLL Ono (To See, to Listen , to Learn onomatopoeia) a website for learning Japanese onomatopoeia has been developed as a group project of the class called Computers in Language Learning, one of the International Exchange Subjects aimed mainly for international exchange students, which was held in

2018 fall semester at the university in a western part of Japan. The objective of SLL Ono is to support Japanese language learners to learn onomatopoeia words.

Websites are superior to documents or PPTs in terms of active learning. Therefore, we have explored creating an onomatopoeia learning website with a quiz function with the use of technology as well as manual power. We have created it with multimedia way by both text, picture, and audio in order to make our website look more attractive as a learning tool. CSS Only Mobile Friendly Comic Book Layout, which was originally developed for comic book layout, was introduced as a basic framework (https://codemyui.com/). It made the learners feel like as if they were learning onomatopoeia by reading comic books (cf. Figure 1).

Figure 1. SSL Ono interface

Pictures and gifs were searched on Yahoo Image, we judged if there were commonly used onomatopoeia by the searching result. And for some onomatopoeia related to sound, related audio sounds were searched from Freesound (https://freesound.org) and put them directly on our website to help to feel it. Github Pages was used since we could publish our website for free(https://pages.github.com).

The website was created to be interactive with its users by adding a quiz function called "Play Ono Game", where multiple choice quizzes were automatically generated from the learning contents (cf. Figure 2). A game to play is obviously more attractive than a paper to read. Li et al. (2013) and Uosaki et al. (2013) reported that quiz function was effective in language learning. Besides, a website is easier to distribute with only a short link as long as one can connect to the Internet.

Figure 2. SLL Ono "Play Ono Game"

5. Evaluation

5.1 The Participants

Sixteen foreigners (3 Americans, 2 Iranians, 2 Thailanders, 1 Bangladeshi, 1 Canadian, 1 Chinese, 1 English, 1 Lebanese, 1 Taiwanese, 1 Tunisian, 1 Ukrainian), collected through personal contacts participated in the pilot experiments.

5.2 Procedures

Figure 3 shows the learning scenario.
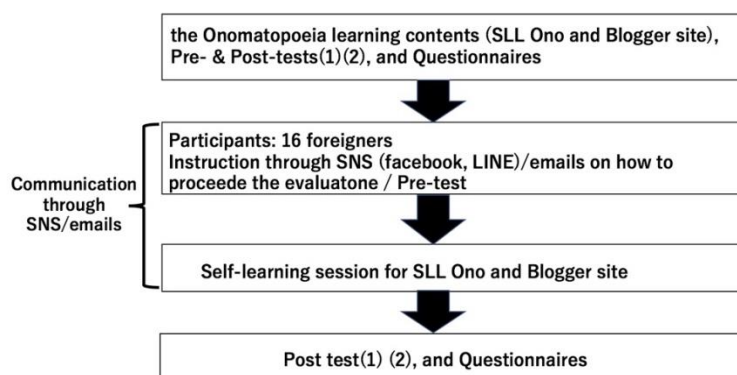
Figure 3. Evaluation Procedures

Fifteen onomatopoeia learning contents were created in SLL Ono such as にこにこ (/nikoniko/smiling), じろじろ(/jirojiro/ staring). For the purpose of comparison, we also created fifteen onomatopoeia learning contents using Google Blogger service such as ひそひそ whispering (/hisohiso/ whispering), がみがみ (/gamigami/ nagging). At the beginning, the participants took the pre-test to examine whether they know the meanings of the target onomatopoeia words. The instructions were made through emails or SNS (social network services) such as facebook or LINE. They were given a briefing on how to use SLL Ono and given the URL of the Blogger site to be learned. Then they were assigned to learn the target words on a self-learning basis using SLL Ono and Blogger site. In order to examine the effectiveness of SLL Ono, the comparison was made between SLL Ono and Blogger's site (Figures 4). A Blogger site was created for learning onomatopoeia words which were given in the pre-test (2).

Figure 4. Blogger onomatopoeia learning

187

There was no control group created in order to give an equal opportunity of learning with the cutting-edge technology. All the participants experienced both medias. They were instructed to click sound icons to listen to the real sounds and try the quiz system called "play Ono-Game" during their self-learning session. After the evaluation, Post-tests (1) & (2) were taken by the participants and the questionnaire was also conducted.

6. Results

Table 1 shows the result of the Pre- and Post-test (1) and (2). Pre- and Post-test (1) were identical to ask them the meaning of 13 Japanese onomatopoeia words to be learned via SLL Ono. Pre- and Post-test (2) were also identical to ask them the meaning of 13 Japanese onomatopoeia words to be learned via Blogger site. One point was given if correct for each question, thus the full mark was 13 points for Pre- and Post-test (1) and (2). The mean scores of the Pre-test (1) and (2) were 7.2 and 6.8 with the standard deviation (SD) of 3.29 and 3.71. After the learning session, the result of Post-test (1) jumped into 12.1 with the standard deviation of 1.59, while that of Post-test (2) was 10.2 with the standard deviation of 3.45. However T values show that there is no statistically significant difference between them. Figure 5 shows that the mean scores increased in both medias but the mean score increased more when they learned with SLL Ono.

Table 1

The results of Pre- and Post-tests

	Pre-test (1) (full mark 13)	Post-test (1) after **SLL Ono** use (full mark 13)	t-value of Pre-test (1)& (2)	t-value of Post-test (1) & (2)	t-value of Pre- & Post-test improvement
Mean	7.2	12.1			
SD	3.29	1.59			
	Pre-test (2) (full mark 13)	Post-test (2) after **Blogger** use (full mark 13)	0.48 (r=0.76)	0.014 (r=0.65)	0.07 (r=0.33)
Mean	6.8	10.2			
SD	3.71	3.45			
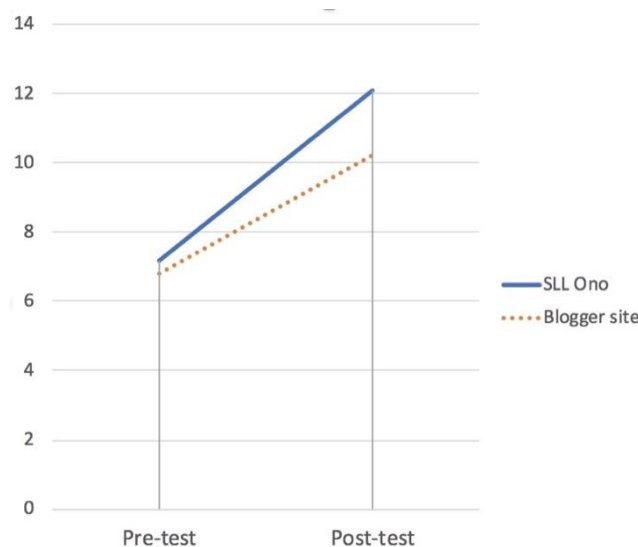
Figure 5. Comparison between SLL Ono learning and Blog learning in terms of the means of Pre- and Post-tests

7. Discussion

At the end of the evaluation, they were asked to answer the five-point-scale-questionnaire on SLL Ono (Table 2) and the Blogger site (Table 3). Q1 was created to examine its fun factor. Q2 was created based on the technology acceptance model proposed by Davis (1989). Q3 was created to examine its effectiveness. Q4 was created to examine the user acceptance of its interface. Q5 was created to examine the user acceptance of the whole system. Q6 was created to examine the effectiveness of it quiz function. SLL Ono was more highly evaluated in every question than the Blogger site. The highest score, 4.76 was given when they were asked about the usability of the system (Q.2). The lowest score, 3.53 was given when they were asked about the likability of its interface (Q. 4).

Figure 6 shows the result of the question: Which do you prefer SLL Ono or Blogger site? Fifteen out of sixteen students preferred SLL Ono to Blogger site. It was in line with the fact that SLL Ono was more highly evaluated in every question than the Blogger site.

Table 2

The results of the 5-point-scale questionnaire on SLL Ono

		Questions	Mean	SD
Q.1		Was it fun for you to use SLL Ono?	4.29	0.92
Q.2		Was it easy for you to use SLL Ono?	4.76	0.56
Q.3		Was it helpful for you to learn Japanese onomatopoeia?	4.47	1.07
Q.4		Please rate how much you liked or disliked its interface.	3.53	0.80
Q.5		Please rate how much you liked or disliked the whole system.	3.82	0.39
Q.6		Wasthe quizzes helpful for your onomatopoeia learning?	4.56	0.51

Table 3

The results of the 5-point-scale questionnaire on Blogger site

	Questions	Mean	SD
Q.1	Was it fun for you to use Blogger site?	3.12	1.58
Q.2	Was it easy for you to use Blogger site?	4.0	1.27
Q.3	Was it helpful for you to learn Japanese onomatopoeia?	3.70	1.49
Q.4	Please rate how much you liked or disliked its interface.	3.06	0.90

Figure 6. Which did you like better SLL Ono learning or Blogger site learning ?

Table 4 shows the participants' free comments on SLL Ono. Some comments were positive using the adjectives such as "easy", "nice", "great", " friendly" (#1, 2, 3, 7, 9). But since our system was a prototype, there were some negative comments with some suggestions concerning the contents such as the ambiguity of picture images (#10) and the overwhelming way in showing learning contents (#15), and the malfunctions of the game (#11, 13). These issues are to be coped with as our future works.

Table 4

The students' impressions of SLL Ono

No.	Comments
#1	It easy to remember the association between the word and its animation
#2	It was a nice site for learning basic onomatopoeia.
#3	It was very easy to understand and helpful for me.
#4	The idea with the pictures and sounds is great. It`s hard to learn anything and especially onomatopoeia without pictures. I also find the blog really helpful since Japanese people use Onomatopoeia a lot in everyday conversation.
#5	Also, I think that adding more onomatopoeia would be wonderful."
#6	Overall, I believe the system was user-friendly and designed well. At times, though, I felt that the pictures shown did not quite correspond to their associated sounds or at least it was difficult to discern what a few pictures were referring to, the first time I saw them. However, I think attempts, such as the one presented here on collecting some of the most frequently used onomatopoeic words in Japanese language and teaching them through gamification, are very valuable and I really found this website useful specially in that sense. I think a lot more people will appreciate this effort if the website is made open to the public. Perhaps, the next attempt could be teaching Japanese compound verbs, which are also very difficult to memorize and use in the right context. Thank you very much again for the precious effort!
#7	it is very helpful
#8	Be able to observe more Onomatopoeia terms.
#9	It looks friendly and easy to understand.
#10	I did not understand the meaning of some pictures. Maybe videos of the action with the sound in background would be useful. Or an explanation for why this sound corresponds to this action
#11	The Ono Game continued forever and it didn't tell me when it would end so I endlessly did the quiz. It should tell the test taker approximately how long or how many questions there are up front. Also, the word repeat frequency was too often.
#12	Was it "just" a list of words coming with illustrations or did I miss something?
#13	There were some small mistakes though. For example, the correct options weren`t included in the answers. I think it would be nice to review all the answers again.
#14	Good but can be more advanced by giving example sentences, scoring the quizzes, and further gamification,
#15	Just presenting all the onomatopoeia at once can be overwhelming. Explanations of the onomatopoeia would be better.
#16	It's a great way to learn onomatopoeia, but I'm not sure how much it can help with long-term retention.

8. Conclusion

In this study, we describe facilitating Japanese onomatopoeia learning by creating SLL Ono. When compared with Blogger site, SLL showed its superiority in many aspects as described in Discussion section. The questionnaire results showed that the students were satisfied with its usability. There was no statistically significant difference in the improvement between Pre- and Post-test results between SLL Ono learning and Blogger learning. Therefore our hypotheses (our system contributes to international students' learning Japanese onomatopoeia: Research Question (1)) was not proved to be correct. However the fact that the mean score increased more when they learned with SLL Ono as well as the fact that 15 out of 16 participants preferred our system endorsed that we are in the right direction

in developing this system for Japanese language learners. Since this is our on-going project, it was pointed out in the participants' feedback that there were some weak points to be improved regarding its contents and the quiz function. It is among our future works to enrich the contents as well as the improvement of our quiz system.

Acknowledgements

References

Asaga, C., Mukarramah Yusuf, M., & Watanabe, C. (2008). ONOMATOPEDIA: Onomatopoeia Online Example Dictionary System Extracted from Data on the Web. *Proceedings of Asia-Pacific Web Conference (APWeb'08)*, 601-612.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of in-formation technology, *MIS Quarterly*, 13 (3), 319–339.

J Hou B., Li, M., Ogata, H., & Yano, Y. (2010). JAMIOLAS3.0 Supporting Japanese Mimicry and Onomatopoeia Learning Using Sensor Data, *International Journal of Mobile and Blended Learning*, 2(1), 40-54, 2010.

Inose, H. (2007). Translating Japanese onomatopoeia and mimetic words. *Translation Research Projects,* 1, 97-116.

Kaneko, K. & Miyakoda, H. (2013). Development of an Onomatopoeia Learning System Based on Multi-media Material (in Japanese), in *Sound symbolism and mimetics: rethinking the relationship between sound and meaning in language*, 279-297, Hituzi Syobo.

Li, M., Ogata, H. Hou, B. & Uosaki, N. (2013). Context-aware and personalization method in ubiquitous learning log system, *Journal of Educational Technology & Society (SSCI)*, 16(3), 362–373.

Ochi, Y., & Kawasaki, K. Y. (1997). JAMIOS: Japanese Onomatopoeia Dictionary For Foreign Students. *IEICE Trans. on Information and Systems D-II*, 3210-3219.

Ochi, Y., Kawasaki, K., Yano, Y., & Hayashi, T. (1997). JAMIOS: Development of Japanese Mimesis and Onomatopoeia Dictionary System for Foreigners. The transactions of the Institute of Electronics, I*nformation and Communication Engineers*, 80(12), 3210-3219.

Ogata, H., Yin, C., & Yano, Y. (2006). JAMIOLAS: Support Japanese Mimicry and Onomatopoeia Learning with Sensors, *Proceedings of the 4th International Workshop on Wireless, Mobile and Ubiquitous Technologies in Education Wmute 2006*, 111-115, Athens, Nov.16-17.

Uosaki, N., Ogata, H., Li, M., Hou, B. & Mouri K. (2013). Enhancing outside-class learning using ubiquitous learning log system, *Workshop Proceedings of ICCE2013*, Bali, Indonesia, 90-99.

Uosaki, N. Ogata,H. Mouri, K. & Lkhagvasuren,E. (2015). Japanese onomatopoeia learning support for international students using SCROLL. *Proceedings of the 23nd International Conference on Computers in Education (ICCE 2015)*, Hangzhou, China, 329-338.

Supporting ubiquitous language learning with object and text detection technologies

Kousuke Mouri [*]**, Noriko UOSAKI** [b]**, Chengjiu YIN** [c]**, Atsushi Shimada** [d]**, Mohammad Nehal Hasnine** [a]**, Keiichi Kaneko** [a]**, Hiroaki Ogata** [e]

[a]*Tokyo University of Agriculture and Technology, Japan*
[b]*Osaka University, Japan*
[c]*kobe University, Japan*
[d]*Kyushu University, Japan*
[e]*Kyoto university, Japan*

[*]mourikousuke@gmail.com

Abstract: Learning log is defined as a digital record of what learners have learned in their daily lives using ubiquitous technologies. By using the ubiquitous learning system named SCROLL(System for Capturing and Remining Of Learning Logs), learners can save what they have learned in their daily lives with photo, such as location (latitude and longitude), learning place, and date and time of creation as a learning log. Although learners have many opportunities to learn words and meanings of objects with taking a photo in their daily lives, SCROLL is not implemented functions for supporting language learning with object and text detection. Therefore, this paper proposes a ubiquitous learning system to support language learning with object and text detection technologies.

Keywords: ubiquitous learning, language learning, text and object detection

1. Introduction

In recent years, many researchers in language learning have constructed smart learning environments to support both in-class language learning and out-of-class language learning (Liu et al., 2019, Song et al., 2019 and Hasnine et al., 2019). To construct smart learning environments, it is often considered how recent technologies such as mobile and ubiquitous technologies can support language learning (Mouri et al., 2017; 2018). By using ubiquitous and mobile technologies, learners can actively save what they have learned as learning logs anytime and anywhere.

For example, Wong et al. (2014) reported a learning system called MyCLOUD (My Chinese UbiquitOUs learning Days), which allows students to learn the Chinese language in both in-school and out-of-school learning spaces. Uosaki et al. (2010) reported a learning system called SMALL System (Seamless Mobile-Assisted Language Learning support system) to support Japanese students who aimed to learn the English language in a formal and an informal setting.

In these learning systems, when learners learn objects in their daily lives, they often take photos regarding the objects and save them as learning logs. Learning words with photos is one of effective language learning methods. In the ubiquitous learning, when learners do not know meaning of the object, they often search it via internet or ask other learners or teachers. If providing the word regarding the object of the photo right after taking a photo, the efficiency of the learning can be enhanced. Therefore, this paper proposes ubiquitous learning system to support language learning with object and text detection technologies.

2. SCROLL

SCROLL project has started to support real-life language learning since 2011. SCROLL aims to aid users to simply capture, review and reflect their learning logs, reuse and share the knowledge. To simplify the process of capturing the learning experience in their daily lives, SCROLL provides a

well-defined form to illustrate a learning log. It adopts an approach to share contents with other users based on a LORE (Log-Organize-Recall-Evaluate) model proposed by Ogata et al. (2014). How the model supports each learning process is described below.

(1) Log: learners are likely to face some problems such as how to read, write and pronounce the object in their daily life. Then, they search the details of the object via internet or ask other learners and teachers about it. They can save what they have learned with photo, such as location (latitude and longitude), learning place, and date and time of creation as a learning log as shown in Figure 1.

(2) Organize: When a learner adds a new learning log, SCROLL compares it with his past learning logs and those of other users, categorize it and shows him related the learning logs. By sharing the learning logs as shown in Figure 2, past learning and current learning can be linked and their knowledge will be reorganized and reinforced.

(3) Recall: Learners are likely to forget what they have learned previously. It is necessary to support re-calling their past learning logs. During this learning process, the system support learners to recall what they have learned by using a quiz function (Li et al., 2013; Ogata et al., 2014). The quizzes are created automatically from uploaded learning logs. By answering the quizzes, the learner's knowledge will be enhanced.

(4) Evaluate: It is important to recognize what and how the learner has learned by analyzing the past ULLs, so that he or she can improve what and how to learn in the future. Mouri et al. (2014; 2015a; 2015b) developed an innovative visualization system that implemented Time-Map with network based graph theory to support this learning process. For example, when learners use the visualization system, they can reflect on what and how they have learned based on their past ULLs. It is expected that enhancing learning activities to share and reflect ULLs.
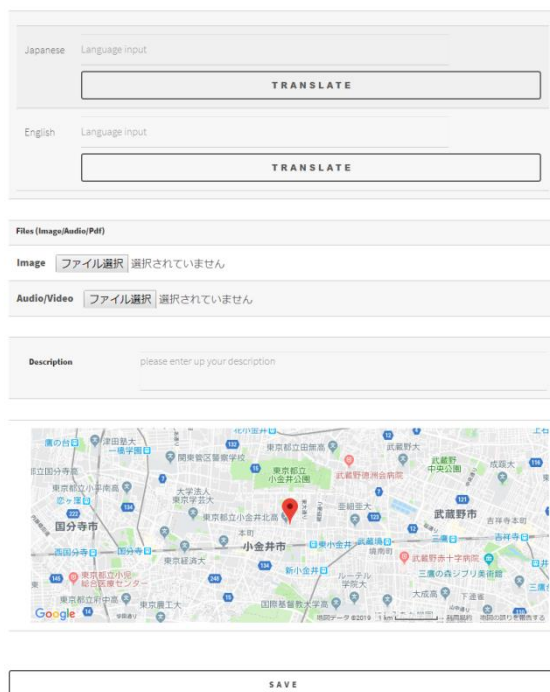
Figure 1. Interface for adding learning logs   Figure 2. Learning logs

3. Overview to support language learning with object and text detection.

As described section 2, learners often search the details of the objects via internet and ask other learners or teachers. To make learners' learning work efficiently, this section describes a method to support language learning with object detection and text detection. Figure 3 shows the overview.

When learners save learning logs with photos, the photo data is sent into cyber space. In the cyber space, our system categorizes whether the images include objects or texts. After categorizing the objects and texts images, the system detects the objects and the texts in the images based on google cloud vision api. After detecting them, the system adds annotations regarding the objects or texts. For

example, when a learner does not know an object (e.g. a folding fan) in his/her photo, he/she uploads the photo into cyber space using SCROLL. Our system detects the object as "a folding fan" and then translate it to the target language (e.g. Japanese: 扇子) that the learner is aiming to study.

In text detection, how does it support learners? For example, when a learner visits places such as temples, shrines and museums, he/she tend to read the sign in front of the artifacts. In most cases, the texts are written in the native language of the country. By using our system, texts shown in their uploaded photos can be detected, and our system translates them into their native language that the learner wants to study. These analysis results are shown in the learner' web browser.
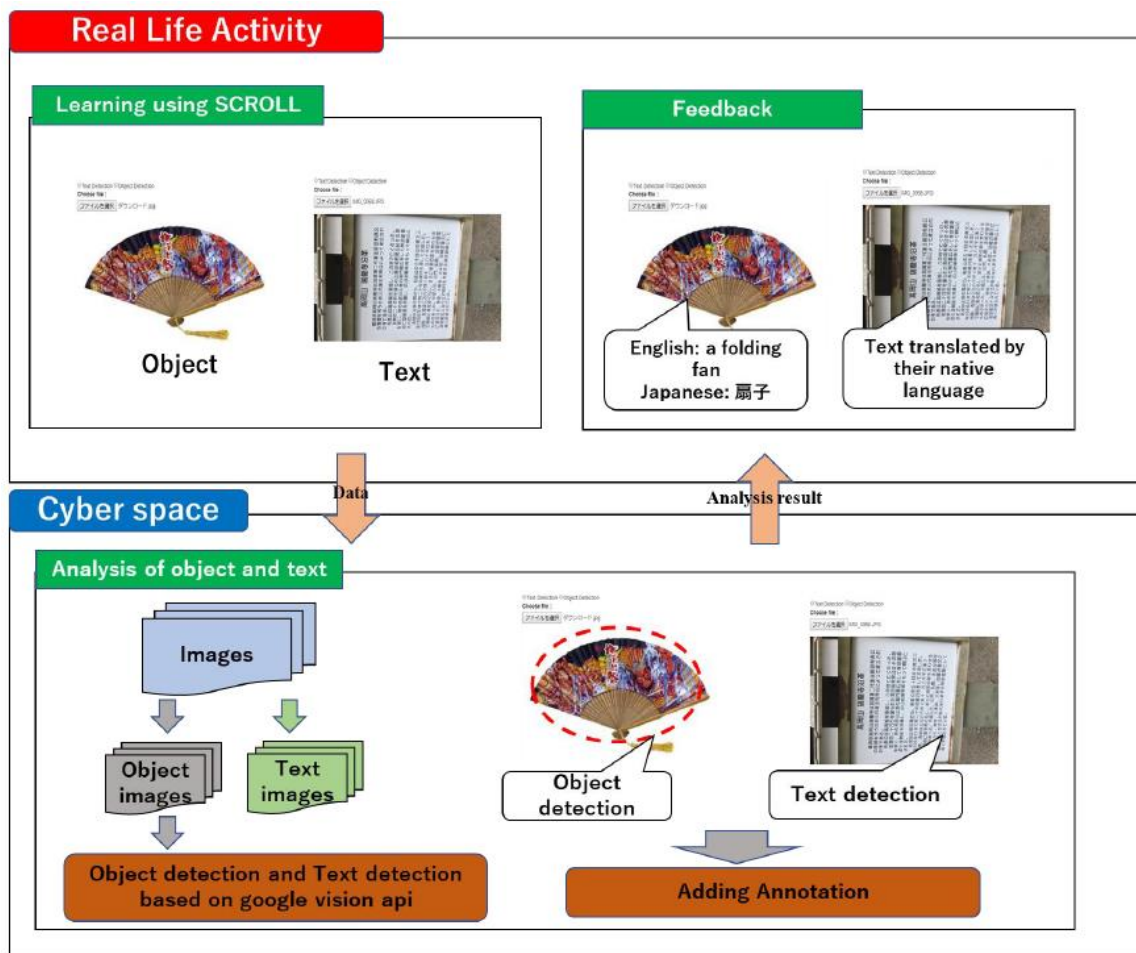
Figure 3. Overview for supporting ubiquitous language learning with object and text detection

4. Implementation

Figure 4 shows the interface for detecting objects and texts by uploading a photo. Firstly, the learner chooses the photo that he/she wants to detect objects and texts. Secondly, he/she chooses object detection or text detection icon.
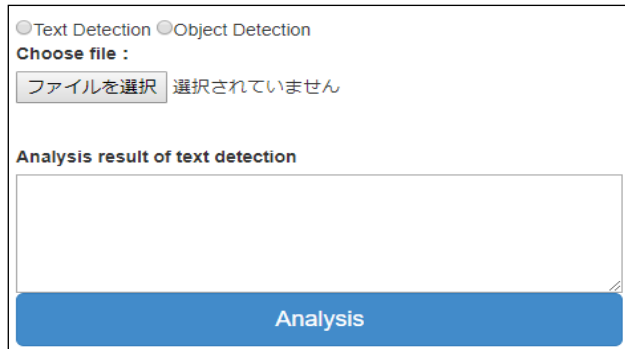
Figure 4. interface for detecting objects and texts by uploading a photo

Figure 5 shows the result of the text detection. This photo is a sign in front of an artifact in a temple. By translating it to their native language, the learner can read and learn the meanings of the artifact. Figure 6 shows the result of the object detection. This photo includes a snake and frog. The table in Figure 7 are displayed in score order based on google vision api calculation. The result shows "serpent", "snake" and "Reptile" such as related to the objects "snake" and "frog". Based on these results, the learner learns the words of the objects in the photo.
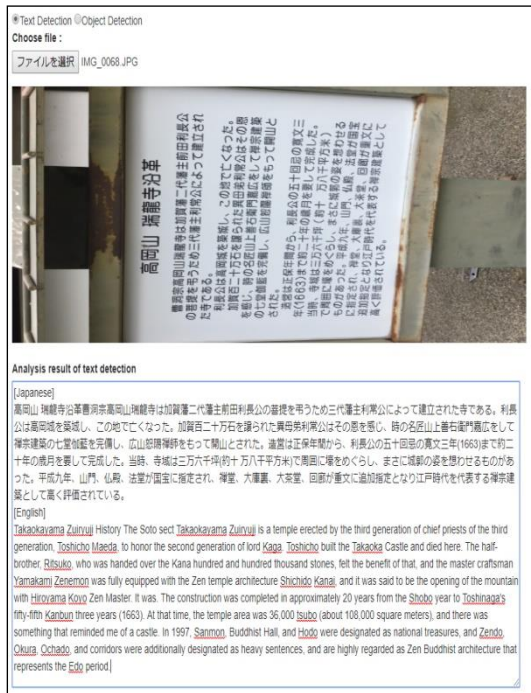
Figure 5. Result of text detetction
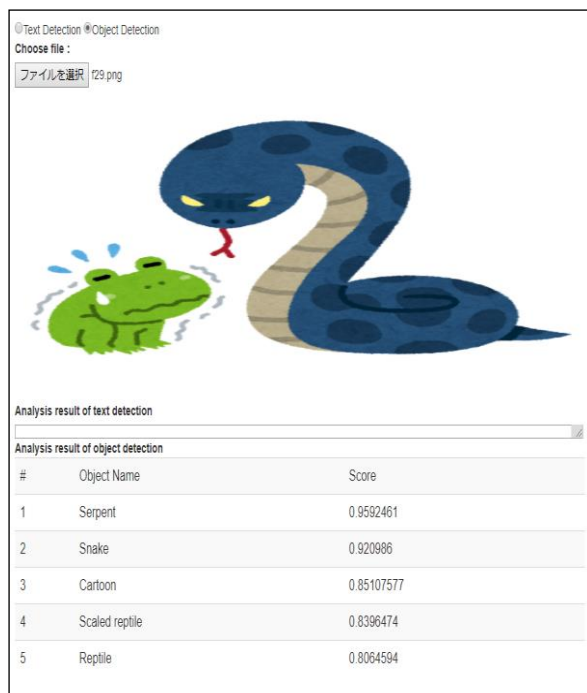
Figure 6. Result of object detection

5. Conclusion and future work

This paper described a ubiquitous learning system to support language learning with object and text detection technologies. To detect objects and texts in photos, this study used google cloud vision api. By this, our system enabled learners to provide the results of text and object detection.

However, it is yet to be evaluated whether these analysis results are effective for language learning and the efficiency of learning can be enhanced. In future work, we will consider to evaluate them.

Acknowledgements

References

Song, Y., Lung, K.M., Ogata, H., Yang, Y, Hasnine, N.H and Mouri, K. (2019), Bridging in-class and real life vocabulary learning using a mobile learner-generated content tool: A case study, the 23rd Global Chinese Conference on Computers in Education, pp.176-186, 2019.

Liu, S., Mouri, K., Ogata, H. (2019), The Information Infrastructure for Analyzing and Visualizing Learning Logs in Ubiquitous Learning Environments. In: Streitz N., Konomi S. (eds) Distributed, Ambient and Pervasive Interactions. HCII 2019. Lecture Notes in Computer Science, vol 11587. Springer, pp.408-418.

Hasnie, M.N, Flanagan, B., Ishikawa, M., Ogata, H., Mouri, K. and Kaneko, K. (2019). A Platform for Image Recommendation in Foreign Word Learning, the 9th International Conference on Learning Analytics and Knowledge, pp.187-188.

Uosaki, N., Li, M., Hou, B., Ogata, H., & Yano, Y. (2010). Supporting an English course using handhelds in a seamless learning environment, Workshop of the 18nd International Conference on Computers in Education (ICCE 2010), 185-192.

Wong, L. H., Chai, C. S., Aw, C. P., & King, R. (2014). Employing the TPACK framework for research-teacher co-design of a mobile-assisted seamless language learning environment. IEEE Transaction on Learning Technologies, 8(1), 31-42.

Ogata, H., Hou, B., Li, M., Uosaki, N. Mouri, K., & Liu, S. (2014). Ubiquitous learning project using life-logging technology in Japan. Educational Technology and Society Journal, 17(2), 85-100.

Li, M., Ogata, H., Hou, B, Uosaki, N., & Mouri, K. (2013). Context-aware and personalization method in ubiquitous learning log system. Educational Technology & Society, 16(3), 362–373.

Mouri, K., Ogata, H., Uosaki, N., & Liu, S. (2014). Visualization for analyzing ubiquitous learning logs. In Proceedings of the 22nd International Conference on Computers in Education (ICCE 2014) (pp. 461-470). Nara, Japan.

Mouri, K., & Ogata, H. (2015a). Ubiquitous learning analytics in the real-world language learning. Smart Learning Environment, 2(15), 1-18.

Mouri, K., Ogata, H., & Uosaki, N. (2015b). Analysis of ubiquitous learning logs using social network analysis. International Journal of Mobile Learning and Organisation, 9(2), 101-123.

Mouri, K., Ogata, H. & Uosaki, N. (2017). Learning analytics in a seamless learning environment, International Learning Analytics & Knowledge Conference, 348-357.

Mouri, K., Uosaki, N. & Ogata, H. (2018). Learning analytics for supporting seamless language learning using e-book with ubiquitous learning system, journal of Education technology & Society, 21(2),150-163.

"Google cloud vision API", retrieved Aug. 22, 2019 from https://cloud.google.com/.

Enhancing Hong Kong Secondary Students' English Grammar Learning and Collaborative Problem-solving Skills with Productive Failure Instructional Design in a MCSCL Environment

Yanjie SONG [a]* & Yin YANG [a]
[a] *Department of Mathematics and Information Technology,*
The Education University of Hong Kong, Hong Kong
*ysong@eduhk.hk

Abstract: In this paper, we proposed a productive failure instructional design (Kapur, 2008) to enhance Hong Kong secondary students' English grammar learning and collaborative problem-solving skills in a MCSCL environment. It is believed that the pedagogical implications of this study will make contributions to the technology-enhanced language learning field. In addition, insight gained from this study will hopefully extend to investigating the impact of productive failure pedagogical design on listening, speaking, writing, and reading skills in the L2 acquisition.

Keywords: Productive failure instruction, grammar learning, collaborative learning, MCSCL

1. Introduction

English grammar is the foundation for communication. Based on Hong Kong English Language Education Key Learning Area Curriculum Guide (Curriculum Development Council, 2017), grammar should be learned through text, providing opportunities for students to explore the grammatical features in an authentic learning context and develop generic skills.

The integration of mobile technology into grammar learning in the L2 has offered an opportunity to create a language learning environment which cannot be realized in a traditional classroom. But the majority of mobile-assisted language learning studies have focused on individual learning as opposed to collaborative learning and have tended to be teacher-centred (Burston, 2014).

Among student-centred approaches, problem-based learning (PBL) serves an instructional learning strategy for better understanding concepts in authentic context (Hung, 2013). English grammar learning, when related to the use in real-life contexts or context-appropriate lexico-grammatical rules, is often ill-structured and hence ideal for PBL instruction in L2. Thus, how to design problem solving tasks in language learning becomes an important issue. "Productive failure (PF)" pedagogical design, proposed by Kapur (2008), argued that support and consolidation should be delayed for students in unguided problem-solving. Kapur's PF studies have been replicated in the world (Pathak et al., 2011; Kapur & Rummel, 2012; Mazziotti, Loibl, & Rummel, 2015; Song & Kapur, 2017; Song, 2018) and proved that PF could be effectively used among learners of various abilities and both well-structured and ill-structured learning tasks. However, no study has been found in applying the "Productive failure (PF)" pedagogical design into language learning.

This study is the first attempt to investigate the effectiveness of PF pedagogical design in English grammar learning in examining the secondary students' grammar competence enhancement and collaborative problem-solving skills.

2. Relevant Literature Review

"Productive failure instruction design" was proposed by Kapur (2008). It is a pedagogical design that entails the design of problems for learners to engage in "generation and exploration", followed by a consolidation phase or instruction (see Figure 1).

The productive failure instruction design consists of two phases (Kapur & Bielaczyc, 2012, p.49): (1) Phase 1 affords opportunities for students to generate and explore the affordances and constraints of multiple representations and solution methods (RSMs); (2) Phase 2 affords organizing and assembling the relevant student-generated multiple representations and solution methods into canonical RSMs.
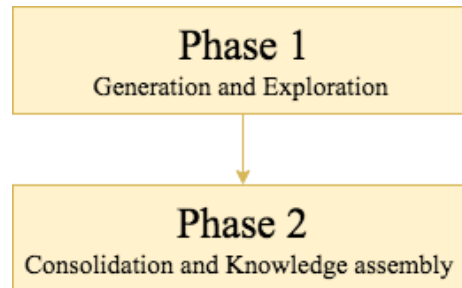
Figure 1. **Productive Failure Instruction Design (Kapur & Bielaczyc, 2012)**

Many studies based on productive failure instructional design have found that when consolidation was delayed, learners were able to perform better when compared those within direct instruction (Kapur, 2010; Kapur, 2011; Kapur, 2014). Kapur (2010) conducted a study in Singapore secondary school to investigate the effectiveness of PF in mathematical problem solving and found that students from the productive failure condition significantly perform better than those from the lecture and practice (LP) condition. One year later, he extended his study in three conditions and affirmed the effectiveness of PF that students from PF significantly performed better than those in the facilitated complex problem-solving conditions (Kapur, 2011). Furthermore, Song and Kapur (2017) proposed "productive-failure based flipped classroom" pedagogical design and tested the effectiveness of productive failure instruction design for mathematical learning in Hong Kong secondary school. Song's study (2018) on Hong Kong primary students' collaborative problem-solving competency in project-based science learning with PF instructional design also proved that PF could help students gain a deeper understanding of conceptual science knowledge and improve collaborative problem-solving skills.

However, the majority of studies using productive failure instructional design have been conducted in mathematics learning (Kapur 2010, 2011, 2014; Westermann & Rummel, 2012; Loibl & Rummel 2014; Mazziotti, Loibl & Rummel, 2015; Song & Kapur, 2017; Loibl, Roll, & Rummel, 2017), some studies were conducted in science learning (Kapur & Kinzer, 2009; Song, 2018). Studies adoping productive failure instructional design have hardly been found in language learning, not to mention studies in technology-enhanced collaborative learning environments.

3. This Study

3.1 Research Questions

In order to investigate the effectiveness of productive failure instructional design in grammar learning and collaborative problem-solving skills in mobile computer-supported collaborative learning (MCSCL) environment, the following three research questions are going to be addressed in this study:
- Research Question 1: What is the impact of productive failure instructional design on students' grammar learning in MCSCL environment?
- Research Question 2: What is the impact of productive failure instructional design on students' problem-solving skills in MCSCL environment?
- Research Question 3: What are students' perceptions of productive failure instructional design (PFI) in grammar learning?

3.2 Research Design

In this study, Padlet will be used as the primary learning platform (https://padlet.com/, see Figure 2). Padlet offers an excellent venue for students to share their thoughts and modify them. Besides, it allows students to post many kinds of files like a web link, text, videos, and images to Padlet notes, which makes students' thinking visible.

Participants will be divided into two groups, one is the experimental group, in which productive failure instructional design (PFI) will be used in MCSCL environment. While in the control group, participants will be involved in direct instructional design (DI) in MCSCL environment.
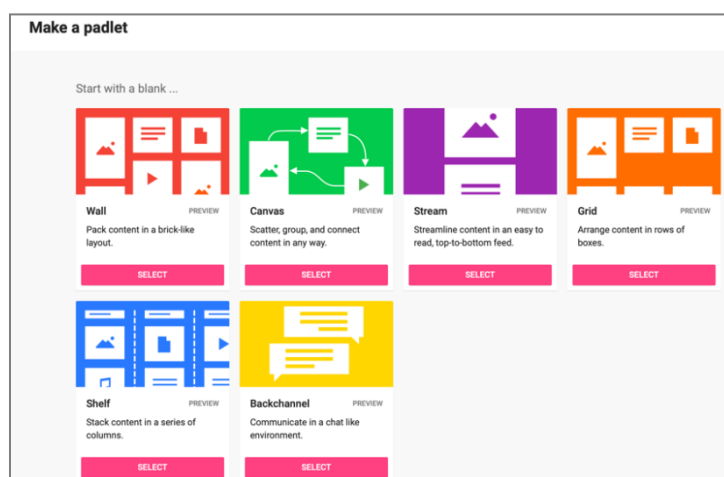
Figure 2. **Proposed MCSCL Environment -Padlet**

3.3 Methods

3.3.1 Participants and Learning Topics

A quasi-experimental design method will be adopted in this study. Three secondary English teachers with six classes of Grade seven from three government secondary schools in Hong Kong will be involved. Three schools with students are above the average, average and below the average (Band 1, 2, 3 in Hong Kong) will be selected to test the scalability of productive failure instructional design in mobile computer supported collaborative language (MCSCL) learning environment. Participants have the experience of using mobile technology to support learning. Three teachers selected should have at least five years of working experience and are willing to accept innovative pedagogical practices and embrace challenges of technology-enhanced language learning.

In the quasi-experiment study, one class is the experimental group which will adopt "productive failure instructional design" (PFI), while the other is the control group which will adopt "direct instructional design" (DI). Each teacher will be responsible for two classes in this study. Each class will be divided into five or six groups, learning styles and performances of students will be taken into consideration when grouping because a study conducted by Saleh et al. (2007) shows that structuring collaboration in mixed-ability groups could promote verbal interaction, learning, and motivation of students. Grammar knowledge included in this study will be "simple past tense", "simple present tense", "simple future tense" and "comparative/superlative".

3.3.2 Study Procedure

All the experimental groups in three schools will adopt productive failure instructional design, while the control group does not adopt the design (see Figure 3). Firstly, students will be given pre-tests to assess if they have prior knowledge of target grammar. Following that, all students in control groups and experimental groups are expected to be provided with the same learning materials, tasks and allocated time.

Productive failure instruction consists of two phases (Kapur & Bielaczyc, 2012), "a generation and exploration phase" followed by "consolidation phase". Students in experimental groups (PFI) are expected to solve problems related to the target grammar points in groups at the beginning of the class

(the problem is scenario-based presented on mobile devices, see Figure 4). For example, they will be required to watch the video about "The Story of Hong Kong" (e.g., in learning "simple present tense") on Padlet. In the video (see Figure 5), all important grammar points will be highlighted. Right grammatical use will be highlighted in red and wrong grammatical use will be highlighted in green. Students are encouraged to guess the use of "simple present tense" and correct the wrong sentence in the video on Padlet collaboratively (see Figure 6). During the process of solving the problem, teachers will give the necessary support, but will not tell students correct answers. Following that, each group will present their findings. They can see peers' ideas and findings on Padlet at the same time. In Phase 2, the teacher could compare groups' findings and make conclusions. At the end of the class, the teacher will elaborate on the rules of target grammar explicitly.

Students in control groups (DI) will involve in direct instruction. The teacher will introduce the rules of grammar at the beginning of the class. Then students solve problems in groups using the iPad (the problem is scenario-based presented on mobile devices, see Figure 4). Students will be expected to watch the video related to the grammar (see Figure 5) and solve the problem collaboratively (Figure 6). After that, the teacher provides feedback and summarizes grammatical rules at the end of the class.
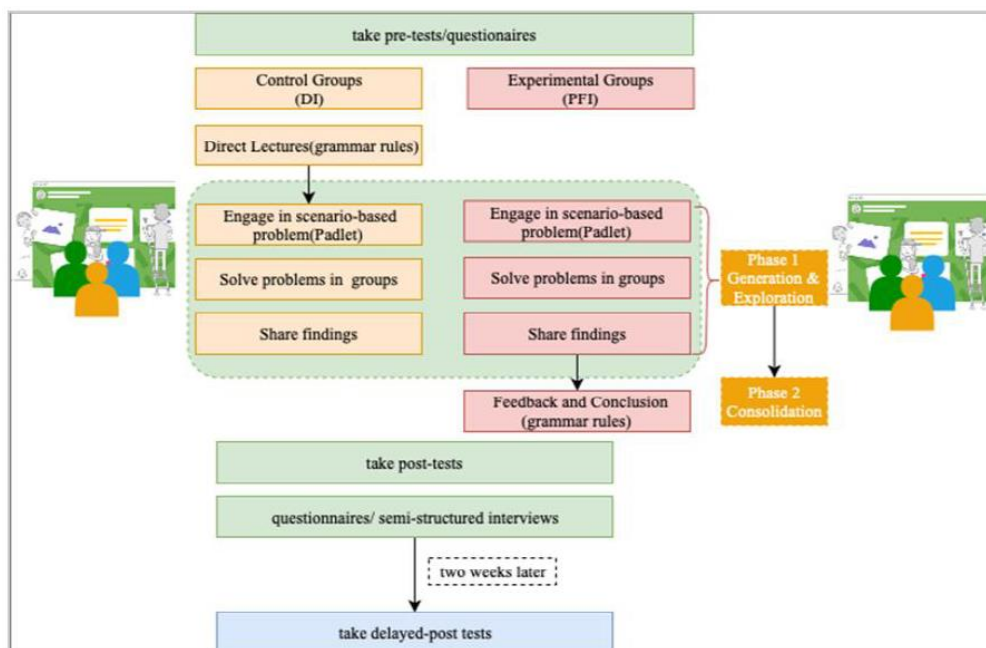
Figure 3. **The Study Procedure**
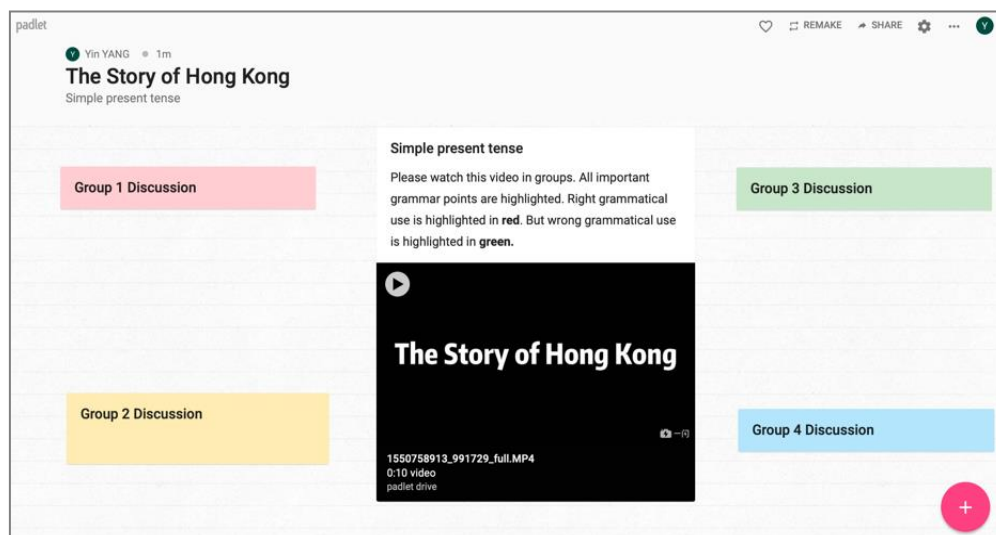
Figure 4. **The Interface of "Scenario-based Problem" on Padlet**

Figure 5. Screencast of "Scenario-based Problem"
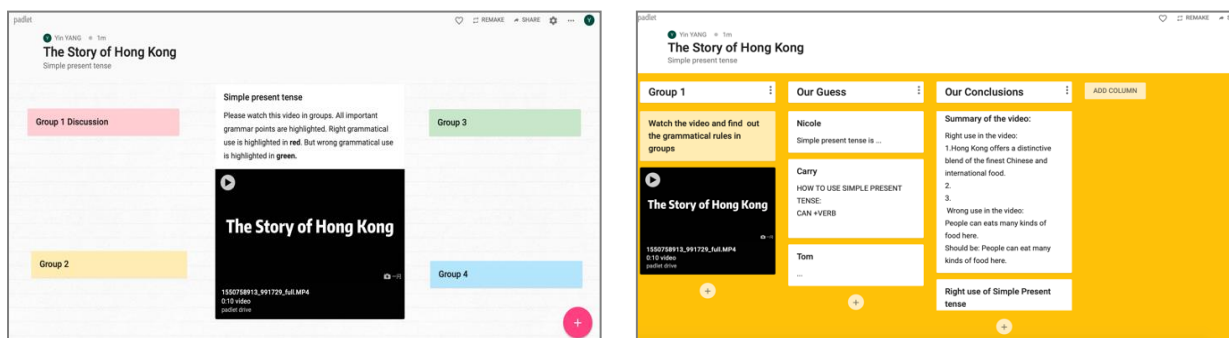
Figure 6. Collaborative Learning on Padlet

3.3.3 Data Collection and Analysis

Mixed research method will be adopted in this study. Both qualitative and quantitative data will be collected and analyzed, which include pre-and post-tests, delayed post-tests, students' logged data on Padlet, pre-and post-questionnaires and semi-structured interviews (see Table 1).

Student's logged data on Padlet will be recorded and analyzed using the coding scheme of for collaborative activities proposed by Erkens and Janssen (2008). Students' interviews will be recorded and analyzed. Quantitative data analysis of pre-and post-tests, delayed-post tests, and pre-and post-questionnaires will be conducted using SPSS version 25.

Table 1
Instruments to Address Research Questions

	Question 1	Question 2	Question 3
Pre-and post-tests, delayed post-tests	√		
Pre-and post-questionnaires		√	√
Students' logged data on Padlet		√	
Semi-structured interviews			√

4. Significance

The study is the first attempt in applying productive failure instructional design into language learning pedagogical practice in a MCSCL environment. The contribution of this project helps: (1) To improve Hong Kong secondary learners' grammar knowledge achievement and problem-solving skills in a MCSCL environment; and (2) to extend the application of productive failure (PF) instructional design in language teaching and learning in MCSCL environment.

References

Burston, J. (2014). MALL: The pedagogical challenges. *Computer Assisted Language Learning*, 27(4), 344-357.

Curriculum Development Council (Hong Kong, China). (2017). *English Language Education: Key Learning Area Curriculum Guide (Primary 1-Secondary 3)*. Curriculum Development Council. Retrieved from https://www.edb.gov.hk/attachment/en/curriculum-development/kla/eng-edu/Curriculum%20Document/ELE%20KLACG_2017.pdf

Erkens, G., & Janssen, J. (2008). Automatic coding of dialogue acts in collaboration protocols. *International journal of computer-supported collaborative learning*, 3(4), 447-470.

Hung, W. (2013). Problem-based learning: A learning environment for enhancing learning transfer. *New directions for adult and continuing education*, 2013(137), 27-38.

Kapur, M. (2008). Productive failure. *Cognition and instruction*, 26(3), 379-424.

Kapur, M., & Kinzer, C. K. (2009). Productive failure in CSCL groups. *International Journal of Computer-Supported Collaborative Learning*, 4(1), 21-46.

Kapur, M. (2010). Productive failure in mathematical problem solving. *Instructional Science*, 38(6), 523-550.

Kapur, M. (2011). A further study of productive failure in mathematical problem solving: Unpacking the design components. *Instructional Science*, 39(4), 561-579.

Kapur, M. (2014). Productive failure in learning math. *Cognitive Science*, 38(5), 1008-1022.

Kapur, M., & Bielaczyc, K. (2012). Designing for productive failure. *Journal of the Learning Sciences*, 21(1), 45-83.

Kapur, M., & Rummel, N. (2012). Productive failure in learning from generation and invention activities. *Instructional Science*, 40(4), 645-650.

Loibl, K., & Rummel, N. (2014). Knowing what you don't know makes failure productive. Learning and Instruction, 34, 74-85.

Loibl, K., Roll, I., & Rummel, N. (2017). Towards a theory of when and how problem solving followed by instruction supports learning. *Educational Psychology Review*, 29(4), 693–715.

Mazziotti, C., Loibl, K., & Rummel, N. (2015). Collaborative or Individual Learning within Productive Failure: Does the Social Form of Learning Make a Difference?. International Society of the Learning Sciences, Inc.[ISLS]..

Pathak, S. A., Kim, B., Jacobson, M. J., & Zhang, B. (2011). Learning the physics of electricity: A qualitative analysis of collaborative processes involved in productive failure. *International Journal of Computer-Supported Collaborative Learning*, 6(1), 57-73.

Saleh, Mohammad, Lazonder, Ard W., & Jong, Ton de. (2007). Structuring Collaboration in Mixed-Ability Groups to Promote Verbal Interaction, Learning, and Motivation of Average-Ability Students. *Contemporary Educational Psychology, 32*(3), 314-331.

Sánchez, J., & Olivares, R. (2011). Problem solving and collaboration using mobile serious games. *Computers & Education*, 57(3), 1943-1952.

Song, Y. (2018). Improving primary students' collaborative problem solving competency in project-based science learning with productive failure instructional design in a seamless learning environment. *Educational Technology Research and Development, 66*(4), 979-1008.

Song, Y., & Kapur, M. (2017). How to Flip the Classroom-" Productive Failure or Traditional Flipped Classroom" Pedagogical Design?. *Journal of Educational Technology & Society*, 20(1), 292.

Westermann, K., & Rummel, N. (2012). Delaying Instruction: Evidence from a Study in a University Relearning Setting. *Instructional Science: An International Journal of the Learning Sciences, 40*(4), 673-689.

Crossing border: Mobile technologies integrating into STEM activity in and out of classroom

Daner SUN [a*], Chee-Kit LOOI [b]
[a.c] The Education University of Hong Kong, Hong Kong SAR, China
[b.] National Institute of Education, Nanyang Technological University, Singapore
[*]dsun@eduhk.hk

Abstract: In this paper, we will present a theory contributing to the development of seamless learning and mobile learning namely: boundary activity based learning principle (BABL), which has been developed by research team for more than two years. The BABL principle has been integrated into the design of seamless learning in science and STEM education. In the paper, we will overview the basic principle of BABL, and present an integrated STEM activity at a primary school. The research will inform the STEM instructional design supported by mobile technology.

Keywords: BABL activity, STEM education, seamless learning, pedagogical design

1. Introduction

STEM education is the hot topic and has permeated into different levels from the primary schools to universities. The definition of STEM education can be broad or narrow. Most of researchers and educators agree with the definition that STEM education is an instructional approach that "integrates the teaching of science and mathematics disciplines through the infusion of the practices of scientific inquiry, technological and engineering design, mathematical analysis, and 21st century interdisciplinary themes and skills" (Moore et al., 2015). The approach fosters a closer connection among engineering and technology design and science and mathematics learning to prepare students to meet the challenges of modern society. Therefore, the nature of STEM education is mostly identified as interdisciplinary approach.

So far, the STEM education has been stated in many educational and policy documents in the world. The STEM education is very active in the primary schools. In Hong Kong, the STEM elements have been written into the primary and secondary curriculum framework (EDB, 2019). Many research has been conducted to explore the status of STEM education at schools. So et al., (2018) looked into the STEM projects at primary schools through content analysis. They found that students managed to apply multiple disciplinary core ideas and crosscutting concepts into the design and implementation of these projects. It has shown the integrative approach with the connection of science, engineering, and mathematics in science education. However, more engineering and science activities than technology and mathematics activities were adopted by the students in their projects. The problems they found that science was not significantly related with technology. And student had difficulties in refining the solution using engineering knowledge and skills. On the other hand, teacher factor was one of the major problem of STEM integration and implementation. Most teachers did not currently have the knowledge to bring integrated STEM to the classroom, and found the balance of developing skills and teaching content knowledge challenging and they overall still viewed STEM disciplines as separate entities (Dare et al., 2018). When designing and implementing integrative STEM activities, it was found that teachers had difficult in communicating with teachers of other subjects due to the nature of other disciplines (Lee & Shin, 2014). Ge et al., (2019) investigated a total of 248 with 120 primary and 128 secondary school teachers' self-efficacy and concerns about STEM education. The results showed that only 5.53% of teachers are well prepared, and almost half of the teacher are not ready for STEM education. Teachers expressed intense concerns on "information- pedagogy/resources/support", "Management- organizing, managing, and scheduling the instructional activities" and "Consequence-

the impacts on learning and professional development" about implementing STEM education in schools. These all affected the integrative nature of the STEM education activities, and the effective implementation of STEM education.

For addressing the above problems, we propose the use of BABL principle as the pedagogical guide for promoting and improving the pedagogical design of STEM activities, which has been integrated into science learning supported by mobile technologies and reported (Sun & Looi, 2018). Therefore, we will briefly introduce the theoretical foundations BABL and show the case study of integrating BABL in STEM education as the exemplar of the potentials of BABL in STEM education.

2. Theoretical Foundations of BABL

The boundary activity based learning principle has been gradually developed in the context of science education. The key idea is that connecting the cognition and skills according to the learning contexts via boundary objects in the structural way (Sun & Looi, 2018). The boundary object has been defined as the common idea generated in the scientific work that needs cooperation among divergent viewpoints and the need for generalizable findings (Star & Griesemer, 1989). In the field of seamless learning, boundary objects can take various forms: for example, it can be the abstract concepts introduced in the classroom and elaborated outside the classroom; it can be a guiding question related to a key concept requiring students to do a series of activities to answer it; it can be an event or science phenomena, which require students' investigation outside and discussed in the class. Relevant studies have conducted research on this viewpoints: If seamless learning is well designed in addressing the generation of boundary objects in different forms, the external representations, idea thread syntheses, artifacts, mediating artefacts and its related conception, ideas, discussion can be the good representatives of boundary objects for connecting learning in formal and informal spaces (Wong, Chen, & Jan, 2012; Zhang, 1997).

Based on the literature review, we have refined the basic elements of BABL, for the details, please also refer to the paper (Sun & Looi, 2019). The key components of BABL principle can be summarized into: 1) The boundary object acts as the key component for designing the boundary activities. It serves as bridging learning in and out of classroom and capturing the learning process in the informal spaces. If the learning design should enable the generation of visible and/or invisible boundary objects, this will probably ensure students' cognition transition between formal and informal learning spaces smoothly. 2) Structure: the boundary activity is executed in pre-, during- and post- activity pattern to guarantee the continuum and stability of cognition or skills developed across the learning contexts. 3) Learning objective: The learner's explicit objective is to gain knowledge, skills and/or competences, and develop attitude.

Considering the interdisciplinary nature of STEM learning activities, it will have great potential for guiding and design STEM activities using BABL principle. The use of BABL would help the educators and teachers to implement STEM activities in the different learning contexts and facilitate the teaching of STEM activities supported by technologies.

3. Lesson design of STEM activity guided by BABL principle

In this lesson design, a student-centered STEM learning environment accommodating formal and informal learning environment is created. The key concepts and skills involved in these lesson plans are from primary science curriculum in Hong Kong and Mainland China. It is a comprehensive project based STEM activity. Table 1 shows the details of lesson design, please click the link: https://drive.google.com/file/d/1OHGxMN8F-MRoNaHZSBKwQzLbpSx5nA5Q/view?usp=sharing.
The topic is exploring the relationship of glass curtain wall and daily life. The inquiry-based learning principle is integrated into the activity design, with aims of guiding students' in and out of classroom activity and tracing their learning process. Most importantly, the BABL principle is used for transforming students' cognition smoothly from formal learning context (i.e. classroom) to informal learning context (i.e. out of school).
The characteristics of the lesson design are as follows:
   1) Different mobile technologies: science data logger, nQuire-it (a learning system with mobile sensors), google maps (i.e. tablets) were integrated into the learning activities.

2) Inquiry-based learning principle was used for better guiding primary students' learning in a step by step manner.
3) The combination of learning in formal (i.e. classroom) and informal contexts (i.e. shopping mall) was supported by the use of science data, peer assessment and reflection in and out of classroom.
4) The elements of engineering design were integrated with science learning activities.
5) The STEM activity was a good representative of knowledge integration in STEM education.
6) Students have the ownership on searching online information, making the data collection plan, edit their survey questionnaire and conduct survey, and fill in their e-portfolio as their final report.

4. A pilot study

A pilot study has been conducted to answer the following research questions:
1) How to integrate BABL into STEM learning activities?
2) What are the impacts of BABL guided STEM learning on students' knowledge and skills ?

Figure 1 shows the key activities in the study. The whole inquiry process can be summarized as (1) students were working collaboratively for search online about the buildings surroundings with glass curtain wall; (2) using baidu map to find the best route of school-building; (3) testing their sensor equipment (4) conducting data collection at the building area; (5) drawing the design schema (5) building models. Students will go out of classroom to collect the real data in the activity (4).

The pilot study has been conducted in a primary school. 27 P-5 students participated in this study. The study focused on engaging students in a series of BABL guided STEM activities with aims of improving conceptual understanding and inquiry skills. The activities were conducted within two days. The data collection including students' pre and post tests on STEM knowledge and skills, on-site observation notes, learning artefacts (i.e. STEM design, responses to the tasks in e-portfolio).

Search online and make plan   Discussion   Indoor testing   outdoor testing
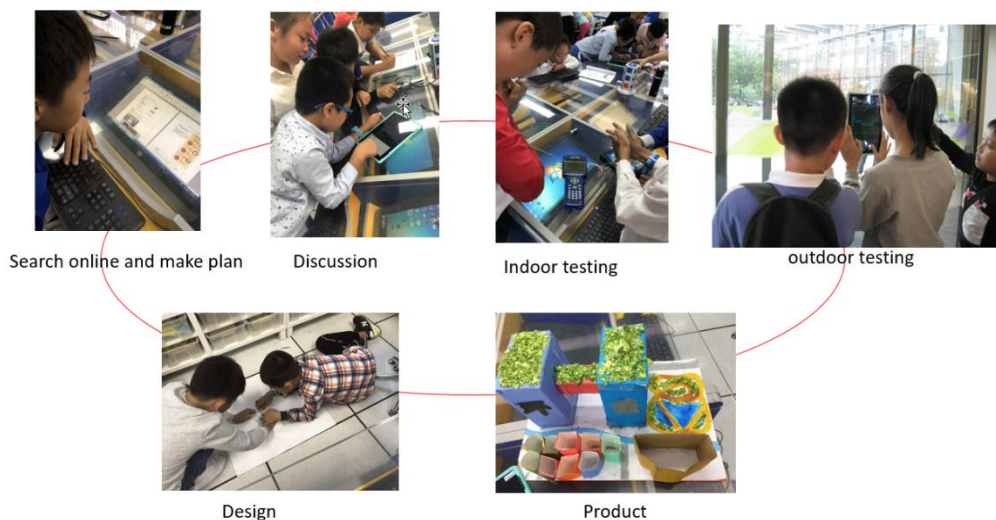
Design   Product

Figure 1. Key activities in BABL guided STEM activity

Figure 2 shows students final design of the life environment with low pollutions. The product shows one of group's efforts on this STEM activity. From the beginning to the end, their plan, design, exploration and model building were proposed and decided by themselves. They may not have enough background information about some activities, for example, the physical properties of curtainwall glass, the engineering design process and skills, the basic knowledge of making survey, as well as using mobile sensors to collect real data. However, their performance were out of our expectation. Most of them were working collaboratively successfully for solving the problem. Overall, the students were actively discussing with their peers on making plans, searching online information and engaged in doing outdoor activities. The high quality and creative STEM design were generated. They felt this

STEM activity providing different experience comparing with pervious learning experiences. They had more opportunities to express their own ideas and applying their knowledge into the practical activities.
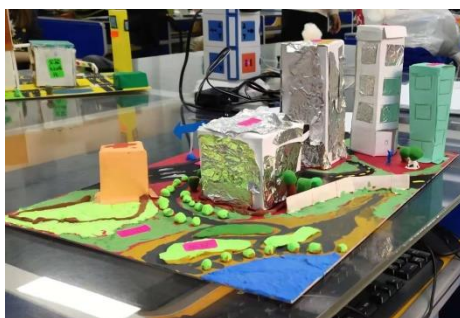
Figure 2. One of groups' final design

5. Conclusion and Implications

Pedagogical design of STEM needs to be explored further. Our study just presents one of the patterns of pedagogical design of STEM activity. There still have more opportunities to integrated different pedagogy with STEM activities. The integration will depends on the content knowledge, skills and nature of the activities, as well as the practitioners of the activities. We need to explore this new opportunities with collecting more evidence on how students' knowledge and skills transfer from one STEM subject into another STEM subject, how to improve the ease of transitions of knowledge and skills across interdisciplinary contexts. In the further research, we will find the boundary objects in the STEM contexts, and expose the characteristics of the cognition and skills transition in different learning contexts. The findings will used to inform the curriculum design of STEM activities and the teacher education of STEM education.

Acknowledgment

References

Education Bureau. (2019). Curriculum Development of Science Education. https://www.edb.gov.hk/en/curriculum-development/kla/science-edu/index.html

Emily A. Dare, Elizabeth A. Ring-Whalen & Gillian H. Roehrig. (2019). Creating a continuum of STEM models: Exploring how K-12 science teachers conceptualize STEM education, *International Journal of Science Education*, 41(12), 1701-1720

Lambrg, T., & Trzynadlowski, N. (2015). How STEM academy teachers conceptualize and implement STEM education. *Journal of Research in STEM Education*, 1(1), 45-58

Lee, J.-M., & Shin, Y.-J. (2014). An analysis of elementary school teachers' difficulties in the STEAM class. *Journal of Korean Elementary Science Education*, 33(3), 588-596

Moore, T. J., Tank, K. M., Glancy, A. W. and Kersten, J. A. (2015), NGSS and the landscape of engineering in K-12 state science standards. *Journal of Research in Science Teaching*, 52 (3), 296-318. doi:10.1002/tea.21199

So, W. M. W., Zhan, Y., Chow, C. F., Leung, C. F. (2018). Analysis of STEM Activities in Primary Students' Science Projects in an Informal Learning Environment.*International Journal of Science and Mathematics Education, 16*, 1003-1023.

Star, S., & Griesemer, J. (1989). Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social Studies of Science, 19*(3), 387-420. Retrieved from http://www.jstor.org/stable/285080

Sun, D.,&Looi, C.-K. (2018). Boundary interaction: Towards developing a mobile technology-enabled science curriculum to integrate learning in the informal spaces. *British Journal of Educational Technology, 49(3)*, 505-515.

Sun.D & Looi, C-K. (2019). *An Inspiration from Border Crossing: Principle of Boundary Activity for Integrating Learning in the Formal and Informal Spaces. In: Looi CK., Wong LH., Glahn C., Cai S. (eds) Seamless Learning. Lecture Notes in Educational Technology*. Singapore: Springer, Singapore.

Wong, L.-H., Chen, W., & Jan, M. (2012). How artefacts mediate small-group co-creation activities in a mobile-assisted seamless language learning environment?, *Journal of Computer Assisted Learni*ng, 28(5), 411-424.

Zhang, J. (1997) 'The nature of external representations in problem solving', *Cognitive Science*, 21(2), 179–217.

WORKSHOP 7 - The 3rd International Workshop on Information and Communication Technology for Disaster and Safety Education (ICTDSE2019)

Practical Evaluation of ICT-based Self-made Regional Safety Map through Residents' Workshop in a Historical Local Town

Yasuhisa OKAZAKI [a]*, Sho MATSUO [b], Hiroshi WAKUYA [a], Yukuo HAYASHIDA [a], Nobuo MISHIMA [a]

[a] *Faculty of Science and Engineering, Saga University, Japan*
[b] *Graduate School of Science and Engineering, Saga University, Japan*
*okaz@cc.saga-u.ac.jp

Abstract: This paper describes a practical evaluation of our ICT-based regional safety map for a historical local town. In this kind of towns, it is required to make daily potential dangers visible and share them as basic information for regional safety. Our system supports local residents to post dangerous points in their living areas and share. We created and revised a local safety map under the cooperation of voluntary disaster prevention members. From the observation of the workshop and questionnaire survey, we found that (1) our system contributes to collect and share distinctive local danger information for the safety map, (2) the map provided by our system leads to awareness of safety by reaffirming nearby danger, and (3) the map is also useful for reviewing danger information and improving reliability through meeting.

Keywords: regional disaster prevention, safety map, voluntary disaster prevention, historical local town, community participation

1. Introduction

In Japan, which has suffered many damage due to natural disasters (Disaster Management, Cabinet Office, 2015), research and various efforts to minimize such damage have being done (Geospatial Information Authority of Japan (GSI),2017; Mitsuhara, H. et al., 2015; Nakai, F. et al., 2014; Nonomura, A. et al., 2016; Sakuma, A. et.al., 2015). Under these circumstances, there are areas where town development is progressing against disasters. However, local towns with historical streets (hereinafter referred to as historical local towns) are vulnerable to disasters due to regional problems (Okazaki, Y., et al., 2016). Historical local towns have traditional landscapes such as post towns or castle towns (Japan Guide.com, 2012). In order to preserve such traditional landscape, it is difficult to improve the infrastructure such as earthquake resistance of building and road construction. Also, as young people flow out to urban areas, the population has been declining and aging in historical local towns. The number of elderly people who can receive support from young people at the time of disasters is limited. People living in these historical local towns need to consider disaster risk in advance and prepare for disasters in such harsh conditions of spatial or human restrictions (Mishima, N., et al., 2014).

Since the Great East Japan Earthquake, hazard maps have been drawing attention as disaster countermeasures. However, the usual hazard map does not consider detailed regional characteristics. In historical local tows with old townscapes, there are many distinctive problems, such as narrow roads and small waterways, where there is no emerging standard when creating hazard maps. Moreover, anxiety that residents feel in their daily lives is often issues that they do not notice unless they actually live in the area. It is necessary to highlight these issues from the perspective of local residents. By reviewing conventional disaster prevention maps from the stage of creation and collecting information by local residents themselves, it becomes possible to create original regional safety maps that posted information on the residents' perspective.

We have been developing and researching a regional safety map creation support system based on the characteristics of the town in utilizing ICT (Kozaki, S. et al., 2017; Okazaki, Y., et al., 2017;

Okazaki, Y., et al., 2018). In this system, while actually walking around the district using the tablet terminal, the residents register the information (kind of danger, picture, comment, position) of the points that can be danger. By integrating the collected information and displaying the information on the map, a local safety map is created. By residents participating, we are expecting recognition of local dangers by collecting and sharing detailed information on the area and raising awareness of disaster prevention for residents.

In this study, we evaluate the local safety map we created using our regional safety map creation support system at Hizen Hamajuku which we selected as model area. This region has remained old city from the Edo era and has been designated as nationally important traditional buildings preservation districts (Agency for Cultural Affairs, 2017; Saga Trip Genius, 2014). We asked representatives of the local residents to consider evacuation plans assuming disasters. At that time, they actually used the tablet terminal in using the regional safety map created by previous activities. Through these activities, we evaluated our maps from the viewpoint of the usefulness as a disaster prevention map and the validity of information, the readability of the information being posted, and the ease of use as a safety map.

The rest of the paper is organized as follows. Section 2 presents how to create a local safety map. Section 3 describes results and discussion of the evaluation through the workshop. Section 4 gives summary of the paper.

2. Collection and Review of Danger Information by Town Walking

2.1 Collection of Danger information by Town Walking

On September 29, 2017, 11 local residents and 8 our members took a walk using our system and gathered information (Okazaki, Y., et al., 2018). About 15 minutes, we explained the way of using the system to the residents. After that, we assigned persons in charge of the six districts in the target area. They are "Shokin", "Minamifunatsu", "Kitafunatsu", "Nakamachi", "Hashuku" and "Shinmachi". The person in charge of each district is a group of 2 to 4 people including the local residents of the district and our student members. Each group searched for each district and registered district danger information. The time to walk around town was around 1 hour including the round trip to the starting point.

Figure 1 shows the safety map created in this activity. A total of 50 regional danger information was registered. We asked local residents to input information. Most of the information was input by the residents themselves, but our members (students) entered information on the support of uneasy people and the information they found themselves. Figure 2 shows information posted in each district. The type and number of registered information are different for each district. Moreover, these differences reflect the anxiety of each district against these disasters including the town specific. We believe that we could create a safety map reflecting the characteristics of the district by walking around and registering information in using our system.

2.2 Review Meeting for Posted Danger Information

The review meeting was held at Hama public hall, which is a community hall in target area, on April 19, 2018. There were 9 participants, who are 5 local residents, one Kashima city official staff and 3 our members (one professor and two graduate students). The residents are representative for voluntary disaster prevention activities from each district in the target area. The city official belongs to the City Construction Division which administer the target area. We held the meeting for about 2 hours from 10 AM.

In this review meeting, there were opinions that it would be better not only to have specific points, but also to have danger information on roads, certain areas, or information useful in case of a disaster (AED(Automated External Defibrillator), fire hydrant, evacuation center). Therefore, we improved the system so that such information can be provided. We also changed the crime icon from a suspicious person to a police officer.
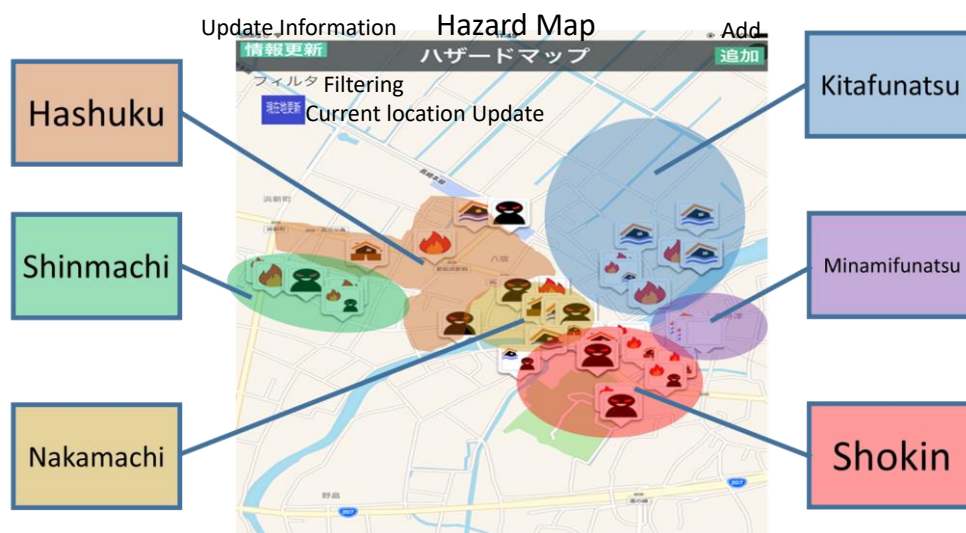
Figure 1. The created safety map.
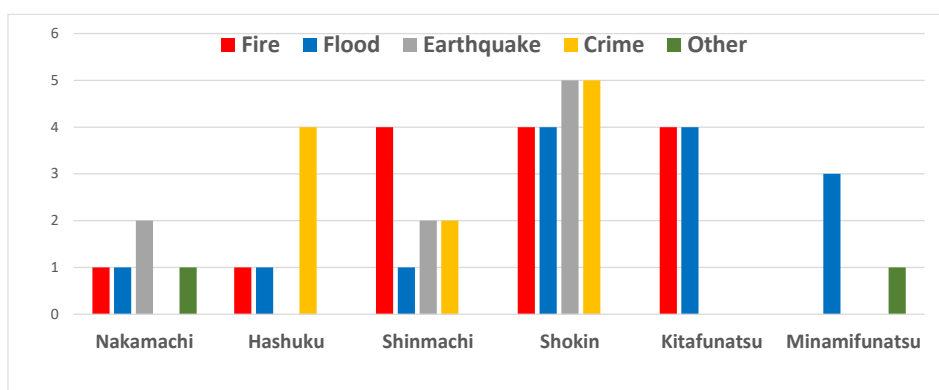
Figure 2. Danger information posted in each district.

2.3 Additional Danger Information Collection

On October 4, 2018, 5 local residents, one Kashima city official staff and 3 our members gathered at Hama public hall and collected additional area information described in section 2.2. This time, instead of actually walking around the towns, we used a customized Zenrin Map. A total of 29 information is added. Many of them are information on narrow roads where fire truck cannot pass and low land where water flows. We made the safety map reflecting such information.

3. Evaluation of Safety Map through Regional Safety Workshop

3.1 Outline of the Workshop

In this workshop, we evaluate whether disaster prevention map created using this system have practical roles and objectives expected by the residents. Local volunteers who actually use the disaster prevention map examined evacuation plans assuming disasters in using the regional disaster prevention maps created by our system. The viewpoint of evaluation is the practicality of the disaster prevention map, characteristics and validity of information, easiness of viewing and ease of operation.

On December 20, 2018, we held a meeting at Hama public hall in Hizen Hamajuku about 2 hours from 10:00 am. Participants were 8 local residents, one Kashima city official staff, and 5 Saga University officials (1 professor, 4 students). Of the 8eight local residents, five were participating in both town walking and review meeting , and one was participating in town walking. Two people and the city staff participated only in this workshop. Figure 3 shows two photos of the workshop. The procedure is as follows. We organized four groups of two local residents and one student. A city office staff joined
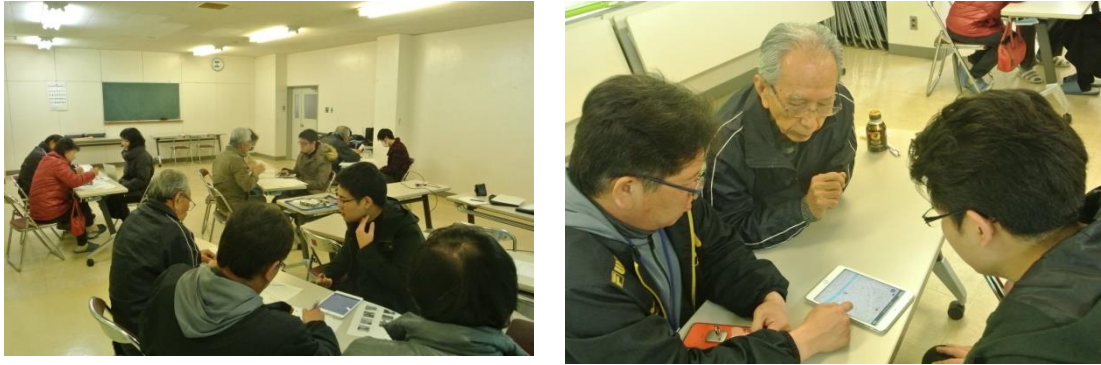
Figure 3. Snapshots of the workshop

one of them. For about 20 minutes, students used the actual equipment to explain disaster map viewpoints and operations to local residents. After that, each group took about 70 minutes to check the information that was posted and to examine the evacuation plan. In order to examine the evacuation plan, we distributed maps of paper that printed Hizen Hamajuku area and self-made evacuation plan examination sheet. They confirmed the danger in their daily life and evacuation route. Finally, we conducted a questionnaire survey on the system and disaster prevention map for about 10 minutes. The record of this workshop is only photographs and memos in consideration of participants who are reluctant to record (video and audio recording). Workshop analysis by protocol analysis is a topic for the future.

3.2 Items and Methods in Evaluation

The questionnaire has 13 items in all. Question 2 to Question 11 are five-point scale selective question. Evaluation items of the questionnaire were practicality of safety map (Questions 8 and 9), characteristics and validity of information (Questions 5 to 7), ease of viewing, ease of operation (Question 2 To 4, 10 to 13), and the experiences of electronic devices (Question 1).

3.3 Results and Discussion

3.3.1 Practicality of the Map

Figure 4 shows the answer to the question No.8 (whether this safety map is effective for each role or purpose). Since we were able to obtain positive evaluation, we believe that we were able to achieve role and purpose of the map in general. Although we did not compare with official hazard maps, the conversation among the residents at the workshop showed that they were able to know information on their own risks not listed in the safety map, and also provided a good opportunity to think about disaster prevention.

The answers that it is moderately effective were also high percentage. This indicates that the map has room for improvement. There were requests such as adding information and improving the degree of danger to Question 13 (Improvement points and functions / information you would like added). Improvement proposals include establishing standards of danger levels and visualizing them, making it possible to register not only the cause items of the disaster but also damage prediction, and making it possible to register more than one photo.

There were many positive answers to the questions of "Improvement of disaster prevention awareness by using on a daily basis" and "Documents for use in discussion and disaster prevention workshops". We think this is because the review of the evacuation plan in this workshop was useful. Several improvement points were pointed out on the map, but we believe that the workshop was meaningful and successful.

Although there were many positive answers about improving disaster prevention awareness, it is not easy to show it as objective data by using the map. It is a future task to conduct this evaluation after examining concrete evaluation methods.
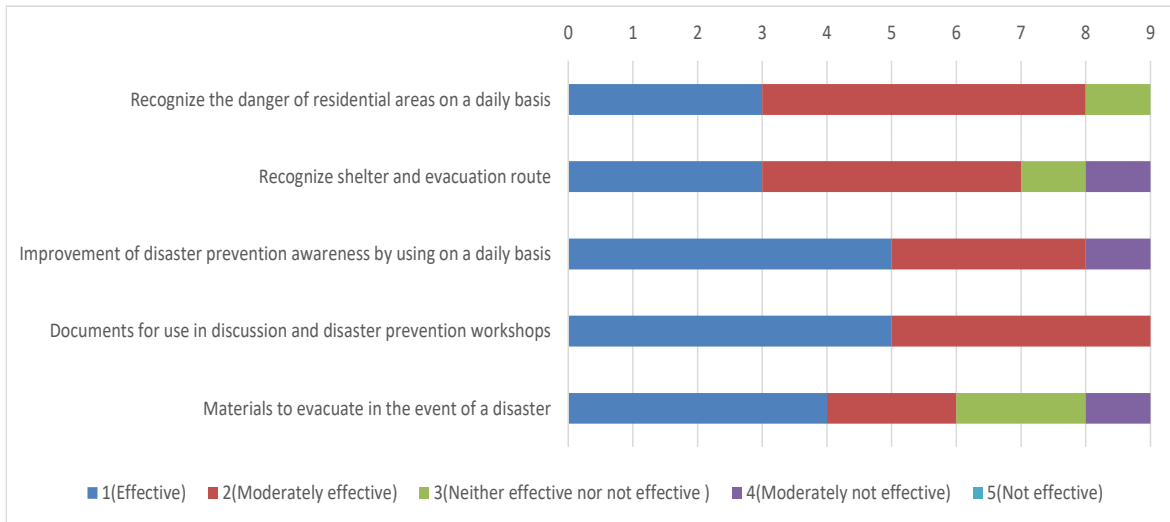
Figure 4. Answers to Question No.8 (Practicality of the map)
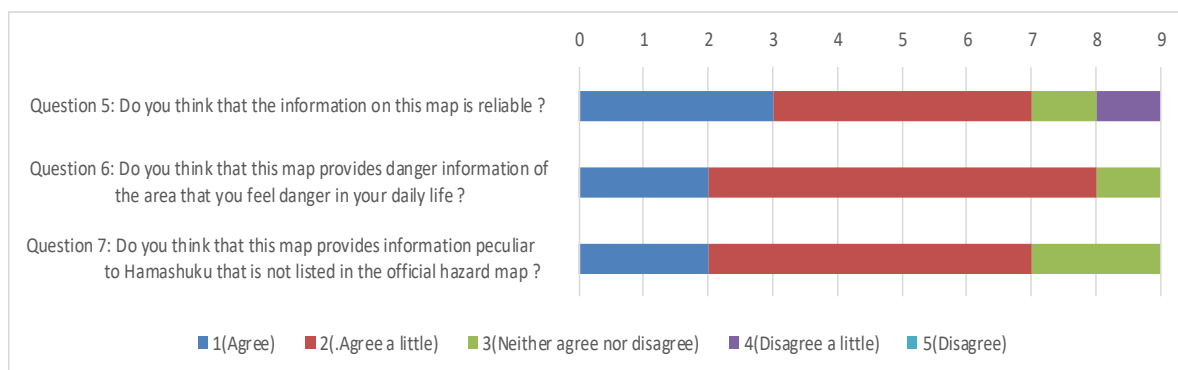
Figure 5. Answers to Question No.5-No.7(Characteristics and validity of information)

Two questions, "Recognize shelter and evacuation route" and "Materials to evacuate in the event of a disaster", were somewhat sluggish with good evaluation. Both of them are questions about evacuation. The reason for this may be that the system is designed to use before disaster occurrence. We think that it will become possible to use the system even when evacuating by additionally installing the function to register evacuation route.

From these results, we can say that our safety map makes it possible to recognize the danger of the area on a daily basis and it is effective as a material for local disaster prevention activities. We believe that it is useful to use this safety map when deepening the understanding of regional dangers as part of disaster prevention activities by local residents.

In this type of system, maintaining and updating information is necessary. In this area, voluntary disaster prevention member gathers every year to exchange information. Our system is expected to supply updated information. However, some members are worried about using electronic devices. Therefore, at this point, it would be best to examine with paper map and reflect the result tothe system.

3.3.2 Characteristics and Validity of Information

We show the answers to the question about characteristics and validity of information (No.5 to No.7) in Figure 5. The answer to Question 5 ("Do you think that the information on this safety map is reliable?") was generally positive. The following two reasons can be considered. The first is that the information was collected by residents walking around their districts. The last is they have a review meeting on the information they have collected so far.

For questions No.6 ("Do you think that this safety map provides danger information of the area that you feel danger in your daily life ?") and No.7(" Do you think that this safety map provides danger information peculiar to Hizen Hamashuku that is not listed in the safety map distributed by the administrative organs?"), there was no negative answer. There was no direct comparison with the official hazard map at this workshop. We had the participants compare with the hazard map which had been distributed. The official hazard map shows the classified areas expected to be flooded. By comparing with the self-made regional safety map, residents were able to compare with their own recognition and confirm the danger again for flood damage. Other disaster forecasts are not included in the official hazard map and cannot be compared. These results indicate that detailed local information on areas that are not listed in the official hazard maps can be posted on our safety map.

This series of activities demonstrates that the residents themselves can create an original regional safety map with gathering information on dangerous points by walking around the area and examining information by review meeting. By creating a safety map in using our system, it is possible to reflect issues that do not emerge as standards of creating normal safety maps, such as narrow roads and small waterways, and anxiety that local residents feel in their lives. Based on past experiences of disaster, it is also possible to register in the system what they learned from actual damage situation. We believe that these are meaningful when creating safety maps, such as in historical local towns with regions-specific issues.

3.3.3 Ease of Viewing and Operation

Figure 6 shows the results of questionnaire on usual usage of electronic equipment, and Figure 7 shows the results of questionnaire on ease of viewing and operation of safety map. Three participants in the experiment had never used smart phones or tablet terminals. We checked the answer of these three people to the question No.10 ("Do you think that this safety map is easy to operate?"). Two people had a positive evaluation as "Agree" (One person missed entry). This is because students instructed participants on how to use, so that even participants who have hardly used electronic devices can get
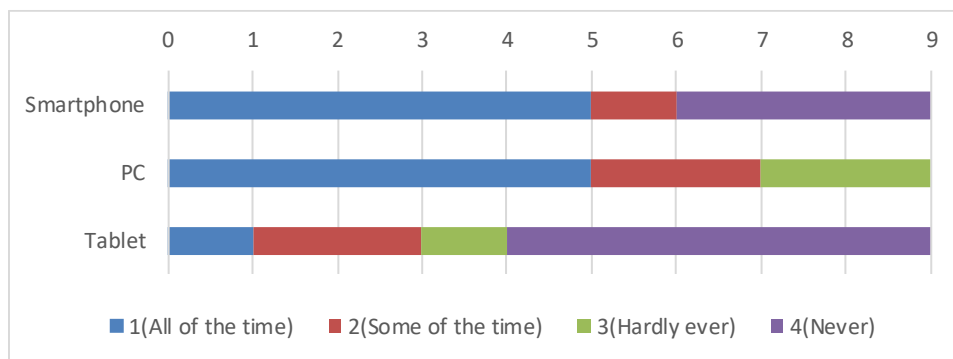
Figure 6. Answers to Question No.1(Usual usage of electronic equipment)
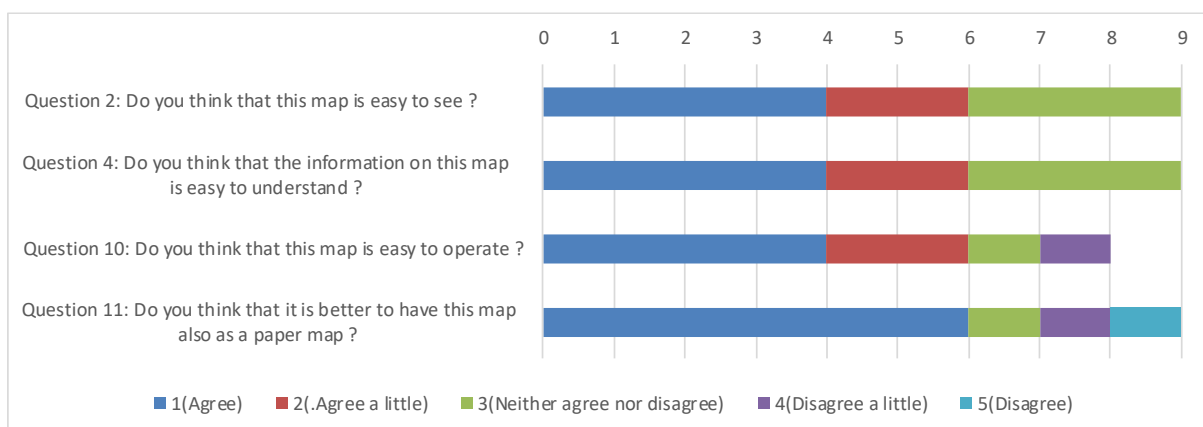
Figure 7. Answers to Question No.2, No.4, No.10 and No.11(Ease of viewing and operation)
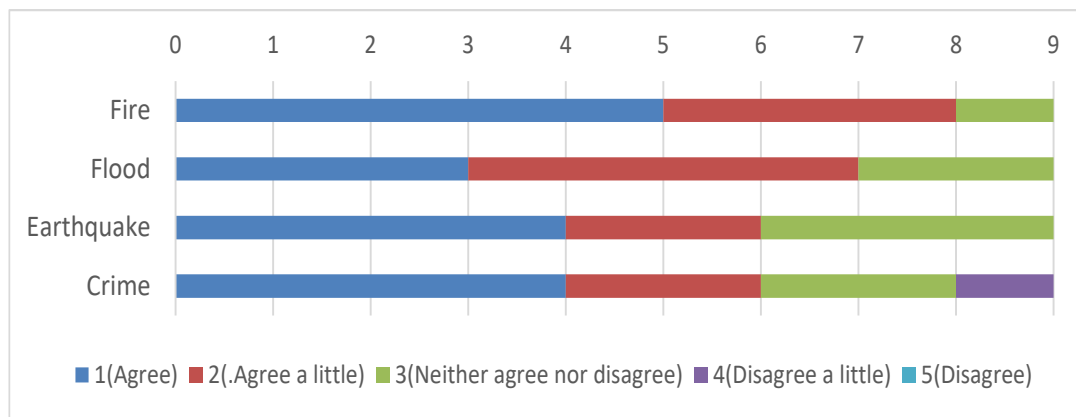
Figure 8. Answers to Question No.3(Evaluation on icons)

used to it soon and think that they were able to handle the system. This demonstrates that even elderly people with little experience handling electronic equipment can handle our system by instructing the operation method for a short time. All the participants were able to get guidance from the students this time. However, there was an opinion that I was worried about my own operation. When considering actual operation, preparation of operation manual is required.

The evaluation results of the icons are shown in Figure 8. The fire and flood icons got a good rating in general. On the other hand, in the icons of the earthquake and crime, three participants answered that they would be lost in judgment of good or bad, or slightly disagree. Icon design is considered to express the cause. Earthquake icons express the appearance of the earthquake by shaking the house with a wavy line around the house and cracking the ground. However, it seems that it was not clear what these lines express. For crime icons, three did not make a positive evaluation despite revision. Icon of crime expresses police with reference to crime hazard map. Since crime has many varieties, intuitive icon design is difficult. It is necessary to re-examine the crime icon.

The fact that the evaluation on Questions No.2 and No.4 is not very high indicates that there is room for improvement in the user interface of our system. There was an opinion that the photo and the characters were small. Also, there was an opinion that characters overlapped and they were hard to see at the case of information filtering. This indicates that it is necessary to reexamine the color and size of characters or background of the filtering screen. Question No.4 is an evaluation of the comprehensibility of the posted information. The reason why the evaluation of this item was not high can be ascribed to the difficulty in understanding icons and danger levels as described above. Based on these points, it is expected that the convenience of the system can be enhanced by improving the user interface for elderly persons and presenting the information being posted more intuitively.

4. Conclusion and Future Works

In this research, local residents evaluated the original regional safety map created in using tour safety map creation support system through workshop activities. As a model district, we selected Hizen Hamashuku, Kashima City in Saga Prefecture, where historical townscape remains. Our system supports local residents to post dangerous points in their living areas and share. Through review meeting and workshop activities, we evaluated our maps from the viewpoint of the usefulness as a safety map and the validity of information, the readability of the information being posted, and the ease of use as a safety map. Using the map as a material of the disaster prevention workshop, we demonstrated that (1) our system contributes to collect and share distinctive local danger information for the safety map, (2) the map provided by our system leads to awareness of safety by reaffirming nearby danger, and (3) the map is also useful for reviewing danger information and improving reliability through meeting.

Our activities, including this workshop, are part of the district's voluntary disaster prevention activities, and the staff of the City Planning Division of the city is always participating. In order to publish the information of our system, it is necessary to improve the reliability and understandability of the information and discuss with the city officials how to integrate the information of our system and the information of the official hazard map. So far, our system has been used only by the district's voluntary disaster prevention organization. Future challenges will include disaster prevention education and information gathering from the perspective of children by applying it to school education.

Acknowledgements

References

Agency for Cultural Affairs. (2017). Preservation Districts for Groups of Traditional Buildings August 1, 2019, from http://www.bunka.go.jp/english/policy/cultural_properties/introduction/historic_buildings/

Disaster Management, Cabinet Office. (2015). Disaster Management in Japan. Retrieved August 1, 2019, from http://www.bousai.go.jp/1info/pdf/saigaipamphlet_je.pdf

Geospatial Information Authority of Japan (GSI). (2017). Disaster Measures. Retrieved August 1, 2019, from http://www.gsi.go.jp/ENGLISH/page_e30066.html

Japan Guide.com. (2012), Historic Sites. Retrieved August 1, 2019, from http://www.japan-guide.com/e/e2422.html

Kozaki, S., Okazaki,Y. Wakuya, H., Mishima, N., Hayashida, Y. & Min, B. W. (2017). Development of a Community-based Hazard Information Sharing System for Traditional Towns with Local Heritage, *25th International Conference on Computers in Education Main Conference Proceedings*, 712-714.

Mishima, N., Miyamoto, N., Taguchi, Y. & Kitagawa, K. (2014). Analysis of current two-way evacuation routes based on residents' perceptions in a historic preservation area, *International Journal of Disaster Risk Reduction*,8, 10-19.

Mitsuhara ,H., Inoue, T., Yamaguchi, K. Takechi, Y., Morimoto, M., Iwaka, K.,Kozuki Y. & Shishibori, M. (2015). Web-Based System for Designing Game-Based Evacuation Drills. *Procedia Computer Science*, 72, 277-284.

Nakai, F., Hatayama, M., & Yamori, K. (2014). A Study on Evaluation for Community Based Planning Process of Tsunami Evacuation using Agent Based Simulation. *SIG Technical Reports of IPSJ*, IS-127(6), 1-9.

Nonomura, A., Hasewaga, S & Inomo, H. (2016). Use of the community disaster prevention map for community disaster prevention plan. *Environmental science*, 28(1), 45-49.

Okazaki, Y., Mori, S., Wakuya, H., Mishima, N., Hayashida, Y. & Min, B-W. (2016). Development of a Sustainable Community-based Hazard Map Creation Support System for Traditional Towns with Local Heritage. *International Journal of Contents*, 12(2), 58-65.

Okazaki, Y., Kozaki, S., , Matsuo, S., Wakuya, H,, Mishima, N., Hayashida , Y. & Min, B-W. (2017). Prototyping of Community-based Hazard Mapping Support System for Traditional Towns with Local Heritage. *25th International Conference on Computers in Education Workshop Proceedings,* 171-179.

Okazaki, Y., Kozaki, S., , Matsuo, S., Wakuya, H., Mishima, N., Hayashida, Y., & Min. B-W. (2018). Review of Hazard Information Collected for Local Disaster Prevention by Residents in a Historical Local Town. 26th International Conference on Computers in Education Workshop Proceedings, 1-5.

Saga Trip Genius. (2014). Hizenhamashuku Area. Retrieved August 1, 2019, from http://www.saga-tripgenius.com/tourism_search/hizenhamashuku-area.html

Sakuma, A., Matsuo, I., Ito, S., Tanaka, S. & Nakaseko, T. (2015). Disaster Prevention Activities of Japanese Fire Companies. *Journal of disaster research*, 10(5), 929-938.

Exploring Application of an ICT-Based Disaster Education System for Foreigners in Japan

Meiqin LIU[a*], Hiroyuki MITSUHARA[b] & Masami SHIHIBORI[b]
[a]*Graduate School of Advanced Technology and Science, Tokushima University, Japan*
[b]*Graduate School of Technology, Industrial and Social Sciences, Tokushima University, Japan*
*c501947008@tokushima-u.ac.jp

Abstract: In Japan, a disaster-prone country, foreigners may fail to survive in disasters because they lack disaster-related knowledge, so disaster education for foreigners living in Japan is necessary. However, many foreigners are unwilling to spend time on disaster education. To improve this situation, gamification is employed. Gamification is to use game design elements or mechanisms in non-game contexts. For example, in the educational field, gamification makes learning easy and attractive, which motivates participants and encourages engagement in learning activities. This paper explores an information and communication technology–based system with application of gamification in disaster education for foreigners living in Japan.

Keywords: Foreigners in Japan, disaster education, gamification, ARCS+G motivation model, ICT-based disaster education system, cross-platform app

1. Introduction

Japan is attracting an increasing number of foreigners from all over the world with its natural and cultural environments. According to statistics from the Japanese Ministry of Justice, the number of foreigners residing in Japan increased dramatically from around 2 million to more than 2.6 million between 2011 and 2018, and the rising trend is continuing. The large number of foreigners have brought new social problems into the country. One of the important issues is disaster education, particularly how foreigners will survive during disasters.

Japan is a disaster-prone country. However, Japan has generally had low numbers of casualties caused by disasters, especially by earthquakes. Japan's comprehensive and advanced disaster education is one of important reasons contributing to the low casualties. In Japan, even among kindergarteners, disaster education, including disaster knowledge, survival techniques, and evacuation drills, is conducted regularly. Therefore, the Japanese know how to quickly get to designated sites or safe places by proper methods.

However, disaster education for foreigners living in Japan is not as effective, and it is unclear how it should be improved. Unlike the Japanese, most foreigners have neither disaster awareness nor disaster knowledge relevant to their adopted country, and they have no understanding of how to survive when encountering disasters in Japan. Even if disaster lectures and experience activities are organized regularly in universities, the popularity of disaster education among international students is not satisfactory. It can be inferred that general foreigners in Japan are in the worse situation than international students on receiving disaster education because they have fewer opportunities to be exposed to disaster education and knowledge.

Such foreigners may not survive disasters, which may contribute to serious social problems. This is a negative factor in Japan's efforts to attract more foreigners. Thus, it is indispensable to popularize disaster education among foreigners, to enhance their disaster awareness, to impart disaster knowledge, and to help them build confidence in meeting possible disasters. To solve this problem, an information and communication technology (ICT)–based disaster education system is designed and developed in this study.

Complicating this problem, disaster education can be boring, and it is not compulsory for adult foreigners. As a result, people are reluctant to invest time in disaster education, which reflects their lack of disaster awareness. Considering this situation, gamification is employed in the presented disaster

education system, which is expected to make the education more engaging to encourage foreigners' participation.

Considering the following properties of earthquakes:

1. Unpredictability. Earthquakes cannot be predicted accurately yet and may hit anytime or anywhere. The unexpected nature of earthquakes means many people fail to prepare for this type of disaster.
2. Great hazard. The destructiveness of strong earthquakes and possible sequent tsunami is frightening. For example, in the Tohoku district off the Pacific Ocean, an earthquake occurred in 2011 that, with the sequent tsunami, resulted in a missing and death toll of more than 15,000 people.

In Japan, earthquakes strike with a high frequency. Based on these considerations, this paper focuses on disaster education related to earthquakes. If not specified, disaster education in the following sections refers to earthquake education.

2. Fundamental Ideas on Earthquake Education

2.1 Study Outline

In this study, earthquake education is divided into three learning phases that foreigners enter in sequence: (1) preparation phase, (2) practice phase, and (3) influencer phase. The first phase, the preparation phase, means people start accessing earthquake knowledge in their home country before visiting Japan. This is necessary to help build awareness of earthquakes. For example, if foreigners intend to visit Japan, they should know that there is a high frequency of earthquakes in Japan.

The second phase, the practice phase, involves gaining practical knowledge after arriving in Japan. For example, it is important to know detailed shelter information, to know where and what types of shelters are in the community, and to participate in evacuation drills and other exercises that help people get to the nearest evacuation site during an earthquake.

The third phase, the influencer phase, involves learning to become influencers, i.e., instructors or facilitators. Foreigners with disaster education can act as influencers to impart earthquake knowledge to those who intend to visit Japan, to help them build earthquake awareness and confidence, or to nationals in their home countries to promote earthquake education. The three learning phases are shown in Figure 1.
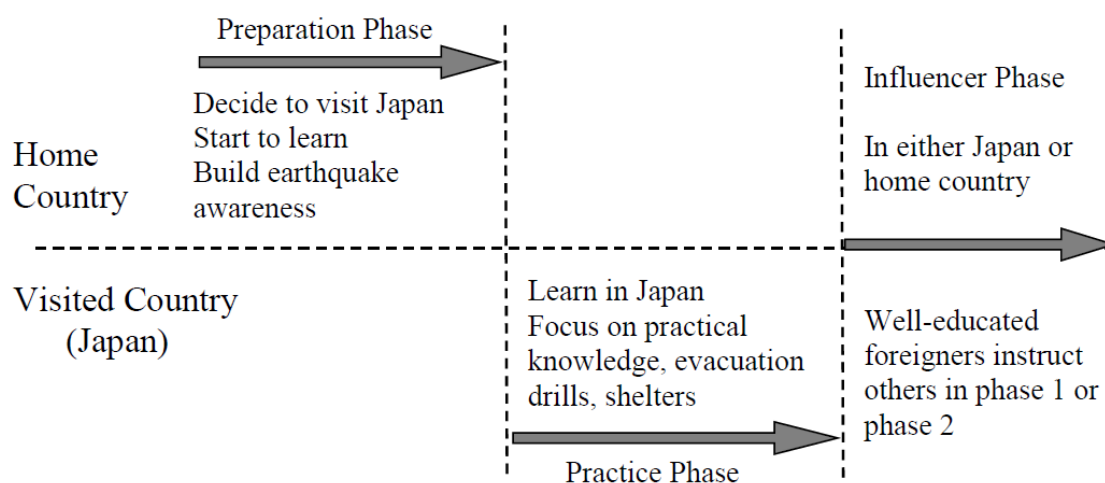
Figure 1. Three learning phases by timeline.

2.2 ICT-Based Disaster Education

In disaster education, disaster knowledge and evacuation drills are indispensable. However, in conventional disaster education, arranging a disaster lecture or organizing an evacuation drill is time consuming. Furthermore, such evacuation drills cannot create an immersive experience, and participants may not be serious about learning because they know the drill is just a drill and not real.

ICT-based disaster education, as a complement to conventional methods, is in a boom phase (Rahman et al., 2016) (Leelawat et al., 2018). Compared with conventional disaster education, ICT-based disaster education has several advantages. With the diversification of electronic equipment, different ICT-based systems have emerged and play an increasingly important role in disaster education. Some ICT-based systems obtain effective and instant disaster information by using portable devices and the Internet. In particular, by using virtual-reality or augmented-reality technology, as well as some wearable intelligent devices, some systems can simulate a disaster scenario and create an immersive experience for users (Kawai et al., 2015) (Mitsuhara et al., 2016). Backtracking is also an important property in disaster education. Some ICT-based systems record all procedures of evacuation drills, which enable facilitators to check and improve participants' missteps when evacuation drills fail. This increases the success of drills in real evacuations.

This paper concentrates on the first phase of research: beginning earthquake education when foreigners are still in their home countries. An ICT-based system, combining with the application of gamification, will help fulfill the requirements.

2.3 What the System Is Like

The system consists of two parts: server side and client side. The server side supports the WebSub open protocol, and the client side is designed and developed as a cross-platform app for smartphones.

Besides high efficiency and backtracking, this system has other advantages, such as the following:
1. Accessibility. As a cross-platform app, the client side allows the system to be unrestricted by time and space. Disaster information and knowledge can be easily accessed.
2. Timeliness. WebSub improves the polling mechanism that lets the server side receive almost real-time seismic information and alarms.

Explanations of the system, including WebSub and the cross-platform app, are given in section 3.

2.3.1 Achieving the First Phase

In this phase, disaster education mainly focuses on two aspects: (1) improving foreigners' earthquake awareness and (2) helping foreigners acquire earthquake knowledge.

For the first aspect (i.e., improving foreigners' earthquake awareness), a parameter called frequency of earthquakes (FOE) is introduced into the system. The FOE is the number of earthquakes occurring in Japan within 1 year. It can be seen clearly that the number is in the thousands. Every year, each time an earthquake occurs in Japan, the FOE will increase by 1, and earthquakes with a seismic magnitude of 3 or greater will also be counted and displayed. For example, in 2018, the FOE was 2,179, which meant Japan experienced 2,179 earthquakes, and the number with magnitude 3 or greater shocks was 256. It is clear from the FOE that earthquakes happened 6 times per day on average in Japan and that those of magnitude 3 or greater occurred every 1.4 days on average. Through these intuitive data, the "Japan is an earthquake-prone country" concept will become concrete instead of abstract. If the system was in use in 2018, users' smartphones would be overwhelmed by earthquake warnings, which promotes foreigners to change their views and builds earthquake awareness.

For the second aspect (i.e., helping foreigners acquire earthquake knowledge), the system provides a learning module that includes various materials as text, pictures, videos, links, quizzes, etc. Earthquake information and knowledge, as well as corresponding measures to help survive an earthquake, can be accessed easily. Quizzes help to check whether users have a good command of the earthquake education.

2.3.2 User Customization

User-customized settings are available. Settings based on destination are supported, placing emphasis on the seismic information for specific places. For example, if a Chinese woman is about to visit Tokushima, then Tokushima can be set as a favorite place; meanwhile, a Malaysian man going to Hiroshima can mark Hiroshima as a favorite place. If an earthquake occurs in Tokushima, the Chinese user will receive a warning message with a ring or vibration, including detailed earthquake information and learning links, and FOE of Japan and Tokushima will be increased by 1; meanwhile, the Malaysian user will receive only a simple prompt message. Similarly, if an earthquake happens in Hiroshima, the situation will be reversed. If an earthquake hits Tokyo, both users will only receive a simple prompt message. The example is shown as Figure 2.
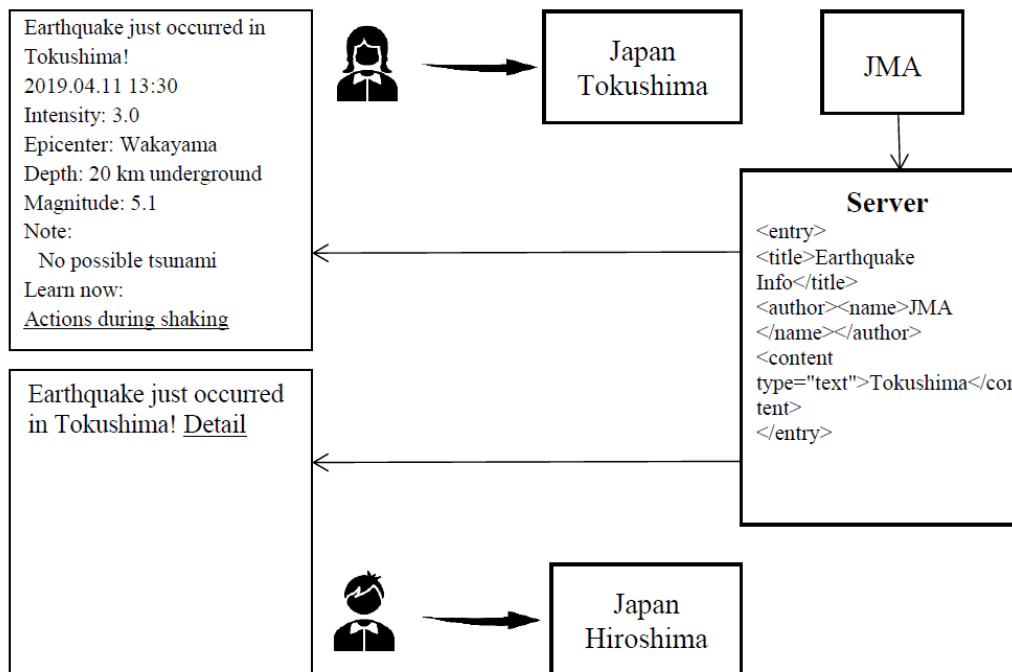
Figure 2. Example for user customization based on location.

Customized setting that use a specific seismic magnitude as the message-receiving threshold is also supported, allowing the users to receive only earthquake messages of the specified magnitude or greater. Multilingual support is also available. The appropriate language can be chosen for those who have difficulty understanding Japanese.

2.3.3 Motivation Model Employed in the System

The system conforms to the so-called enhanced ARCS+G learning motivation model (Amir Fazamin et al., 2014). ARCS stands for attention, relevance, confidence, and satisfaction (Keller, 1987). In simple terms, the ARCS motivation model refers to paying attention to related issues and then benefiting from positive feedback to build confidence and acquire satisfaction. In the enhanced model, G refers to gamification.

Gamification is the use of game design elements in non-game contexts (Deterding et al., 2011) (Werbach & Hunter, 2012). The definition contains three key points: design elements, game mechanism, and non-game context. Gamification is learning techniques from games and thoughtfully applying them to non-game situations. Gamification is being widely in many fields, including Internet, medical or health care and finance (Cudney et al., 2015) (Robson et al., 2016) (Yang et al., 2017) (Hiroyuki & Masami, 2017). In the educational field, gamification has also been playing a role (Hanus & Fox, 2015) (Roy & Zaman, 2018) (Yildirim, 2017). In disaster education, gamification is expected to help more foreigners living in or coming to Japan receive disaster education. Common game design elements include badges, levels, points, leaderboards, virtual currency, characters, maps, challenges,

competitions, and collaboration. Game mechanisms include rewards, achievement, progress, self-expression, and community.

In this system, a growing FOE may urge users to pay more attention to earthquakes and realize that Japan is a country with frequent earthquakes, which meets the attention component of the ARCS+G motivation model. Each time an earthquake occurs, users have the opportunity to learn about earthquakes, which meets the relevance component of the ARCS+G model. The more users learn, the more relevant knowledge they obtain, the more confidence they gain to survive earthquakes, and the more satisfaction they receive from the positive feedback resulting from their confidence, which meets the confidence and satisfaction components of the ARCS+G model. The gamification, including some basic design elements and game mechanisms that are explained in detail later, introduced in the system is expected to contribute to user satisfaction.

3. System Prototype Design and Gamification

3.1 System Prototype Design

This system consists of two parts: (1) the server side, which mainly takes charge of the user management module, message pushing, and subscribing to and pulling earthquake information from the Japan Meteorological Agency (JMA), and (2) the client side, which oversees the user management module, learning and quiz management module, earthquake information processing module, and multilingual support. The system architecture diagram is shown in Figure 3.
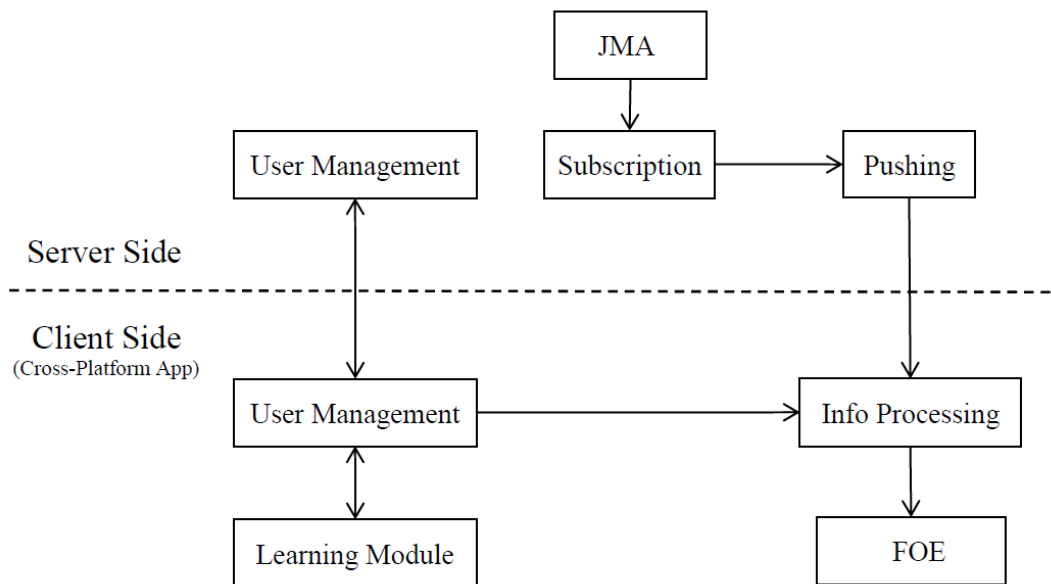
Figure 3. System architecture diagram.

3.1.1 Server Side

In this system, the server is implemented in Java based on the Spring Boot framework, and it supports 100 concurrent users in this version. The server side achieves the following functions:

1. User management module. This module is mainly for managing personal information, such as user signup with username and password or a unique device serial code; user sign-in status; user profile, including favorite location and language; user rewards as points, badges, and a leaderboard (PBL), which are explained later; and user learning record, with total learning duration, quiz scores, etc.

2. Earthquake statistics. The earthquake information processing records details of all earthquakes occurring in Japan, giving the epicenter, occurrence time, magnitude, etc.

3. Multilingual support. On the server side, the translating function supports multiple languages. The raw seismic information from JMA is in Japanese, which hinders those who

have difficulty understanding Japanese. Therefore, the server side keeps a user list, recording each user's setting language. The raw messages are translated to the language of each user's setting before they are pushed to the user.

4. Subscription module. A subscription service is also available that is responsible for obtaining seismic information from the JMA website. Subscription to the earthquake topic from the JMA website occurs via WebSub (previously known as PubSubHubbub), which is an open standard for communication between publishers and subscribers. See Figure 4. WebSub improves polling, so when an earthquake occurs, the server obtains almost real-time seismic information in extensible markup language (XML) format and pushes it to users.
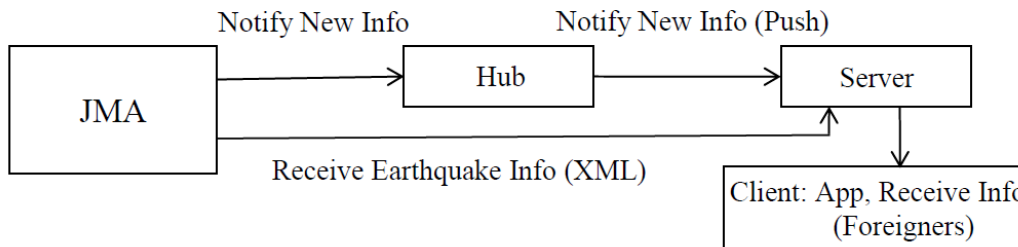
Figure 4. WebSub flow diagram.

5. Pushing module. A pushing service is available. After obtaining new earthquake information, the server pushes messages at different levels to users according to the epicenter and each user's setting location. Detailed seismic information, including magnitude, epicenter, depth, and tsunami warning, as well as some related links that can increase earthquake knowledge, are pushed to those whose setting location is the same as the earthquake site. Those whose setting location is different from the epicenter receive only simple earthquake notification messages.

3.1.2 Client Side

In this system, the client part is in the form of a cross-platform app that supports iOS and Android operating systems. The app fulfills basic functions, including the user management module, FOE statistics and display, learning module, and multilingual support:

1. The user management module focuses on user signup, sign-in, personal settings, and saving the user profile, as well as user learning status, similar to the server.
2. The message processing module receives and parses earthquake messages from the server.
3. The FOE module takes charge of FOE statistics and display. The receiving message is divided into two types. One type of message is the local earthquake message, i.e., an earthquake occurred in the same area as the setting location, which contributes to both local FOE and Japan FOE by adding 1. Another type of message contains information on earthquakes happening elsewhere; then, only the Japan FOE increases by 1. Earthquakes with the specified magnitude or greater are also counted, including the frequencies of both in Japan and in the setting location.
4. The learning module provides various learning materials, including text, videos, and pictures. Users can obtain earthquake information, i.e., the FOE in Japan, and earthquake knowledge that may help them survive earthquakes. It also provides quizzes, helping users to check whether they have good earthquake knowledge.
5. With the multilingual function module, multiple languages are supported on the client side. A preferred language can be chosen, which may help those who have difficulty understanding Japanese improve their earthquake education. In addition, the setting language is recorded in the server to push messages in the same language.

After it is released, it will be possible to download and install the app from the Apple App Store or major Android stores, allowing users to explore disaster education in their own country before arriving in Japan.

3.2 Gamification Applied in the System

In this paper, some basic game design elements known as PBL are employed. These elements are known as reward and achievement mechanisms. At the beginning of earthquake education, proper reward and achievement mechanisms are considered effective approaches to attract users. After realizing the importance and necessity of earthquake education, users will be willing to learn. In the follow-up work, some new game elements and mechanisms will be designed and applied to stimulate learning motivation so as to maintain long-term engagement.

In general, the rules of applying PBL in the system are the more often people use the system, the more points they obtain, the more types of badges they gain, and the higher their rank. The specific rules are as follows:

1. Awaking the app earns 1 point, no more than 1 point per day.
2. Browsing the pushed message earns 1 point, no more than 1 point per day.
3. Reading learning materials for at least 5 minutes can earn 1 point, at most 2 points per day.
4. Completing a quiz can earn 1 point, at most 1 point per day.
5. High accuracy in the quiz of more than 90% will gain an extra point.
6. Using the app for at least 5 days in a week will win a bee badge for hard work.
7. A 100% score on a quiz earns the fox badge for cleverness.
8. Each week, based on number of badges, first place on the leaderboard is rewarded by a mystery chest box that includes a random number of points between 1 to 5, as well as the title of Survival Master.

How these points can be used is under consideration, such as redeeming them for small gift or a discount for meal in a university café.

Two app snapshots are shown in Figure 5.
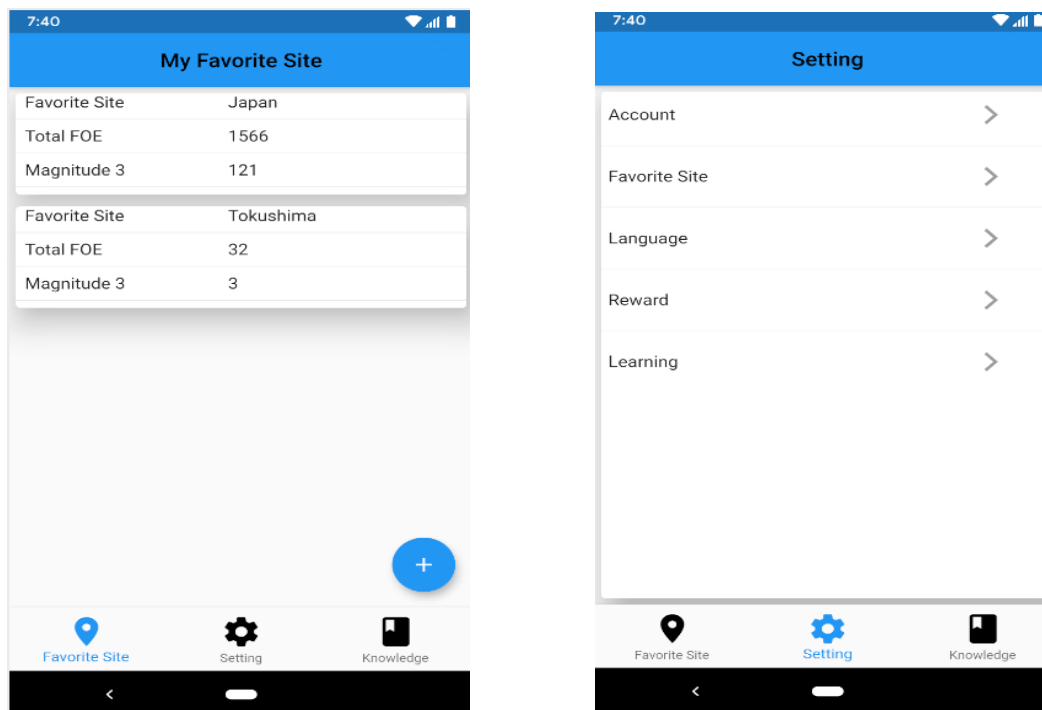
Figure 5. App snapshots for FOE and user customization.

4. Summary and Future Work

Previous research on the application of gamification in education was concentrated in the classroom or on special education for special groups, with experimental samples of around 25. Whether gamification can play a role in the open nonmandatory education field combined with ICT has been explored in this paper. It proposed that gamification in earthquake education, combining it with ICT, is expected to have excellent performance in this field.

This paper described the fundamental ideas and developed a system prototype. In the near future, the system, including the cross-platform app and server, is expected to be completed. After being launched in the iOS App Store and major Android app stores, an open experiment in which number of samples and time are unlimited will be conducted. Statistics will be analyzed periodically to verify the role of gamification in earthquake education combined with ICT.

In future work, the second phase, the practice phase, will be carried out. The practice phase focuses on users' practical learning. Practical information, such as an online earthquake evacuation drill and detailed information about nearby shelters, will be provided. New game design elements, like maps and challenges, as well as a new learning theory and model, will be introduced into the system. In addition, the server program and configuration will be improved to increase the concurrent number of users.

References

Amir Fazamin, W. M., Hamzah, W., Ali, N. H., Saman, M. Y. M., Yusoff, M. H. et al. (2014). Enhancement of the ARCS model for gamification of learning. *Proceedings of 3rd International Conference on User Science and Engineering (i-USEr2014)*, 287-291.

Cudney, E. A., Murray, S. L., Sprague, C. M., Byrd, L. M., Morris, F. M. et al. (2015). Engaging healthcare users through gamification in knowledge sharing of continuous improvement in healthcare. *Procedia Manufacturing, 3,* 3416-3423.

Damage Situation associated with 2011Tohoku district - off the Pacific Ocean Earthquake. Retrieved from http://www.npa.go.jp/news/other/earthquake2011/pdf/higaijokyo_e.pdf

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness. *Proceedings of the 15th International Academic MindTrek Conference on Envisioning Future Media Environments* - MindTrek 11, 9-15.

Hanus, M. D., & Fox, J. (2015). Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance. *Computers & Education, 80*, 152-161.

Kawai, J., Mitsuhara, H., & Shishibori, M. (2015). Tsunami Evacuation Drill System Using Smart Glasses. *Procedia Computer Science, 72,* 329-336.

Keller, J. M. (1987). Development and use of the ARCS model of instructional design. *Journal of Instructional Development, 10(3)*, 2-10.

Leelawat, N., Suppasri, A., Latcharote, P., Abe, Y., Sugiyasu, K., et al. (2018). Tsunami evacuation experiment using a mobile application: A design science approach. *International Journal of Disaster Risk Reduction, 29,* 63-72.

Mitsuhara, H., Iwaka, K., Kozuki, Y., Shishibori, M., Inoue, T. et al. (2016). Penumbral tourism: Place-based disaster education via real-world disaster simulation. *Proceedings of 3rd International Conference on Information and Communication Technologies for Disaster Management (ICT-DM2016).*

Mitsuhara, H., & Shishibori, M. (2017). Virtual Currency as Gamification for Learning in a Disaster Museum to Increase the Number of Revisitors. *Proceedings of 25th International Conference on Computers in Education, ICCE 2017 - Main Conference.* 746-754

Rahman, M. U., Rahman, S., Mansoor, S., Deep, V., & Aashkaar, M. (2016). Implementation of ICT and wireless sensor networks for earthquake alert and disaster management in earthquake prone areas. *Procedia Computer Science, 85*, 92-99.

Robson, K., Plangger, K., Kietzmann, J. H., Mccarthy, I., & Pitt, L. (2016). Game on: Engaging customers and employees through gamification. *Business Horizons, 59*(1), 29-36.

Roy, R. V., & Zaman, B. (2018). Need-supporting gamification in education: An assessment of motivational effects over time. *Computers & Education, 127*, 283-297.

WebSub. Retrieved from https://www.w3.org/TR/websub/

Werbach, K., & Hunter, D. (2012). *For the win: how game thinking can revolutionize your business*. Philadelphia: Wharton Digital Press.

Yang, Y., Asaad, Y., & Dwivedi, Y. (2017). Examining the impact of gamification on intention of engagement and brand attitude in the marketing context. *Computers in Human Behavior, 73*, 459-469.

Yildirim, I. (2017). The effects of gamification-based teaching practices on student achievement and students attitudes toward lessons. *The Internet and Higher Education, 33*, 86-92

The Development of a Hand-Washing Education System

Katsumi NAGATA[a], Masaki OONO[b] & Masami SHISHIBORI[b*]
[a]*Affiliation A, NTT Plala Inc., Japan*
[b]*Affiliation B, Tokushima University, Japan*
*bori@is.tokushima-u.ac.jp

Abstract: This study develops a system that focuses on proper hand-washing patterns to examine whether hands are being washed properly. By comparing images of hand-washing taken at sinks and the like with model images, it informs users in real-time whether they are using proper hand-washing patterns. Optical flow and skin-color pixel areas are used as feature amounts for recognizing proper hand-washing patterns. SVM (Support Vector Machine) is introduced as the recognition model in this system.

Keywords: health education, image processing, machine learning, support vector machine

1. Introduction

Every year, the likes of influenza and norovirus become problems to the extent that Japan's Ministry of Health, Labor, and Welfare releases information regarding their spread and relevant vaccines and treatments. They are highly contagious diseases with intense symptoms that can easily become severe.

Gargling and hand-washing are ways to prevent their spread. Particular importance is attached to hand-washing. However, few people are cognizant of proper hand-washing. Causes of this include not knowing how to properly wash one's hands, hand-washing being perceived as a job, and it being difficult to see whether one's hands have become clean.

This study developed a system that focuses on proper hand-washing movements to examine whether hands are being properly washed. By comparing videos of hand-washing taken at sinks and the like with model hand-washing videos, it informs users in real-time whether they are engaging in a proper hand-washing pattern.

The outline of this system is shown in Figure 1. The learner washes the hand in actual environment and records the movement of hands by the fixed camera. And then, hand-washing video is uploaded to the system in real time. The system analyzes the video, and informs the insufficient hand-washing patterns to the learner.
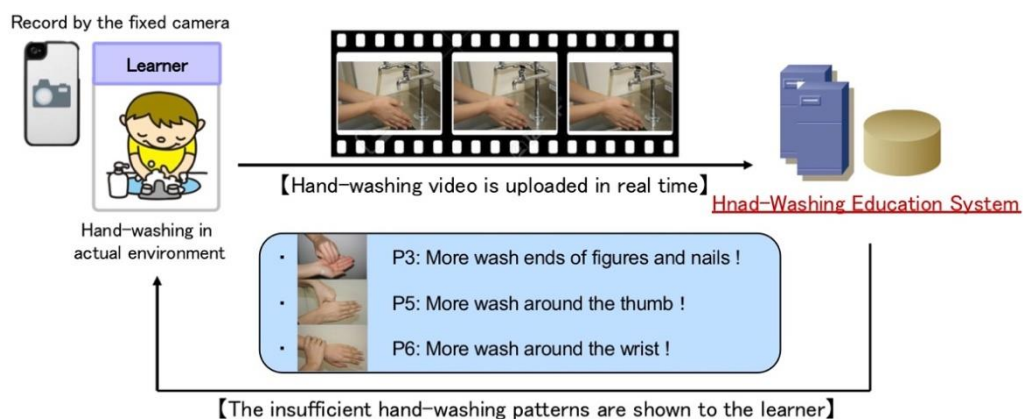
Figure 1. Hand-Washing Education System.

2. Related Works

Much research has been carried out on hand-washing, and it has been proven that proper hand-washing is effective from a hygiene perspective. However, existing examination methods are not easy to carry out. For example, they involve kits that use chemicals or specialist observation.

In existing scholarship, an examination system for proper hand-washing has been developed that uses movement and form characteristics related to hand gestures found in sign-language recognition (Igari, & Fukumura, 2016) and gesture recognition (Sawada, Hashimoto, & Matsushita, 1998). However, there has been the issue of decreased recognition accuracy due to noise included because of hand-shaking during washing and changes in lighting. Therefore, when removing causes of noise and capturing movement characteristics, the decrease in accuracy that results from hand-shaking is addressed by this study by carrying out correction that takes into account the hands' center of gravity.
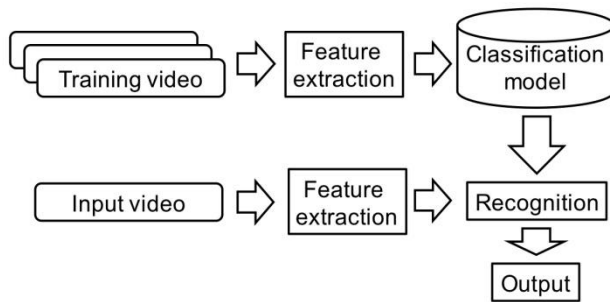
Figure 2. System Flow.
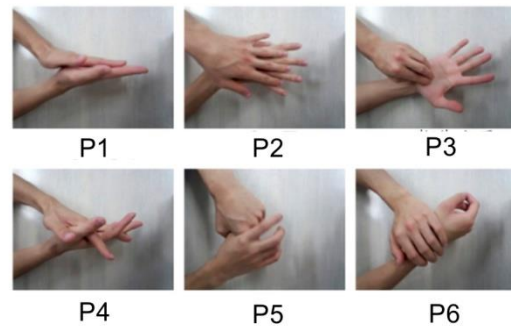
Figure 3. Proper Hand-Washing Method.

3. Hand-Washing Education System

3.1 System Construction

Figure 2 shows the flow of hand-washing examination system. For the input video, hand-washing videos shot in real-time are used. For the training video, proper hand-washing videos are used. We used SVM (Suykens, & Vandewalle, 1999) as a recognition classifier.

The proper hand-washing method is, as shown in Figure 3, "P1: Scrub palms," "P2: Scrub back of hands," "P3: Scrub ends of fingers and nails," "P4: Scrub between fingers," "P5: Twist opposite hand around thumb," and "P6: Rotate wrist in palm of other hand." After examining whether the six patterns have been followed, the output shows undetected patterns.

3.2 Feature Extraction

3.2.1 Skin-Color Image Extraction

Using HSL color spaces, the skin-color region is cut out as the hand region. By carrying out contraction and expansion on this skin-color region, noise is removed. Moreover, based on labeling, noise is removed so that only the largest area in the image is left behind as shown in Figure 4.
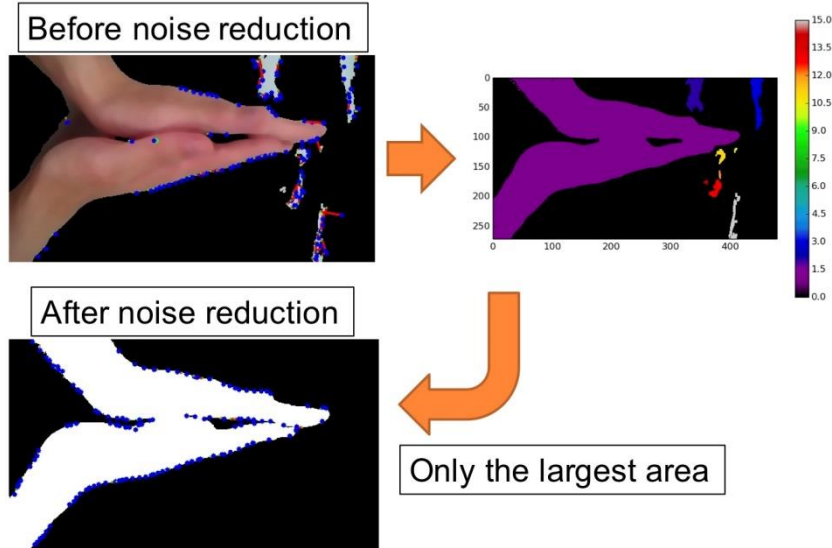
Figure 4. Example of Noise Removal Image.
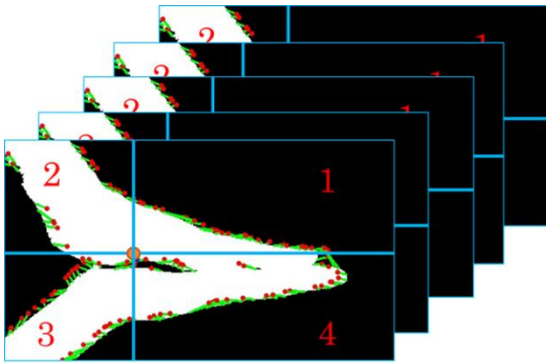
Figure 5. Example of Skin-Color Area.
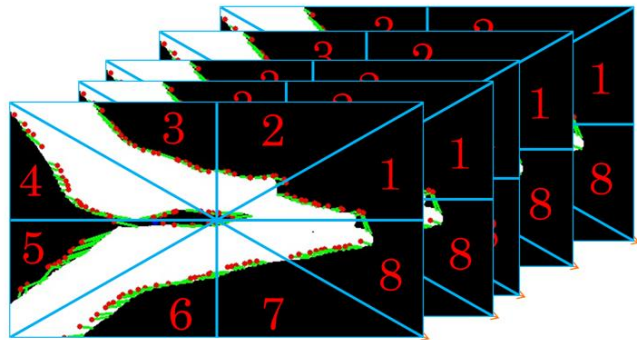
Figure 6. Optical Flow Acquisition (8 Categories).

3.2.2 Skin-Color Area Extraction

Feature extraction is done by, as shown in Figure 5, identifying the hands' center of gravity and dividing the skin-color area into four ranges (1: 0°–90°，2: 90°–180°，3: 180°–270°，4: 270°–360°). The skin-color areas in the divided ranges are captured every few frames, and the average area values for each range are used as feature amounts.

3.2.3 Optical Flow Extraction

The optical flow shows the pixel movement vectors from the previous frame to the current frame. The pyramid LK method, which iteratively implements the LK method (Lucas-Kanade method) (Lucas, & Kanada, 1981), was used as the optical flow detection method. This method withstands noise well and involves little computational effort, enabling stable and swift detection. It is therefore well-fit for a real-time examination system.

Feature extraction was done by calculating vector angle T acquired in the optical flow (Figure 6), and categorizing angle T into eight ranges (1: 0°–45°, 2: 45°–90°, 3: 90°–135°, 4: 135°–180°, 5: 180°–225°, 6: 225°–270°, 7: 270°–315°, 8: 315°–360°). Every few frames, the appearance frequency and size of the vectors in the categorized ranges are acquired. The vectors in each of the ranges are used as appearance frequency and the average size and variance as feature amounts.

4. Evaluation

4.1 Experimental Environment

In order to investigate the effectiveness of this method's feature extraction, our experiments only recorded the movement of hands in order to remove as much as possible the external factors that could get in the way of the features. External factors for hand-washing include soap bubbles, water from the faucet, the environment around the sink, and so on. Therefore, for both the input and training videos, we placed a camera at a fixed height on a table and filmed multiple people washing their hands, directly from the above. A premise of our experiment was that proper hand-washing involves doing the six patterns for 30 or more seconds (each pattern for five or more seconds).

For our database, with the six patterns in one person's hand-washing video (one pattern lasting approximately five seconds) as a set (six videos), we filmed eleven sets for six people. In total, we prepared 66 sets (396 videos). On each video, we carried out feature extraction and created a categorization model. We used C++ (OpenCV v. 2.4.9) for our development system language. For our development equipment, we used a web-camera to acquire images in real-time.

Table 1 *Accuracy Using the Only Skin-Color Area*

Input / Output	P1	P2	P3	P4	P5	P6
P1	16%	0%	25%	50%	0%	8%
P2	0%	58%	33%	8%	0%	0%
P3	0%	8%	83%	8%	0%	0%
P4	16%	0%	0%	83%	0%	0%
P5	0%	0%	0%	0%	91%	8%
P6	8%	16%	33%	0%	16%	25%

Table 2 *Accuracy Using the Only Optical Flow*

Input / Output	P1	P2	P3	P4	P5	P6
P1	66%	0%	0%	33%	0%	0%
P2	0%	100%	0%	0%	0%	0%
P3	0%	16%	75%	8%	0%	0%
P4	8%	0%	0%	83%	0%	8%
P5	0%	0%	0%	0%	100%	0%
P6	0%	0%	0%	0%	8%	91%

Table 3 *Accuracy Using Both the Skin-Color Area and the Optical Flow*

Input / Output	P1	P2	P3	P4	P5	P6
P1	58%	0%	0%	41%	0%	0%
P2	0%	100%	0%	0%	0%	0%
P3	0%	16%	83%	0%	0%	0%
P4	0%	0%	0%	100%	0%	0%
P5	0%	0%	0%	0%	100%	0%
P6	0%	0%	0%	0%	0%	100%

4.2 Evaluation: Is Each Pattern Properly Recognized?

We carried out experiments to determine if each pattern is properly categorized. To do so, we used one set (six videos) out of the 66 sets (396 videos) as input data and the remaining 65 sets (390 videos) as training data. Via cross-validation, by switching the input data set by set with the training data, we carried out a total of 66 experiments. Three types of methods were used to output data in order to compare each feature: the only skip-color area, the only optical flow and both of them.

We have shown the results of the experiments using these methods in Tables 1 through 3. The vertical axis shows the input and the horizontal axis the results of recognition. The closer the results of the diagonal axis to 100%, the higher the categorization accuracy.

Using the results in Tables 1 to 3 to compare the overall proper recognition rate of three proposed features, the average correct recognition rate of the only skip-color area was 59.3%, and the average correct recognition rate of the only optical flow 85.8%, and the average correct recognition rate of both the skip-color area and the optical flow was 90.2%. Our proposed two features have improved accuracy complementary, showing a higher correct recognition rate.

From Table 3, we can find that the category P1 has a lower correct recognition than other categories. Especially, about 40% of input data P1 are recognized to the category P4 by mistake. This is probably caused by hand-washing styles of P1 and P4 being very similar. Because not only the hand shape but also the hand movement direction of their hand-washing styles are very similar, P1 and P4 can't be classified by the only skin-color and optical flow. In order to classify between P1 and P4, new features other than the skin-color and optical flow will be required. Moreover, it appears that in order to increase overall recognition accuracy, measures need to be taken for videos with low accuracy in which skin color is not being properly detected (for example, Figure 7).
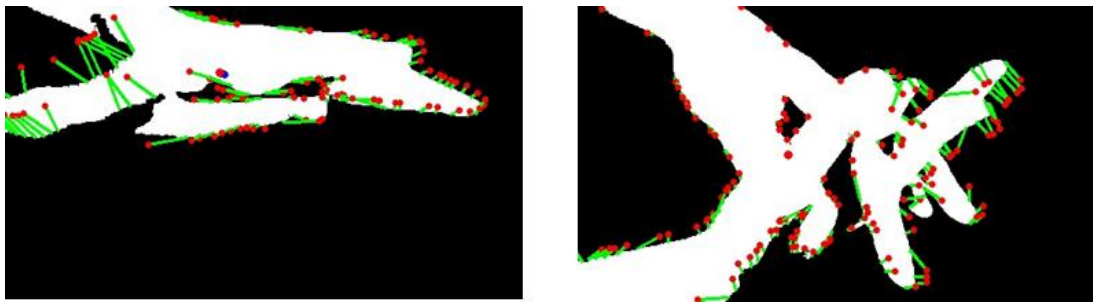
Figure 7. Cause of Decrease in Accuracy (Example of Failed Skin-Color Detection).

5. Conclusion

This study, comparing a method found in existing scholarship and our proposed method, carried out experiments to test feature amount effectiveness. Our experiment results showed that recognition of each pattern is possible, confirming the effectiveness of our confirmed method's feature amounts.

Future tasks include examining videos for which our method was not very accurate, improving upon the causes of this, as well as carrying out experiments using the feature amounts regarding external factors such as soap bubbles and water.

References

Igari, S., & Fukumura, N. (2016). Recognition of Japanese Sign Language Words Represented by Both Arms Using Multi-Stream HMMs. *Proceedings of the 7-th International Multi-Conference on Complexity, Informatics and Cybernetics*, 157-162.

Sawada, H., Hashimoto, S. & Matsushita, T. (1998). A Study of Gesture Recognition Based on Motion and Hand Figure Primitives and Its Application to Sign Language Recognition. *Transactions of Information Processing Society of Japan*, *39(*5), 1325-1333.

Suykens, J. A. K. & Vandewalle, J. (1999). Least Squares Support Vector Machine Classifiers. *Neural Processing Letters*, 9, 293-3000.

Lucas, B. D. & Kanada, T. (1981). An Iterative Image Registration Technique with an Application to Stereo Vision. *Proceedings of the 7-th International Joint Conference on Artificial Intelligence*, 2, 674-679.

Examination of the Learning Effects of Creating Disaster Prevention Maps Outdoors Using ICT Devices as a Learning Activity

Hisashi HATAKEYAMA[a, b]*, Masahiro NAGAI[c] & Masao MUROTA[d]
[a] *Library and Academic Information Center, Tokyo Metropolitan University, Japan*
[b] *Graduate School of Decision Science and Technology, Tokyo Institute of Technology, Japan*
[c] *University Education Center, Tokyo Metropolitan University, Japan*
[d] *Institute for Liberal Arts, Tokyo Institute of Technology, Japan*
*hatak@tmu.ac.jp

Abstract: In this study, we conducted a learning activity with high school students on creating disaster prevention maps using tablet devices, in order to improve learners' awareness of disasters through experiential activities. The learners moved around outside the school premises and recorded locations such as dangerous places, evacuation sites in the area, and useful facilities for disasters in the disaster map creation support system. They then learned about local characteristics and disaster preparedness through classroom activities that used the information they had gathered. It was confirmed from the learning records that the students recorded freely at various places within the learning area. Those who used the system frequently evaluated their operation experience positively. A subjective survey revealed that the learner's awareness of disaster prevention, and their understanding of the area where they live, changed following the learning activities. The students who participated in the learning activity by actively using the system had a better learning experience, and could better understand local characteristics.

Keywords: Disaster prevention, mobile learning, classroom practice

1. Introduction

Disasters occur frequently in Japan, making it important to prepare for disasters on a daily basis. Disaster prevention education is being implemented in various environments, including schools. Experiential activities are one way for students to actively participate in disaster prevention learning. Most experiential activities are classified into Local and Individual activities according to the Global-Local-Individual (GLI) model of disaster prevention education (Mitsuhara, 2018). However, because the number of hours of safety education is limited in school environments in Japan, many of the basic contents regarding disasters are classified into the Global activities. For example, according to a survey conducted by the Shizuoka Prefectural Board of Education, in addition to evacuation drills, most of the activities implemented as disaster prevention education are limited to lectures on disaster prevention.

We focus on creating disaster prevention maps as a hands-on activity. This corresponds to the Local activities, and is implemented to create knowledge of general disasters that is specific to the region. The creation of disaster prevention maps has been adopted in local communities. In recent years, there have been some practical cases of disaster prevention education using Information Computer Technology (ICT) (e.g., Okazaki et al., 2016). However, there few studies have focused on learning effects.

2. Objectives

In this study, we examined the learning effects of disaster prevention learning, incorporating disaster prevention map creation. Learners learned local disaster prevention knowledge through disaster

prevention learning. We expected this to increase learners' regional understanding and awareness of disaster prevention. Through questionnaire surveys, we will examine how the understanding and awareness of learners have changed.

As a specific learning content, we conducted lessons themed on creating a disaster prevention map, following an assumed earthquake. Records of information gathered in the area were collected on a disaster prevention map using a learning support system. The map was used for reflection, based on the records and the learners' experiences.

3. Methods

A disaster prevention map is a collection of disaster prevention information presented as a map. There are no rules regarding the information that can be included, but it often includes dangerous places, evacuation sites, facilities, and useful articles. In this study, we aimed to improve learners' local understanding and disaster prevention awareness by getting them to create disaster prevention maps.

In this study, we incorporated "Town Watching" (Shaw and Takeuchi, 2009) into disaster prevention learning, and created a disaster prevention map through outdoor activities. Small group activities are desirable when learning outdoors. In this case, the information collected and recorded by each group needed to be aggregated and shared, which could be done smoothly using a system that supports learning through creating disaster prevention maps. The local understanding of learners was promoted by reflection learning activities using an integrated disaster prevention map.

To realize these learning activities, we used a system, "Sonael," that supports the creation of disaster prevention maps (Hatakeyama, Nagai and Murota, 2017). Sonael is a client application that runs on Android devices. The recorded information is collected on a dedicated online server. The aggregated information can be viewed via a browser, and via the client application.

4. Classroom Practice

We conducted five classes at prefectural high schools in Chiba Prefecture from September to November 2018. Classes were conducted as a unit of comprehensive class time for first-year high school students (96 students in 4 classes). The students were divided into a total of 34 groups of around 3 people, and the home-room teachers taught each class.

4.1 Learning Basic Knowledge

At the beginning of a series of classes, students learned basic knowledge about earthquake disasters (Global activities). They watched video footage detailing the damage caused by earthquakes and the characteristics of their region. They learned about disasters in the area around the school using an original textbook, which compiled information such as past regional disaster cases and hazard maps.

4.2 Outdoor Learning Activities

Outdoor learning activities were twice conducted for each group in the area around the school. Each group was lent one Android device and one portable Wi-Fi source, so that Sonael could operate outdoors. We decided to leave and then return to each school carrying a terminal with each group. We used a different area for the second outing to prevent repetition.

The school in question is located in the Uchibo district of Chiba prefecture, Japan. We set up a learning area that the students could return from within the time period of one class. In Sonael, information can be inputted as three classes: "dangerous place in case of disaster," "useful place in case of disaster," and "other." The students were instructed to move freely within the area and record what they noticed in the event of an earthquake disaster in three categories.

4.3 Reflection Learning Activities

The records of outdoor learning were collected for each class, and reflection learning activities were conducted after each outdoor learning activity under the initiative of the homeroom teacher. Each group was lent Android devices so they could view the records collected by Sonael. The teachers explained that the regional features that could be understood from records and outdoor activity experiences using group-specific worksheets.

At the second reflection learning, the students played a paper-based simulation like Disaster Imagination Game (DIG, Komura and Hirano, 1997), corresponding to the Individual activities. Based on the assumptions of disasters in the area, students were asked to consider what actions they should take based on the regional features and specific places that they had recorded. They then held group discussions and each group gave presentations.

5. Results

5.1 Records of Outdoor Learning Activities

In total, 364 records were collected in the two outdoor leaning sessions, including 163 dangerous places at the time of a disaster, 138 useful places at the time of a disaster, and 63 others. The results are shown in Figure 1. These records include duplication of the same object because fieldwork and recordings were done for each group. It is important to discuss ways to measure aspects of disaster situations that cannot be assumed. The field of disaster prevention must value diverse viewpoints because there are no certain answers for protecting against disaster. Therefore, these records did not make judgments about the levels of importance and validity.
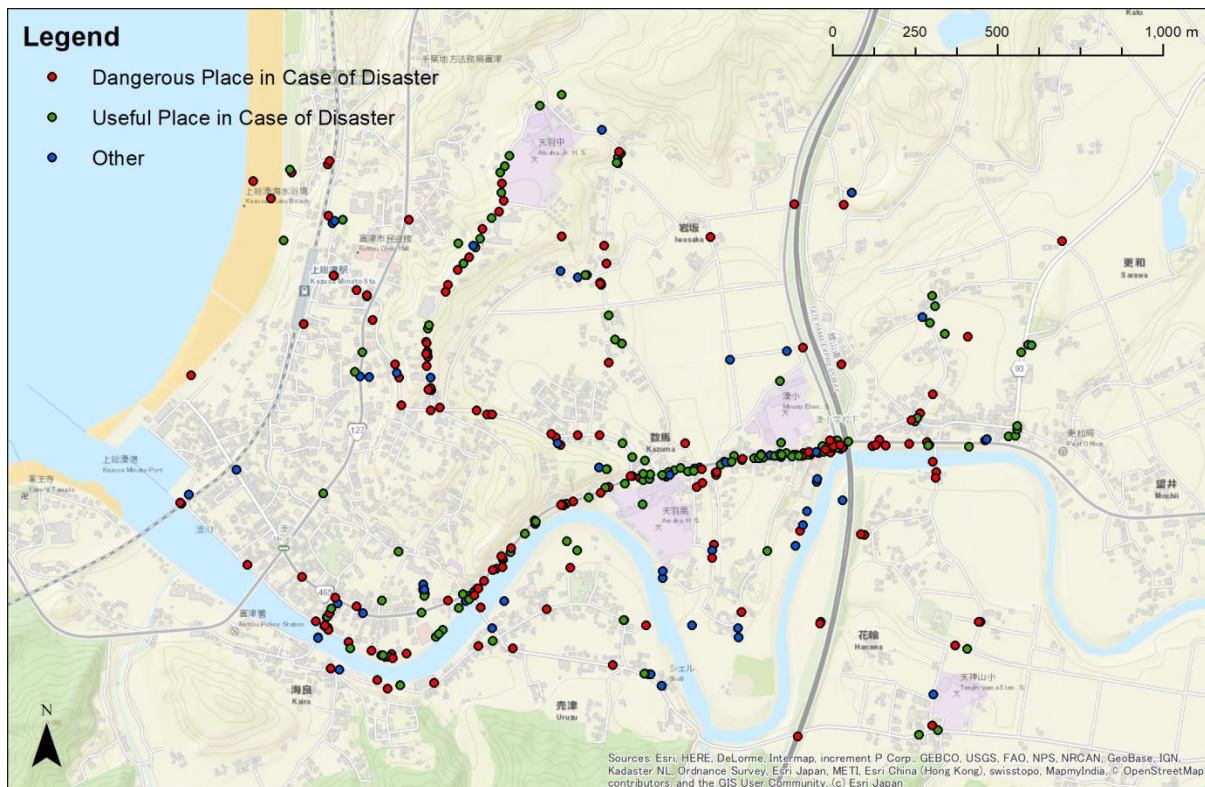
Figure 1. Distribution of Records in the Learning Area.

5.2 Subjective Survey

Subjective surveys were conducted before the first class and after the last class. In the questionnaire, 10 items related to disaster prevention awareness were set, with reference to the supplementary book on

disaster prevention education published by the Tokyo Metropolitan Board of Education (2017): Yes (1 point), No (0 points). The total scores (up to 10 points) were prepared as a disaster preparedness score. T-tests revealed a significant difference between the two surveys.

The 6 items related to local understanding as a learning objective and self-efficacy during disasters were set originally. The items corresponding to imagination during disasters are from Shimazaki and Ozeki (2017). In all cases, the answer was based on the six-point scale. There were significant differences in all items, as shown in Table 1.

Table 1

*Subjective Survey Before and After Learning (M : Arithmetic Mean, S.D. : Standard Deviation, ** : p < .01)*

	N	Before		After	
		M	S.D.	M	S.D.
Disaster Preparedness Score					
Total score**	81	3.33	2.608	4.28	2.972
Learning Objectives and Self-efficacy					
A. I can explain the geographical features of the school. **	84	2.48	1.359	3.85	1.256
B. I can specifically explain the damage that may occur around the school when an earthquake occurs. **	83	2.66	1.337	3.90	1.144
C. I can specifically explain disaster preparedness around the school. **	84	2.21	1.152	3.81	1.146
D. I think I can judge dangerous places by observing the surroundings when a big earthquake occurs. **	82	3.26	1.225	3.95	1.121
E. There is a specific image of what actions I should take when a disaster occurs. **	83	3.22	1.105	3.93	1.187
F. There is a specific image of what happens to the town when a disaster occurs. **	82	2.95	1.304	3.82	1.287

After each outdoor learnings, the operability of the app was rate on a six-point scale. The first score was 3.75 and the second was 3.94.

6. Discussion

6.1 System Evaluation

The Sonael system used here was modified to record information more freely. The records are spread throughout the learning area, centering on the school, as shown in Figure 1. In particular, many places tended to be recorded along the main street that would be used for evacuation.

The operation evaluation of the Sonael system was similar in the two field studies. As only one device was lent per group, teachers advised students to use them evenly. However, the time using the system in the learning activities varied per member. We classified students into one group that frequently used the device, and was another that did not, based on students' self-evaluations. Table 2 shows the average evaluations of frequent users was highest in both the first and second survey in both cases. The users who did not use the device frequently could not evaluate the system.

Table 2

Operation Evaluation of the Sonael System

	Frequently used			Not frequently used		
	N	M	S.D.	N	M	S.D.
The application was easy to operate. (first)	31	4.26	1.182	60	3.48	1.420
The application was easy to operate. (second)	45	4.53	1.100	43	3.33	1.322

6.2 Disaster Awareness, Self-efficacy, and Imagination

Learners' awareness of disaster prevention improved through disaster prevention learning, as shown by our subjective survey. In addition, changes occurred in their local understanding, self-efficacy, and imagination at the time of disaster.

To discuss this difference, we again classified students into two groups based on how frequently they used the system. We calculated the average self-evaluation scores in the two outdoor learning activities and compared them between a group larger than the average (3.5) on the 6-point scale, and a smaller group. In addition to the items shown in Table 1, a learning experience evaluation item was also added to the analysis; the results are shown in Table 3. The evaluation of the group using the system frequently was high for every item. There were significant differences between the two groups for items A-C, and for learning experience. This shows that students who actively used the system during the activity had a better learning experience and, could better understand local characteristics. Learners who used the system frequently seem to have verbalized what they saw and thought by recording information in the system. It is suggested that active participation in learning activities led to improved awareness. However, there was no clear difference in self-efficacy or imagination. Creating disaster prevention maps encourages students' local understanding about the Local activities. It may not have promoted the learning activity as an Individual activities, to help students to foster disaster awareness for themselves. We approached linking learning from the Local activities to the Individual activities using reflection learning activities, but we think that the content for this approach needs to be reexamined.

Table 3

Subjective Survey After Learning Grouped by the Usage of Self-Evaluation (** : p < .01, * : p < .05)

	Frequently used			Not frequently used		
	N	M	S.D.	N	M	S.D.
Learning Objectives						
A. I can explain the geographical features of the school. **	28	4.39	1.100	43	3.37	1.215
B. I can specifically explain the damage that may occur around the school when an earthquake occurs. **	28	4.50	1.036	43	3.42	1.139
C. I can specifically explain disaster preparedness around the school. *	27	4.04	1.055	43	3.44	1.181
D. I think I can judge dangerous places by observing the surroundings when a big earthquake occurs.	26	4.15	1.223	43	3.58	1.139
E. There is a specific image of what actions I should take when a disaster occurs.	27	4.00	1.109	43	3.58	1.277
F. There is a specific image of what happens to the town when a disaster occurs.	27	3.89	1.281	42	3.55	1.400
Learning Experience						
I enjoyed a series of learning activities for disaster prevention. *	26	4.85	1.255	43	4.05	1.214

7. Conclusion

Various disaster prevention education efforts are being carried out at school environments. However, few studies have focused on disaster prevention learning effects using ICT. In this paper, we held a disaster prevention learning activity themed on earthquake disaster prevention at a high school, using a tablet device. The purpose of this learning was to deepen regional understanding and raise disaster prevention awareness, using learning disaster prevention knowledge that matches the region. The learners used "Sonael" to record and collect information outdoors.

The students freely recorded at various places within the learning area. The learners who used the system frequently rated their operation experience of the application highly in both the first and second outdoor activities. Subjective surveys recorded students' awareness of disaster prevention and improvement of local understanding before and after the learning activities. The students who actively used the system had a better learning experience, and could better understand local characteristics. However, it is possible that students did not reach the level of thinking of disaster as oneself, because the reflection learning activities were insufficient. Based on these, future studies are needed to guide class design, especially regarding reflection learning activities to lead more effective learning activities.

In this study, only the self-assessment from the questionnaire survey was considered. However, these questionnaire surveys are not sufficient for describing participants' disaster comprehension. It remains a challenge for future research to analyze the records and learning logs to confirm that the learner properly understood the regional features through the learning activities properly.

Acknowledgments

References

Hatakeyama, H., Nagai, M., & Murota, M. (2017). Acquiring Disaster Prevention Knowledge from Fieldwork Activities in a Region. *Human-Computer Interaction. Interaction Contexts, 19th International Conference, Proceedings, Part II* (pp. 433-442). Springer.

Komura, T., & Hirano, A. (1997). Disaster Imagination Game (DIG), A drill using maps. *The annual conference of the Institute of Social Safety Science*, *7*, 136–139. (in Japanese)

Mitsuhara, H. (2018). The Present and Future of ICT-Based Disaster Education Systems. *Transactions of Japanese Society for Information and Systems in Education*, *35*(2), 66-80. (in Japanese)

Okazaki, Y., Mori, S., Wakuya, H., Mishima, N., Hayashida, Y., & Byung-Won Min. (2016). Development of a Sustainable Community-based Hazard Map Creation Support System for Traditional Towns with Local Heritage. *International Journal of Contents, 12, 2*, 58-65.

Shaw, R., & Takeuchi, Y. (2009). *Town Watching Handbook for Disaster Education*. EU, UNDRR and Kyoto University.

Shimazaki, K., & Ozeki, M. (2017). Development of a new Disaster-prevention consciousness scale (1). *The 81st Annual Convention of the Japanese Psychological Association*, 1A-020. (in Japanese)

Tokyo Metropolitan Board of Education. (2017). *Earthquake and Safety: Before the Shake Hits Tokyo*. Retrieved August 23, 2019, from http://www.kyoiku.metro.tokyo.jp/school/study_material/safety/files/jishin_and_anzen/kou.pdf (in Japanese)

Workshop 8 - The 8th International Workshop on ICT Trends in Emerging Economies (WICTTEE 2019)

Value-based Adoption of Open-Source Software in Higher Education: An Empirical Investigation

Hazel A. TRAPERO[ab]*, Cecilia B. LEAÑO[a] & Ma. Rowena CAGUIAT[a]
[a]*De La Salle University, Philippines*
[b]*University of the Philippines Cebu, Philippines*
*hazel_trapero@dlsu.edu.ph

Abstract: Open-Source Software (OSS) is computer software developed in a public collaborative manner with source codes available under a license that guarantees certain freedom. This includes the right to study, modify, and distribute the source code to any individual for any purpose without constraint or undue cost. It has gained much importance in the academic sector because it is best used for research, derivatives, analytics, statistics, and even the use of the Linux operating system is highly recommended. Academic institutions, particularly in emerging economies like the Philippines, are also under pressure to look for the lowest-cost solutions while having an effective course provision. However, several issues and challenges are identified, especially when it comes to its usability in terms of learnability, efficiency of use, memorability, and subjective satisfaction, among others. Thus, this study was conducted to investigate the different factors that can influence students to appreciate the open-source software's value and adoption in the classroom setting. The results of the study showed that enjoyment, technicality, and attribute have a significant correlation with perceived value while usefulness has no significant correlation with perceived value. Also, perceived value has a significant correlation with software adoption intention, while gender and age have no significant correlation with adoption intention. Therefore, enjoyment, technicality, and attribute are predictors of one's perceived value of OSS. The students' OSS adoption intention is also determined through the positive valuation of it which leads to adoption or continuous usage of it, whether for personal use or classroom use.

Keywords: Open-Source Software, Computer Education, Value-Based Adoption, Higher Education, OSS Benefits and Challenges

1. Introduction

Open-Source Software (OSS) is computer software with source codes that can be studied, modified, and distributed to any individual and for any purpose (St. Laurent, 2008) since it is developed in a collaborative public manner (Levine and Prietula, 2013). Despite its nature, users must still abide by the license terms upon using it, though the terms differ dramatically from those of proprietary licenses. Concerning the monetary aspect, while most of the OSS is free of charge, programmers and troubleshooting experts can make money by helping others troubleshoot the source codes, install, and use it (Opensource.com, 2018). With usage increase of OSS, it was reported that the revenue of open source services in 2018 has increased to \$14.1 billion from \$11.4 billion in 2017 and is projected to continuously increase to 32.95 in 2022 (Statista, 2018).

The use of OSS in the past several years has grown dramatically. This is because of several benefits of using OSS that have been observed nowadays. One example of this is the free access of source codes which enables developers to improve it if there is a need to, and more interoperable design applications (Hahn, 2014). Using it has also a cost advantage since it does not require a per-seat license. With all the benefits enumerated, as reported by Jon Brodkin (2011), the National Aeronautics and Space Administration (NASA) has already partnered with Rackspace, an American cloud computing company based in Texas, to design OpenStack and open-source software for building cloud computing networks. Aside from them, the U.S. Department of Defense (DoD) acquired a government-developed

worker management system, which is known as the Open Source Corporate Management Information System, to manage agency personnel.

In the academe, OSS has gained much importance due to the reason that, oftentimes, a course requires a specific version of educational software to reflect the course content and pedagogical approaches. Like for instance, OSS is best used for research, derivatives, analytics, statistics, and even the use of the Linux operating system is highly recommended (Khan and UrRehman, 2012). Academic institutions, particularly in emerging economies like the Philippines, are also under pressure to look for the lowest-cost solutions while having an effective course provision (Attwell, 2005; Nuñez et al., 2017). A University has been implementing courses that promote and use open-source technologies within the curricula (Ebardo, 2018a).

However, despite the benefits that one can get from using OSS, several issues and challenges are also identified, especially in the technical aspect. One of these is its usability in terms of learnability, the efficiency of use, memorability, and subjective satisfaction, among others. This is so because the majority of the users have been using proprietary computer programs for a long time already, thus, consider OSS's usability as one of the reasons that limit its use. Second is its performance because it is frequently compared to the performance of closed or licensed software. Another issue is on security – since the source codes are open for any individual, OSS is vulnerable to security bugs and flaws (Sarrab, Elbasir, and Elgamel, 2013). Lack of technical and administrative support is also identified as one of the major challenges of OSS implementation, together with resistance to change in the educational setting where age was an important issue, especially of the teachers. It is said that young ones were engrossed in learning new skills while older ones resisted changes in teaching (Kisanjara and Tossy, 2014; Howard and Mozejko, 2015; Thankachan and Moore, 2017) which may influence the students. Moreover, OSS products are not always endorsed but there is powerful evidence of the success of its performance which boosts its continued use in the public and private sectors. Despite this advantage, there persist the problem of adoption (Okey and Sam, 2019).

2. Statement of the Problem

This study was conducted to investigate the different factors that can influence students to appreciate the open-source software's value and to adopt it in the classroom setting. This study aims to answer the following questions:
1. What are the factors that impact students' perception of OSS value in learning?
2. How students' perceptions of OSS value and worth affect their intention to adopt the software?

Specifically, this study aims to evaluate the hypotheses, listed below, using the Value-Based Adoption Theory lens.

H1. The usefulness of OSS positively influences the student's perception of its value.

This study describes usefulness as to how OSS assist users in accomplishing a task (Venkatesh et al., 2003). Information technology, which includes the software and hardware components of information systems, is now recognized as a useful artifact in the information age, thus, there is a need to understand the level of usefulness of the IT, together with users' perception and level of satisfaction in using it (Kim and Part, 2018). Moreover, the value-based adoption theory claims that when students have a positive perception of the usefulness of a specific IT, their level of the perception of its value also increases.

H2. The student's enjoyment when using OSS positively influences the student's perception of its value.

Today, academic institutions are already adopting blended learning. This is learning where new technologies, software, and hardware, are integrated into the curriculum to transform the traditional way of teaching and learning into more interactive and enjoyable multimedia pedagogy and therefore, attract the students' attention (Huang, Chen, and Chou, 2016). This is related to the results of numerous studies of human interaction with real ecological environments, like in the academe, that "emotion" is a valuable motivation and learning factor (Reis and Roth, 2009; Rowe and Fitness, 2018; Huang and Hsu, 2019).

H3. The technicality of OSS positively influences the student's perception of its value.

OSS customization is seen to be easier than the proprietary or closed software because of the availability of the software source code and its free manipulation and this is one of the challenges observed. This is the reason why it is necessary to formulate and abide by the licensing agreement, local laws, and organization peculiarities (Serrano and Sarriegi, 2006; Zekos, 2016; Ram, 2018).

In terms of OSS usage as an instructional tool, "ease of use" is one of the constructs to be assessed during the technicality evaluation. It is a level of user's belief that using software for a particular task will be free of effort (Venkatesh and Bala, 2008). That software that is perceived to be easier to use is more likely to be accepted by the user compared to other software provided that all other factors are equal. Thus, perceived ease of use is found to greatly influence computer and software usage (Davis, 1989; Teo and Zhou, 2014; Fokides, 2017).

H4. The perceived cost of OSS positively influences the student's perception of its value.

The growing acceptance of OSS in both the industry and academe is due to the low cost it offers to the users since there is no need for them to buy licenses and usually it does not need expensive equipment for it to perform well (Gripe and Rodello, 2011). The high cost of proprietary software packages adds up to the financial burden of students, faculty, and administrators, thus, choosing appropriate tools for academic use is identified as one of the challenges (Nehra and Tyagi, 2014).

H5. The student's perceived value of OSS positively influences their intention to use OSS.

OSS's zero-fee or low-cost licenses play a significant role in its rapid adoption. Aside from that, the usefulness, enjoyment and manageable technicalities enable users to see the value of utilizing it, especially in the classroom (e.g. using Weka in the Data Analytics class). And when it is perceived to be valuable, users intend to use it more often. This is one of the reasons why, aside from the organizations, it is adopted by an increasing number of academic institutions for it has been observed that more opportunities are available for students to learn and create knowledge (Long, 2009; Blake and Morse, 2016).

H6. The demographics positively influence the student's intention to use OSS.

Demographics, such as gender and age, have been used to classify the personality traits and characteristics of groups of participants (Lee et al., 2010). They have been identified as predictors of adoption behavior (Im, Bayus, and Mason, 2003; Rojas-Mendez, Parasuraman, and Papadopoulos, 2017). Demographics are still incorporated in a study, though their effects are known to be weak, because of their considerable presence in adoption literature. Nevertheless, it was found out that age and gender significantly influence the intention to use a particular technology (Lee et al., 2010).

3. Review of Related Literature

3.1 Open-Source Software in the Philippines

Way back in 2002, members of Open Minds Philippines, which is an open-source advocacy group having Manny Amador as the official spokesman, stated that a lot of very good open-source software can already be used, not just word processors but business packages and suites of applications for different organizations. However, proprietary software vendors like Microsoft Corp. disagreed on its use because they have seen that proprietary and commercial software offer more value for businesses in terms of cost-effectiveness. It was reported that government offices are now beginning to use open source technologies and even consider it as the primary option (Mamuyac, 2017). The Philippines' PHL-Microsat team designed its round receiving station data subsystems of the first earth observation satellite, DIWATA, in 2016. DIWATA is designed to provide information about the Philippines for disaster and environmental purposes (Aranas et al., 2016). Just recently, the Department of Information and Communications Technology (DICT) has already teamed up with Red Hat Inc. The partnership aims to create a community of independent software vendors (ISVs) and developers within the Philippines that can influence open-source innovations. This will also encourage them to create applications that are beneficial for the government agencies and the Filipinos in general (Umali, 2018). But despite the increase in the adoption of these technologies in the Philippines, its adoption is moving slowly because of the challenges like in the case of the academic institutions, there are no clear guidelines on its adoption. Aside from that, proprietary vendors influence the universities' decisions by

donating computers and educational software licenses with the condition that the software should be taught and included in the curriculum (Mamuyac, 2017).

3.2 Open-Source Software in Education

With the availability of the Internet, several educational resources and free software are now freely accessible (Gupta and Surbhi, 2018). Several open-source tools have been used in computer science and IT courses (Lipsa and Laramee, 2011; Dundas and Singh, 2014) and some projects are formulated to assist students' learning development through improved educational methods. Thus, the value of Open Source tools has been increasingly appreciated and the number of users continuously increases. This is because it offers the principles of openness, collaboration and interactive knowledge-sharing that are important in the academe. Furthermore, open-source adoption in education would enable stakeholders to have control over its technology resources. However, the big challenge is changing the mindset of users, such as students, faculty, and even staff, to openness and open thinking, not on the change of actual tools like for example from Microsoft Office to OpenOffice or from SPSS to Weka (Oduor, Honkavuori, and Pasma, 2012). As it is observed, teachers usually teach how to use a particular tool rather than teaching students the fundamentals of graphic design or the format and layout for essays or the fundamentals on how data are computed and analyzed. Thus, it is encouraged to teach and learn computing concepts in the classroom instead of products (Bhura, 2018).

4. Theoretical Framework

Value-Based Adoption Model by Kim, Chan, and Gupta (2007) as shown in Figure 1 is a combination of the Technology Acceptance Model (TAM) by Davis (Davis, 1989) and the Theory of Perceived Value by Zeithaml (1988). This is mainly because VAM emphasized the significance of "usefulness" and "enjoyment" as the benefits and "technicality" and "perceived fee" as sacrifice which are identified as the primary factors of perceived value leading to the users' intention to use a particular IT, rather than just based on usefulness and ease of use from TAM.
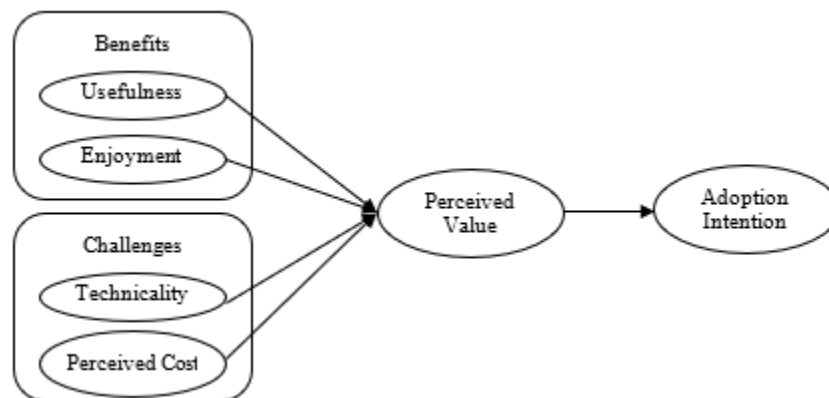
Figure 1. Value-based Adoption Model

5. Operational Framework

This study wanted to conduct an empirical investigation of VAM in the Philippine setting. However, some constructs were changed and added to fit into the perspective of the students. First, "adoption intention" is evaluated based on the academic institution's perspective, thus, in this study, it was changed to "intention to use" due to the nature of the respondents who are students. Second, demographic variables are described as the major factors that may influence the use of IT tools and applications (Aramide, Ladino, and Adebayo, 2015). Thus, this study also investigated whether the demographics such as gender and age, as shown in Figure 2, influence the students' intention to use OSS.
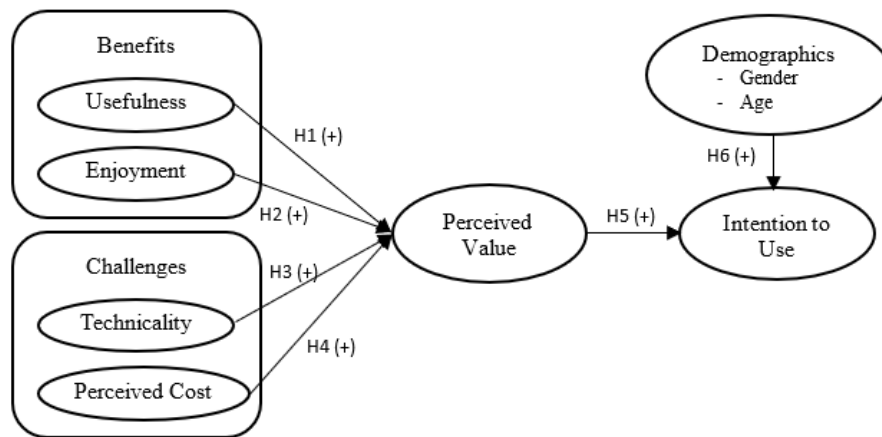
Figure 2. Operational Framework

6. Methodology

A survey instrument was constructed through Google Forms. The majority of the questions were taken from the survey instrument by Kim, Chan, and Gupta (2007). A pilot test was conducted using the instrument to sixteen (16) college students on Facebook who have experienced OSS in the classroom. The validity of the said instrument was then analyzed using the Partial Least Squares (PLS) algorithm of SmartPLS 3.2.6 statistical tool, as recommended by Ebardo (2017). After the analysis, a total of six questions (indicators) were removed (one-by-one) since it was found out that they are below the Chronbach's Alpha critical level of 0.7. Two of these are from "usefulness" construct, three from 'attitude", while one from "perceived value".

When the survey instrument was finalized, it was again deployed, but this time, to several student communities on Facebook already. The data were then gathered and all the constructs in the proposed framework were analyzed using SmartPLS bootstrapping technique (Ebardo, 2018b).

7. Results and Findings

A total of 167 respondents answered the survey, 62% of them are males while 38% are females. 68% of the total respondents are currently studying while the remaining 32% are already working, however, they stated that they used OSS when they were in college.

Based on test statistics, as shown in Table 1, usefulness has no significant correlation with perceived value. This may imply that students would not appreciate the software's value and worth just because of the assistance that it offers to accomplish a task. This opposes Kim, Chan and Gupta's (2007) claim that the more the students have a positive perception of the usefulness of an IT, the higher their level of perception of its value. This may also imply that they haven't learned to appreciate the OSS that they are using (e.g. OpenOffice) because they prefer the licensed software that they are usually exposed to (e.g. Microsoft Office). This confirms Bhura's (2018) observation that teachers usually introduce software and teach them how to use it, rather than teaching them the fundamentals of concepts regardless of what software is used. Like for instance, teaching the techniques on how to write a comprehensive essay using any word processing tool.

Table 1

Descriptive Statistics of the Respondents' Characteristics

Measure	Items	Frequency	Percentage
Gender	Male	104	62
	Female	63	38
Age	< 21	49	19
	21-25	121	73
	>25	14	8
Aware/With experience using OSS	Yes	160	96
	No	7	4
Course	IT	98	57
	Engineering/Math	16	13
	Animation/Design	32	20
	Others (Ethics, Business)	21	10

Based on test statistics (Table 2), usefulness has no significant correlation with perceived value. This implies that students would not appreciate the software's value and worth just because of the assistance that it offers to accomplish a task. This contradicts Kim, Chan and Gupta's (2007) claim that the more the students have a positive perception of the usefulness of an IT, the higher their level of perception of its value. This also implies that the students may not have learned to appreciate the OSS they are using (e.g. OpenOffice) because they prefer the licensed software that they are usually exposed to (e.g. Microsoft Office). This concurs with Bhura's (2018) observation that teachers usually introduce software and teach the students how to use it, rather than teach them the fundamentals of concepts regardless of what software is used, for instance, the techniques on how to write a comprehensive essay using any word processing tool.

Table 2

Results of Intention to Use Based on VAM

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics ($|O/STDEV|$)	P Values
Usefulness - > Perceived Value	0.020	0.047	0.122	0.161^{ns}	0.872
Enjoyment - > Perceived Value	0.433	0.416	0.142	3.054*	0.002
Technicality - > Perceived Value	0.200	0.203	0.077	2.578*	0.010
Perceived Cost - > Perceived Value	0.349	0.335	0.066	5.297*	0.000
Perceived Value - > Intention to Use	0.849	0.850	0.034	24.771*	0.000

* Significant ns Not Significant

On the other hand, enjoyment, technicality, and perceived cost showed significant correlations with perceived value. This means that students appreciate the value of a software if it is enjoyable, easy to use, user-friendly, and cheaper. This is why academic institutions nowadays are using technologies like OSS since it is one way of transforming the teaching and learning style into a more interactive and enjoyable one (Huang, Chen, and Chou, 2016). This also confirms Davis' (1989) claim that software that is easier to use is more likely to be accepted by the user. Besides, perceived cost influences students' perception of their value. This means that they prefer software that does not add up to their financial burden as emphasized by Nehra and Tyagi (Nehra and Tyagi, 2014).

Lastly, the perceived value had a significant correlation with software adoption intention. This means that the more the students notice the value of OSS, the more they intend to use it over and over again. This supports a finding that an increasing number of academic institutions are using it because it can provide more opportunities for students to learn and create knowledge (Long, 2009; Saini, 2018; Okey and Sam, 2019).

Table 3

Results of Correlation between Variables

	α	df	X^2_c	X^2_{tab}
Gender - > Intention to Use	0.05	4	2.074^{ns}	9.488
Age - > Intention to Use	0.05	60	36.302^{ns}	79.082

The correlation between gender and adoption intention, as well as between age and intention to use, were evaluated using the chi-square of independence test and the results are presented in Table 2. For "Gender - > Intention to Use", the computed value (X^2_c) of 2.074 was less than the table value (X^2_{tab}) of 9.488, thus, not significant. Gender had no significant correlation with students' adoption intentions with OSS. For "Age - > Intention to Use", the computed value (X^2_c) of 36.302 was also less than the table value (X^2_{tab}) of 79.082. This means that the use of the software does not depend on one's gender and age, but on whether it is enjoyable, it is easy to use and does not burden them financially. This contrasts with Rojas-Mendez, Parasuraman, and Papadopoulos (2017) claim that gender and age have been identified as the predictors of adoption behavior.

8. Conclusion

Therefore, enjoyment, technicality, and perceived cost are predictors of one's perceived value of OSS but usefulness is not. This means that emotion is indeed a valuable learning factor as students appreciate the value of using OSS because they enjoyed interacting with it. In terms of technicality, users more likely to accept and use the software when it is easier to use and the way it is used to accomplish a task will be free of effort. There will also be a higher rate of OSS acceptance if it will be acquired at low cost and will not add up to the users' financial burden, especially the universities regardless of whether it is useful or not in accomplishing a task.

On the other hand, the students' OSS adoption intention is not determined through one's gender and age, but through a positive valuation of it, leading to its adoption or continuous usage, either for personal use or classroom use. It is the users' perception of OSS value that drives them to use it more often.

This paper contributes to the research on the adoption of OSS, especially in higher education, however, the generalizability of the results of this research may be limited because of the following reasons: 1) small sample size, 2) the survey was conducted online, and 3) the conduct of the study was limited to one semester only.

9. Recommendations

In this study, OSS was presented to the students in a generic sense. Because of this, there could have been a tendency for each one to think of different OSS with various levels of applications, hence affecting their responses in the survey. It is recommended that further studies be conducted focusing only on a specific OSS to ensure control of the variables. It is also recommended that future research will be conducted with a bigger sample size using a longitudinal approach and conducting interviews and focus group discussions to improve the results of the study.

References

Aramide, K.A., Ladipo, S., and Adebayo, I. (2015). Demographic Variables and ICT Access as Predictors of Information Communication Technologies' Usage among Science Teachers in Federal Unity Schools in Nigeria. *Library Philosophy and Practice, 1-27.*

Aranas, R.K.D., Jiao, B.J.D., Magallon, B.J.P., Ramos, M.K.F., Amado, J.A., Tamondong, A.M., and Tupas, M.E.A. (2016). Design of a Free and Open Source Data Processing, Archiving, and Distribution Subsystem for the Ground Receiving Station of the Philippine Scientific Earth Observation Micro-Satellite. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 41(B7).*

Attwell, G. 2005. What is the Significance of Open Source Software for the Education and Training Community? *Proceedings of the First International Conference on Open Source Systems.*

Bhura, S. (2018). Learn Computing Concepts, Instead of Products. Accessed on December 11, 2018 from https://www.myscoolserver.com/learn-computing-concepts-instead-products/.

Blake, M.R., and Morse, C. (2016). Keeping Your Options Open. *Reference Services Review, 44(3), 375-389. doi:http://dx.doi.org/10.1108/RSR-05-2016-0033.*

Brodkin, J. (2011). Nonprofit Helps Government Expand Open Source Software Usage. *Accessed on December 10, 2018 from https://www.networkworld.com/ article/2178694/windows/nonprofit-helps-government-expand-open-source-software-usage.html.*

Buelva, A. (2002). Opening Doors for Open Source. *Philippine Star Global. Accessed on December 10, 2018 from https://www.philstar.com/business/technology/2002/12/20/188611/opening-doors-open-source.*

Davis, F. (1989), "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology," *MIS Quarterly*, 13(3), 319-339.

Dundas, D. and Singh, L. (2014). A Model for Introducing FOSS in Education in Guyana. *Journal of Innovation in Psychology, Education and Didactics; Bacau, 18(2), 101-112.*

Ebardo, R. (2017). The Use of Activity Trackers for Health Empowerment and Commitment: The Philippine Cycling Perspective. *2017 7th International Workshop on Computer Science and Engineering, WCSE 2017, pp. 1038-1043. ISBN: 978-981113671-9.*

Ebardo, R. (2018a). Visibility and Training in Open Source Software Adoption: A Case in Philippine Education. *2018 8th International Workshop on Computer Science and Engineering, WCSE 2018, pp. 368-373. ISBN: 978-981117861-0.*

Ebardo, R. (2018b). Predictors of Cyber-Plagiarism: The Case of Jose Rizal University. *Proceedings of the 26th International Conference on Computers in Education. Philippines: Asia-Pacific Society for Computers in Education, 778-783.*

Fokides, E. (2017). Greek Pre-Service Teachers' Intentions to Use Computers as In-Service Teachers. *Contemporary Educational Technology, 8(1), 56-75.*

Gripe, F.G. and Rodello, I.A. (2011). A Theoretical Analysis of Key Points When Choosing Open Source ERP Systems. *Journal of Information Systems and Technology Management (JISTEM); Sao Paulo, 8(2), 441-458.*

Gupta, D. and Surbhi. (2018). Adopting Free and Open Sour Software (FOSS) in Education. *i-Manager's Journal of Education Technology, 14(4), 53-60.*

Hahn, E. (2014). An Overview of Open-Source Software Licenses and the Value of Open-Source Software to Public Health Initiatives. *Johns Hopkins APL Technical Digest, 32(4).*

Howard, S.K. and Mozejko, A. (2015). Teachers: Technology, Change and Resistance. *Teaching and Digital Technologies: Big Issues and Critical Questions, 307.*

Huang, T.C., Chen, C.C., and Chou, Y.W. (2016). *Animating Eco-Education: To See, Feel, and Discover in an Augmented Reality-Based Experiential Learning Environment*. Computers & Education; Elsevier, 96, 72-82.

Huang, W., and Hsu, C. (2019). Research on the Motivation and Attitude of College Students' Physical Education in Taiwan. *Journal of Physical Education and Sport, 19*, 69-79.

Im, S., Bayus, B.L. and Mason, C.H. (2003), "An empirical study of innate consumer innovativeness, personal characteristics, and new-product adoption behavior", Journal of the Academy of Marketing Science, Vol. 31 No. 1, pp. 61-73.

Khan, M.A. and UrRehman, F. (2012). Free and Open Source Software: Evolution, Benefits and Characteristics. *International Journal of Emerging Trends & Technology in Computer Science (IJETTCS), 1(3).*

Kim, H.W., Chan, H.C., and Gupta, S. (2007). Value-based Adoption of Mobile Internet: An Empirical Investigation. *Decision Support Systems, 43, 111-126.*

Kim, S. and Park, H. (2018). Do Female Employees at Small and Medium Enterprises Perceive Open Source Software Usefulness and Satisfaction Differently from Male Employees? A Survey Analysis. *Social Sciences, 7(10).*

Kisanjara, S. and Tossy, T. (2014). Investigating Factors Influencing the Adoption and Use of Free and Open Source Software (FOSS) in Tanzanian Higher Learning Institutions: Towards an Individual Technology-Organizational-Environmental (ITOE) Framework. *International Journal of Research in Business and Technology, 5(2), 645–653. DOI: https://doi.org/10.17722/ijrbt.v5i2.345.*

Lee, H.J., Hyeon, J.C., Xu, W., and Fairhurst, A. (2010). The Influence of Consumer Traits and Demographics on Intention to Use Retail Self-Service Checkouts. *Marketing Intelligence & Planning, 28(1), 46-58.*

Levine, S. and Prietula, M. (2013). Open Collaboration for Innovation: Principles and Performance. *Organization Science, 25(5), 1414-1433.*

Lipsa, D.R. and Laramee, R.S. (2011). Open Source Software in Computer Science and IT Higher Education: A Case Study. *International Journal of Advanced Computer Science and Applications.*

Long, J. (2009). Open Source Software Development Experiences on the Students' Resumes: Do They Count? Insights from the Employers' Perspectives. *Journal of Information Technology Education, vol. 8.*

Mamuyac, C. (2017). Open Source Adoption Continues to be Embraced in the Philippines. Accessed on December 11, 2018 from https://www.ashnik.com/open-source-adoption-continues-to-be-embraced-in-the-philippines/.

Nehra, V. and Tyagi, A. (2014). Free Open Source Software in Electronics Engineering Education: A Survey. *International Journal of Modern Education and Computer Science, 6(5), 15-25.*

Nuñez, I., Matute, T., Herrera, R., Keymer, J., Marzullo, T., Rudge, T., and Federici, F. (2017). Low Cost and Open Source Multi-fluorescence Imaging System for Teaching and Research in Biology and Bioengineering. *PLoS One, 12(11) doi:http://dx.doi.org/10.1371/journal.pone.0187163.*

Oduor, M., Honkavuori, J., and Pasma, J. (2012). Use of Open Source Software for Educational Purposes.

Okey, A. and Sam, A.E. (2019). Web-based Application Tool for Recommendation of Open Source Software for Higher Learning Institution in Tanzania. *International Journal of Modern Education and Computer Science, 10(2), 33. doi:http://dx.doi.org/10.5815/ijmecs.2019.02.05.*

Opensource.com. (2018). What is Open Source? *Accessed on December 10, 2018 from https://opensource.com/resources/what-open-source.*

Ram, N. (2018). Innovating Criminal Justice. *Northwestern University Law Review, 112(4), 659-724.*

Reis, G., and Roth, W. M. (2009). A feeling for the environment: emotion talk in/for the pedagogy of public environmental education. The Journal of Environmental Education, 41(2), 71e87.

Rojas-Méndez, J.I., Parasuraman, A., and Papadopoulos, N. (2017). Demographics, Attitudes, and Technology Readiness: A Cross-Cultural Analysis and Model Validation. *Marketing Intelligence & Planning, 35(1), 18-39.*

Rowe, A.D., and Fitness, J. (2018). Understanding the Role of Negative Emotions in Adult Learning and Achievement: A Social Functional Perspective. *Behavioral Sciences, 8(2), 27. doi:http://dx.doi.org/10.3390/bs8020027.*

Saini, O. P. (2018). The Emergence of Institutional Repositories: A Conceptual Understanding of Key Issues through Review of Literature. *Library Philosophy and Practice,1.*

Serrano, N and Sarriegi, J. M. (2006). Open Source ERPs: A New Alternative for an Old Need. *IEEE Software, Los Alamitos, 23(3), 94-97.*

Statista. (2018). Projected Revenue of Open Source Services from 2017 to 2022 (in Billion U.S. Dollars. Accessed on December 10, 2018 from https://www.statista.com/statistics/270805/projected-revenue-of-open-source-software-since-2008/.

St. Laurent, A. (2008). Understanding Open Source and Free Software Licensing. *O'Reilly Media Inc.*

Teo, T., and Zhou, M. (2014). Explaining the Intention to Use Technology among University Students: A Structural Equation Modeling Approach. *Journal of Computing in Higher Education, 26(2), 124-142. doi:http://dx.doi.org/10.1007/s12528-014-9080-3.*

Thankachan, B. and Moore, D.R. (2017). Challenges of Implementing Free and Open Source Software (FOSS): Evidence from the Indian Educational Setting. *International Review of Research in Open and Distance Learning, 18(6).*

Umali, T. (2018). The Philippines' DICT Collaborates for Open Source Technology. Accessed on December 10, 2018 from https://www.opengovasia.com/the-philippines-dict-collaborates-for-open-source-technology/.

Venkatesh, V. and Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. *Decision Sciences, 39(2), 273–315.*

Venkatesh, V., Morris, M.G., Davis, G.B., and Davis, F.D. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly 27 (3).*

Zekos, G.I. (2016). Intellectual Property Rights: A Legal and Economic Investigation. *IUP Journal of Knowledge Management, 14(3), 28-71.*

Development and Testing of a Mobile Game for English Proficiency Among Filipino Learners

Monica MORENO[a]*, Dominique Marie Antoinette MANAHAN[b], Marika Gianina FERNANDEZ[b], Michelle BANAWAN[b,c], Jose Isidro BERAQUIT[b], Marie Rianne M. CAPARROS[b], Philip CACERES[b], Walfrido David DIY[b], Lean Rimes SARCILLA[b], Francesco AMANTE[b] & Ma. Mercedes T. RODRIGO[b]
[a]*Department of Education, Ateneo de Manila University, Philippines*
[b]*Ateneo Laboratory for the Learning Sciences, Ateneo de Manila University, Philippines*
[c]*Department of Information Technology, Ateneo de Davao University, Philippines*
*mmoreno@ateneo.edu

Abstract: This paper presents the testing and development of *Learning Likha*, an English language-based digital game for Filipino learners from 9- to 12-years old. The game focuses on the literacy skill of noting explicit details while incidentally learning about Filipino culture. In an in-vivo pilot test, we measured student comprehension and engagement. We found that the students who performed better and had greater confidence enjoyed using the software but were less engaged than those who performed more poorly.

Keywords: digital games, English proficiency, second language learning, reading, comprehension, engagement, motivation, Filipino learners

1. Introduction

Filipino graduates averaged a Common European Framework of Reference of Language (CEFR) score of B1, which indicated that they have proficiencies lower than the CEFR B2 proficiency target set for high school graduates in Thailand and Vietnam (Romero, 2018). To improve English proficiency, language teaching must develop skills not only in speaking and writing, but also in listening, viewing and reading. Technology-enhanced Language Learning (TELL), through digital games, has been shown to improve language skills such as listening and pronunciation, vocabulary and grammatical accuracy (Sykes, 2013). One such example is the use of narrative-centered digital games (NCDGs). These are multimodal texts that contextualize educational content and problem solving with interactive story scenarios. Story features (believable characters, rich settings and immersive plots) are combined with digital game environments (interactivity, rewards and immediate feedback) to help motivate learners solve meaningful problems (Rowe, Mott & Lester, 2012). Motivation is conceived as a set of beliefs about oneself, and task interest (Eseryel, Law et al, 2014). If a game-based learning environment can maintain and enhance a player's motivation despite challenges associated with problem solving, then according to the Self-Determination Theory (SDT) (Ryan & Deci, 2000), learners would engage in more gameplay, and exert more effort to complete more tasks, an indicator of *engagement* (Eseryel, Law et al, 2014).

According to the Narrative-Centered Learning Theory, narrative can help motivate learners in two ways: first, learners are transported through text to another time and place that is real to them; and second, learners themselves perform the narrative. As they interact through the narrative, in-game choices and feedback require players to consider cause and effect, develop a rationale for moves, and experience emotions. Narrative has been found to aid in comprehension (Laurillard, 1998), and act as a navigational aid in multimedia environments (McLellan, 1993). Thus, NCDGs have enormous potential for ESL learning, particularly because in-game texts are among the most popular reading materials for young people (Williamson, 2009). To move through an English-language digital game, players must listen to English as a spoken language, read English print, and interpret images.

The broad purpose of this research undertaking (described in Ocumpaugh et al. 2018) is to develop applications that assist students with English language learning. We specifically target

underprivileged students from public schools in the Philippines, as proficiency in English can increase economic opportunities (see Errighi, Bodwell, & Khatiwada, 2016; Viscondi, 2012). Although English is one of the Philippines' two official languages, up to 40% of 6th grade Filipino students have average to poor mastery of the language. This paper attempts to describe the design and development of *Learning Likha* and analyze the relationship between comprehension and engagement scores from an in-vivo pilot test. The paper's research questions are:

1) What is the relationship between English comprehension and game engagement and intrinsic motivation?
2) What is the relationship between English comprehension and game engagement features and in-game behaviors?

2. Game Design

Learning Likha is a narrative-centered English-language digital game intended for Filipino public school students between 9 to 12 years old. The game's goal is to develop students' English comprehension; in particular, the literacy skill of noting explicit details through reading, listening and viewing. A secondary goal is to expose learners to a variety of indigenous Filipino musical instruments.

Learning Likha uses narrative to establish the setting and the initial motivation; Likha and her band need their instruments to play music at a town fiesta. The band has five members and hence needs five indigenous instruments: a *babendir* (a single brass gong on a stand), a *gandingan* (a set of four gongs), a *dabakan* (a type of drum), an *agung* (a pair of gongs), and a *kulintang* (a set of 8 small gongs). From a map scene, the player chooses one of Likha's band mates. A spoken and written dialogue between Likha and the band mate describes the shop where the instrument can be found. The audio is supplemented by images and text on the game screen which contain the descriptive details about the shop. A notepad on the upper right corner contains key details that describe the shop. Once the player selects the correct shop, the shopkeeper and Likha engage in spoken and written dialogue about what the instrument looks like. The player selects the instrument from among three options and receives feedback whether the choice is correct or wrong. The game ends when all instruments are found.

3. Data Collection

We tested *Learning Likha* on 59 learners in Grades 4, 5 and 6 from two state elementary schools (Schools A and B) in Quezon City, the Philippines. The learners' mean age was 10.49 years (SD = 1.040). The participants were divided into groups of 10.

At the start of each session, students were given a survey form that measured their attitudes towards English language usage and access to technology. The form asked students to indicate their levels of agreement (strongly disagree to strongly agree) with statements about their attitudes and usage of English, such as "I want to learn to speak and read in English", and "Learning English is important." After the answered forms were collected, the learners played the *Learning Likha* game. Then, to measure engagement and motivation, the players answered the Game-Based Learning (GBL) Engagement Metric (Chew, 2017) and the Intrinsic Motivation Inventory (IMI) (Ryan, 1982). Both questionnaires were adapted for *Learning Likha* and had both English and Filipino translations. Examples of adapted questions were:

- I enjoyed playing *Learning Likha* very much. (Adapted from the IMI item: "I enjoyed doing this activity very much.")
- When we are playing *Learning Likha*, I feel interested. (Adapted from the GBL Learning Engagement Metric item: "When we are working on the activity, I feel interested.")

The players ended the session by answering an English comprehension test with 16 multiple choice questions and 4 open-ended questions to determine how many of the narrative's details they remembered.

3.1 Data features

The data collected were as follows: the English comprehension total score and the GBL Engagement Metric subcomponents, the IMI subcomponents, the attitudes and usage of English survey, and the interaction logs (tap count). Table 1 presents the description of each data item.

Table 1

Description of features used for data analysis

Feature	Definition
Total Score	Number of items correct on the English comprehension test divided by highest possible score.
Tap Count	Number of times a learner tapped the screen of the phone while playing the game.
Enjoyment	Enjoyment is a subcomponent of the IMI. It is the sustained interest of the learner while playing the game.
Effort	Effort is a subcomponent of the IMI. It refers to the learner's self-reported estimate of how much effort and importance was placed in completing the game.
Perceived Competence	Perceived competence is a subcomponent of the IMI. It refers to the learner's perception of their own competence in completing in-game tasks.
Emotion Engagement	Emotion engagement is a subcomponent of GBL Engagement Metric. It refers to the learner's physiological state, e.g. bored or having fun, while playing the game.
Cognitive Engagement	Cognitive engagement is a subcomponent of the GBL Engagement Metric. It refers to the learners' experience of conceiving strategies and linking the activity to prior knowledge and skills.
Behavior Engagement	Behavior engagement is a subcomponent of the GBL Engagement Metric. It refers to the actions a learner does which signals attentiveness to the game and engagement. This includes listening to instructions and problem solving.
Attitude towards English	Includes the learners' motivation, degree of ease experienced, enjoyment they feel when learning English, and their actual usage of the spoken English language amongst their social circles.

4. Analysis

4.1 RQ1: English Comprehension Scores vs. Engagement and Intrinsic Motivation

Of the 59 participant data points gathered, four were identified as outliers using Box Plot analysis, Mahalanobis distance analysis, and leverage hat analysis. These four were removed from the data set. To explore the relationship between English comprehension scores and engagement and intrinsic motivation, data was analyzed by obtaining a series of Pearson's product-moment correlation coefficient (r). Results showed that the reported engagement of a participant did not indicate any relationship with the participant's English comprehension score ($r = .003$, $n = 54$, $p = .980$). Intrinsic motivation as measured by the IMI did not indicate any relationship with engagement ($r = 0.78$, $n = 54$, $p = .078$) and English comprehension total scores ($r = -.036$, $n = 54$, $p = .796$). As shown in Table 2, the English comprehension total score had no significant relationships with any of the subcomponents of engagement and intrinsic motivation.

Table 2

Correlation coefficients between Total Score, and subcomponents of engagement and intrinsic motivation

Measure	Correlations	En	Ef	PC	EE	CE	BE
Total Score	Pearson correlation	-.106	.194	-.162	-.136	.071	.064
	Sig. (2-tailed)	.440	.157	.238	.323	.609	.642

Note. En = enjoyment; Ef = effort; PC = perceived competence; EE = emotion engagement; CE = cognitive engagement; BE = behavior engagement.

4.2 RQ2: English Comprehension Scores vs. Game Engagement and In-Game Behaviors

We attempted to determine if the participants fell into identifiable, distinct clusters. After normalization using z-transformation, we ran x-means clustering and found that two well-separated clusters exist in the data (See Table 3). From the cluster centroids, we find that Cluster 1 is characterized by students who had lower comprehension scores, lower tap count, less enjoyment and perceived competence, but higher effort and overall engagement. In other words, the students who performed better and had greater confidence enjoyed using the software but were less engaged than those who performed more poorly.

Table 3

X-Means Clustering Results

	Cluster 0	Cluster 1
Total Score	0.07	-0.06
Tap Count	0.23	-0.21
Enjoyment	0.17	-0.16
Effort	-0.29	0.26
Perceived Competence	0.04	-0.04
Emotion Engagement	-0.79	0.71
Cognitive Engagement	-0.49	0.44
Behavior Engagement	-0.81	0.73
Attitude towards English	-0.53	0.48

A linear regression model was developed to investigate which features exhibited significant relationships with English comprehension and student progress/learning. Using M5 Prime for feature selection, linear regression resulted in:

Total Score =
- + 0.004 * Tap Count
- + 1.822 * Behavior Engagement
- - 2.636 * Emotion Engagement
- + 0.186 * Enjoyment
- - 0.408 * Perceived Competence
- + 1.122 * Effort
- + 0.729 * Attitude towards English
- + 8.614

Tap count, behavior engagement, enjoyment, perceived competence, and attitude towards English showed no significant relationship with total English comprehension scores. On the other hand, emotion engagement was shown to have a significant inverse relationship with comprehension (p=0.038), while effort was seen to have a significant positive relationship with comprehension (p=0.047). The linear regression was validated using 5-fold cross validation and resulted in a root mean squared error of 3.138 and an r^2 of 0.080.

5. Discussion

In the context of game-based learning, motivation literature suggests that increased motivation during the game results in increased engagement (Ryan & Deci, 2000). The study also assumed that the game's narrative and use of text and audio would aid players' story comprehension and recall of details, as suggested in literature (Laurillard, 1998; Spires, 2015). The results of the analyses did not provide evidence of this claim as we did not find a significant correlation between test scores, engagement or intrinsic motivation. The cluster analysis did help characterize the students further. In one cluster, students with a weaker command of English were less able to find strategies to overcome game challenges, possibly due to the game's English-language content. They perceived themselves to be less competent in overcoming the game's challenges. As a result, they needed to exert more effort in completing the game's tasks and did not enjoy the game as much. In the second cluster, students showed higher final scores and higher perceived competence. It seems that this group of students had a better command of English. These students were able to use the narrative to strategize their moves in the game, perceiving themselves as competent enough to accomplish the game's challenges. This finding supports the theory that narrative aids comprehension (Laurillard, 1998; Spires, 2015). It is interesting that perhaps because of their stronger proficiency in English, the learners in this cluster enjoyed their experiences yet exerted less effort to complete the game. The findings contrast with the Self-Determination Theory (Ryan & Deci, 2000), which ascertains that sustained motivation during gameplay would result in higher engagement. It seems that players who are proficient in the language need less effort to complete the game. It is also possible that students in this cluster were less engaged because they saw the game as a classroom task they were simply required to do.

The regression analysis further showed an inverse relationship between emotion engagement (affect) and reading comprehension, and a positive relationship between effort and comprehension. It implies that the higher the English proficiency, the higher the decrease of emotions felt about the language. Perhaps there is less anxiety about reading or listening to English as one becomes more adept at it. The English comprehension scores are also related to learners' efforts to recall details; the level of expended effort may depend on their adeptness with the language.

6. Conclusion

The findings of the study show that while narrative-based digital games have the potential for motivating learners and engaging them in language-driven tasks, the use of educational games designed to improve English proficiency can pose a challenge for ESL learners. The study's results point out two types of language learners: (1) one who struggles in English, perceives oneself to be less competent, enjoyed the game less and exerts more effort in it; and (2) one who is more proficient in the language, perceives oneself as more competent, and enjoys the game but is not as engaged. It also shows that for ESL learners, English comprehension is related to efforts in recalling details and decreased emotional engagement (i.e. anxiety, stress).

Moving forward, it would be interesting to try *Learning Likha* with different populations. We hypothesize that students of the same age from schools with greater educational resources will be less engaged with the software but will still score well on the comprehension test. Hence, under better-resourced circumstances, the game might be appropriate for lower grade levels. If this is true, then the software would have achieved its purpose of addressing underprivileged learners.

Acknowledgements

References

Alberta Education. (2019). Strand Specific Competencies. Retrieved from
https://www.learnalberta.ca/content/eslapb/communicative_areas.html

Aquino, C. Tan, W., Haarms, R., & Diamante, M. (2017, January). The Philippines' English Proficiency Report Card: Summary of Preliminary Findings (2015 – 2016). Paper presented at ASEAN Tourism Research Association Conference (ATRC) 2017, Singapore. Retrieved from
http://dosen.univpancasila.ac.id/dosenfile/8010211005150529062113September2017.pdf

Chew, B. S. (2017, December). An efficient framework for game-based learning activity. In *2017 IEEE 6th International Conference on Teaching, Assessment, and Learning for Engineering (TALE)* (pp. 147-150). IEEE.

Errighi, L., Bodwell, C., & Khatiwada, S. (2016). Business process outsourcing in the Philippines: challenges for decent work (No. 994945093202676). International Labour Organization (ILO). Accessed: http://www.ilo.org/wcmsp5/groups/public/---asia/---ro-bangkok/---sro-bangkok/documents/publication/wcms_538193.pdf

Eseryel, D., Law, V., Ifenthaler, D., Ge1, X., & Miller, R. (2014). An Investigation of the Interrelationships between Motivation, Engagement, and Complex Problem Solving in Game-based Learning. Journal of Educational Technology & Society,17(1), 42-53. Retrieved from
http://rizal.lib.admu.edu.ph:2087/stable/jeductechsoci.17.1.42

Guieb, D.S. & Ortega-Dela Cruz, R. (2017). Viewing Teaching Techniques in Enhancing Viewing Comprehension Skills of Undergraduate Students in Literature. International Journal of Languages' Education. 1. 271-279. 10.18298/ijlet.1762.

Laurillard, D. (1998). Multimedia and the learner's experience of narrative. Computers in Education, 32, 229-243.

McLellan, H. (1993). Hypertextual tales: Story models for hypertext design. Journal of Educational Multimedia and Hypermedia, 2, 239-260.

Ocumpaugh, J., Rodrigo, M. M. T., Porayska-Pomsta, K., Olatunji, I., & Luckin, R. (2018). Becoming Better Versed: Towards the Design of a Popular Music-based Rhyming Game for Disadvantaged Youths. In Yang, J.C. et al., (Eds.) *Proceedings of the 26th International Conference on Computers in Education*. Asia-Pacific Society for Computers in Education.

Romero, P. (February 22, 2018). Senate to probe declining English proficiency. *The Philippine Star*. Retrieved from:
https://www.philstar.com/other-sections/education-and-home/2018/02/22/1790069/senate-probe-declining-english-proficiency#Y0y9qcde2LAIrFPi.99

Rowe J., Mott B., Lester J. (2012) Narrative-Centered Learning Environments. In Seel N.M. (Eds.), *Encyclopedia of the Sciences of Learning*. Springer, Boston, MA.

Ryan, R. M. (1982). Control and information in the intrapersonal sphere: An extension of cognitive evaluation theory. *Journal of Personality and Social Psychology*, *43*, 450-461.

Ryan, R., & Deci, E. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. American Psychologist, 55(1), 68-78.

Spires, H. (2015). Digital Game-Based Learning: WHAT'S LITERACY GOT TO DO WITH IT? *Journal of Adolescent & Adult Literacy*, 59 (2), 125-130. Retrieved from
http://rizal.lib.admu.edu.ph:2087/stable/44011231

Sykes, J.M. (October, 2013). Technology – Just Playing Games? A Look at The Use of Digital Games for Language Learning. *The Language Educator*. Retrieved from
https://www.actfl.org/sites/default/files/pdfs/TLE_pdf/TLE_Oct13_Article.pdf

Viscondi, K. (2012). Beyond English: the key skills BPOs need. Accessed:
https://www.rappler.com/business/13699-what-key-skills-are-needed-to-work-in-bpo

Williamson, B. (2009).*Computer games, schools, and young people: A report for educators on using games for learning*. Bristol, England: Futurelab.

An Interactive Story-based Mobile Application with Personal Recommendation and Notification for Sexual Health Education in Ethnic Adolescents

Suphaphan CHANSIRI[a] & Charoenchai WONGWATKIT[b*]
[a]*School of Nursing, Mae Fah Luang University, Thailand*
[b]*School of Information Technology, Mae Fah Luang University, Thailand*
*wongwatkit.c@gmail.com

Abstract: In mountainous border areas, most hill tribe and ethnic adolescents encounter poverty and limited access to good quality of education and healthcare services. They are confronting the severity and high rate of Unplanned Pregnancy (UP) and Sexually Transmitted Diseases (STDs) population due to their sexual misconception, risky behaviors, contextual belief, and negative attitudes, and improper pedagogical instructions and materials. In this study, the Akha ethnic group in Thailand was considered as they are facing the highest number of UP and STDs among other hill tribes in the northern region of Thailand. Therefore, the authors aim to address these critical issues by proposing a mobile learning application for enhancing their understanding of Sexual Health Education (SHE), STDs and UP prevention through a designed interactive learning story with context-based storytelling. The students can get personal recommendation of first-aid instruction and nearby contact points based on their search queries of symptom, conditions, or keywords. Moreover, the application can analyze their responses during learning for giving personal notifications based on their sexual behaviors, and remind the users regularly for having safe sex. Before this application is successfully developed, this study firstly carried out the contextual analysis of their needs and requirement in order to design the associated content for interactive learning story, to propose a system structure and design and to present a mechanism for personal recommendation and notification. The evaluation was later conducted with similar groups of samples and experts towards the proposed interactive learning story and application prototyping. The findings show that the proposed mobile application received satisfied attitudes and perceptions on both learning content and story, and mobile learning experience. The investigations of learning effects on students in formal and informal learning environments are to be studied.

Keywords: Mobile web application, recommendation and notification, interactive learning story, sexual health education, ethnic adolescents

1. Introduction

In the past decades, Sexual Health Education (SHE) has provided young people to sexually healthy, increased student's knowledge, skills and behaviors associated with the reduction of unplanned/intended pregnancy, Sexually Transmitted Diseases (STDs) and HIV. SHE has a positive impact on safer sexual behavior, could delay initiation of sexual intercourse, decreased frequency of sexual intercourse, decreased number of sexual partners, and increased use of condom and contraception (UNESCO, 2018). Those who have a good understanding of SHE, they tend to pursue and accomplish study in school and college. In the workplace, they can work with different gender with empathy. In family, SHE can help improve parent-child communication about sex-related information and perceptions and knowledge of parents, they could guild their children and protect themselves from sexual risk (Dinaj-Koci et al., 2015). In the broad scale, more population with SHE can help reduce risk of unplanned pregnancy (UP), abortion, and STDs.

Most adolescents in Thailand have limited knowledge and misconception of birth control and unsafe sex (UNICEF Thailand, 2016). Those who have STDs have dramatically shifted twice in the past decade, mostly found in adolescents (Bureau of Reproductive Health, 2019). In Thailand, most

adolescents in hill tribes and ethnicity groups encounter several limitations and problems due to the limited use of Thai national language; meanwhile, they have uncomfortable discussion/consultation with parents. Therefore, it gives this significant burden to the teachers at schools. There are a really limited number of teachers who are ready to teach the sexual topics; in the meantime, only limited hours are provided, while the students have weak intention to learn due to the non-engaging learning materials and all materials are not in their local language. Eventually, they tend to ask friends and look for information on the Internet, which result in improper understanding or misconceptions of sexual health understanding (Ministry of Education, 2016).

Based on this perspective, therefore, this study aims to address the above-mentioned issues of SHE, STDs and UP prevention, especially in an ethnicity group of Thailand, by employing a number of mobile learning advantages. In particular, a mobile learning application is proposed for Akha adolescents in Thailand with a careful design of interactive learning story. An overall framework of the application and the personal features are highlighted. The findings of this paper aim to gain insights and a more in-depth understanding of the proposed mobile application for further development.

2. Sexual Health Education and Mobile Learning

Sexual Health Education (SHE) plays an essential role in enabling quality of personal life, career, family, and society. It is mandatory to have a basic understanding of sexual changes, development, and hygiene; also, how to delay first sexual intercourse at an early age, how to have safe sex, how to not addict to sex and how to prevent unplanned pregnancy with proper methods.

In Thailand educational system, many reports have shown that SHE is merely involved by students' interaction or discussion. Students are not encouraged to learn this essential content; consequently, they hold a misconception, do not have sufficient knowledge and understanding, and cannot apply in their daily life. These are risky to UP and STDs. Moreover, most classrooms arrange to learn SHE in a mixed gender environment in which most students are not willing to ask and discuss, where the assessment is often operated in the form of paper-based examination which may not reflect their skills (Ministry of Education, 2016).

In the past decade, mobile learning has become more important as it enables more effective personal learning anytime anywhere (Hwang & Wu, 2014). It has been widely proved to be one of the technology-enhanced learning approaches that enhance the learning possibilities and performance; in the meantime, it elevates self-efficacy of learning. With the advancement of mobile technology, the device supports several output and input interactions. Besides, mobile learning has increasingly developed in various platforms, ranging from application, website, game, augmented reality, virtual reality and recent mixed reality (Guse et al., 2012; Liu & Tsai, 2013).

Mobile learning is even more powerful when it comes with personal features in order to tailored provide the accurate, timely, useful experience according to the individual differences of conditions, background, and status (Hwang, Yang, & Wang, 2013). Personal notification can alert, notify or give caution promptly at a certain time regarding the conditions or situation. Besides that, recommendation can analyze the previous/ongoing profile and status and provide a tailored guideline or instruction to address or enhance the success with a clear message. With personal features, mobile learning is more impactful that can individually address the differences of individual users.

3. Learning Design and System Architecture

In this study, the context of Akha was considered as it is the most density among other Ethnic groups in Thailand. From research studies, Akha adolescents have a high risk of UP and STDs due to two main reasons. First, their risky behavior with alcoholic drink and drug addiction which lead to unconsciousness; moreover, it is found that over 40% of adolescents have sex before 16 years old. Second, most Akha family are in poverty and low-educated. Furthermore, Akha adolescents most infect STDs, e.g., HIV/AIDs than other ethnic or hill tribe groups (Apidechkul, 2016).

In order to understand the actual context of teenagers in Akha group, the authors went to visit them in the community in order to assess their understanding and attitudes. Both one-on-one and group

interviews with voice recordings have been used by following a series of open-ended and close-ended questions. Note that each student with the parents' permission agreed to participate in this research willingly, while their data is kept anonymously. In addition, all Akha adolescents can access to the Internet over their own smart phones.

3.1 Interactive Learning Story Design

There are three learning topics in this application. First, sexual health (SH), gives an understanding of how changes happen to the body physically and mentally. Second, unplanned pregnancy (UP) and prevention, including the contraceptive pill, condom. Third, sexually transmitted diseases (STDs), e.g., Gonorrhea, Syphilis, Vaginitis, Genital Herpes, and HIV. Each learning topic is associated with certain literacy, as shown in Figure 1 with color indication. After the content association is done, it proceeds to make interactive learning story by considering three components: character design, storytelling and scenarios, and situations. The learning story is designed to be an interactive motion graphic with the characters in a local outfit and local sound option for Akha-preferred language. With context-simulated atmosphere design, it brings the storytelling more relevant to the students' real context with surrounding scenarios and situations. With this design, the students can learn interactively by interacting with the ongoing story, prompts, and responses in order to gain more sexual health literacy.
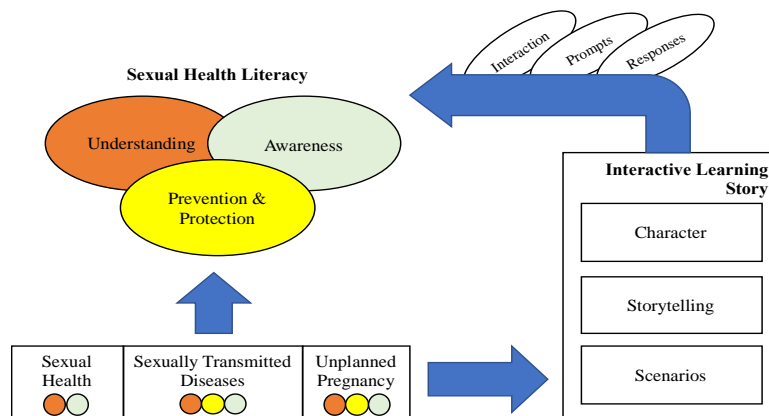
Figure 1. Learning Design and Interactive Story Association.

3.2 Personal Recommendation and Notification
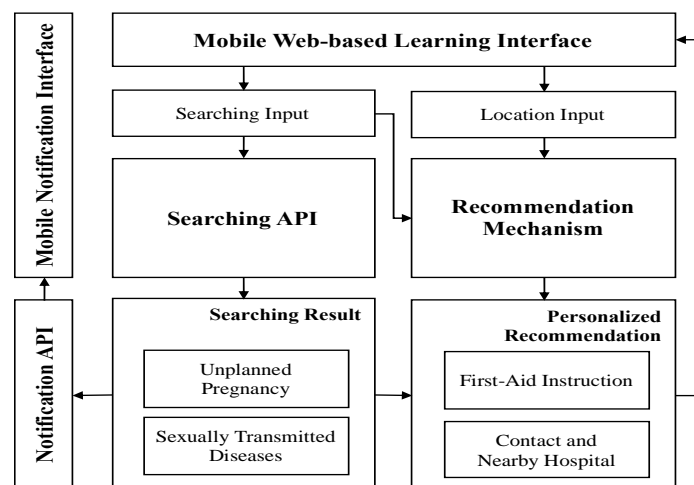
Figure 2. Personal Recommendation and Notification Agent.

In this application, there is a personal feature of recommendation and notification that can help support the learning more straightforward but powerful, see Figure 2. The students can give the query of keywords or symptoms relevant to STDs or UP as a search input. The searching API can then analyze and look for the results showing practices and examples with visual graphics and a brief explanation for

better understanding; in the meantime, this input runs to the recommendation mechanism for generating the basic first-aid instruction with nearby contact and hospital for further consultation. Nevertheless, based on the search, the system triggers the notification API and can send the notifications to students based on conditions provided via a mobile notification interface, while the recommendation is presented on the learning interface.

4. Evaluation and Results

4.1 Interactive Learning Story

In this section, a simple evaluation of interactive learning story design was conducted with ten similar participants (students) and five professionals on learning innovation.

All participants were given a complete story design with full interaction embedded on the mobile application, sample screenshots shown in Figure 3 with a brief description. After evaluating the learning story, the participants rated their satisfaction on twenty items of 5-point Likert Scale questionnaire.

Figure 3. Screenshots of Interactive Learning Story.

Table 1

Evaluation Results of Interactive Learning Story

Dimensions	Similar participants (N = 10)		Professionals (N = 5)		t
	M ± SD	Interpretation	M ± SD	Interpretation	
MTA	4.78 ± 1.23	Very satisfied	4.32 ± 0.32	Satisfied	0.808**
STL	4.84 ± 0.89	Very satisfied	4.71 ± 0.54	Very satisfied	0.297
AnR	4.21 ± 0.35	Satisfied	3.86 ± 0.61	Neutral	1.431*
LFP	4.40 ± 1.73	Satisfied	4.54 ± 0.45	Very satisfied	0.175

* $p < 0.05$, ** $p < 0.01$

As shown in Table 1, it was found that the design of interactive learning story is accepted for using with the students to enhance their understanding of SHE, STDs and UP prevention.

4.2 System Prototyping

Besides, a user testing of the mobile application was conducted with 27 similar participants (male= 12, female = 15) to understand their user experience.

All participations were experienced with a proposed mobile application on the interactive prototyping, sample screenshots shown in Figure 4 with a brief description. After evaluating the mobile application, the participants rated their satisfaction on 16 items of 5-point Likert Scale questionnaire.
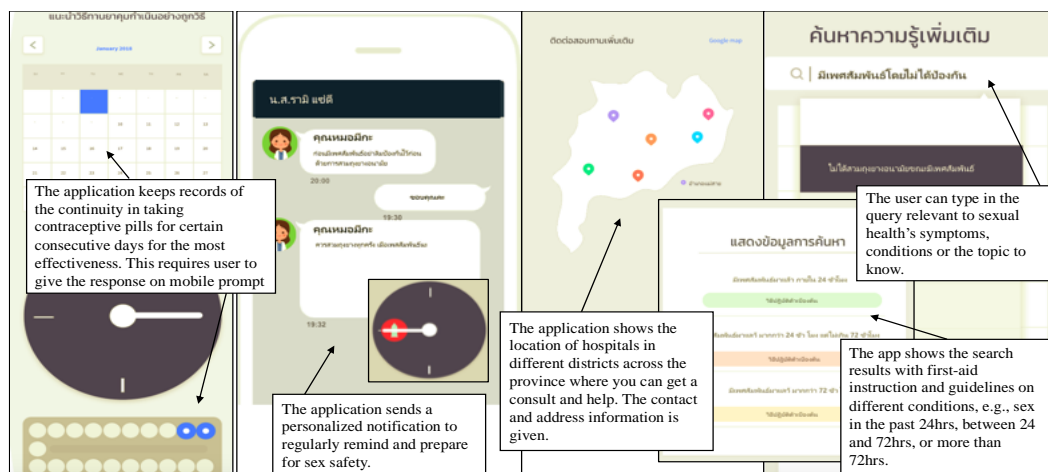
Figure 4. Screenshots of Mobile Application Prototyping.

As shown in Table 2, it was found that the mobile application can help students to learn with good learning experience on the proposed application.

Table 2

User Testing Results on the Interactive Prototyping of Mobile Application

Dimensions	Similar participants [Male] (N = 12)		Similar participants [Female] (N = 15)		t
	M ± SD	Interpretation	M ± SD	Interpretation	
Mobile navigation	4.73 ± 0.62	Very satisfied	4.68 ± 0.44	Very satisfied	0.245
Transition and motion	4.26 ± 0.39	Satisfied	4.43 ± 0.52	Satisfied	0.939
Consistency in theme and pattern	4.35 ± 0.44	Satisfied	4.49 ± 0.63	Satisfied	0.652
Elements and composition	4.60 ± 0.57	Very satisfied	4.74 ± 0.12	Very satisfied	0.930

5. Conclusion and Discussion

In this study, the authors have designed an interactive learning story to be localized with their context based on storytelling and interactive learning to enabling them more understanding of the SHE, UP and STDs. Moreover, the users can look for nearby contact information and first-aid instruction based on their search query. They can also receive personal reminders for safe sex based on their responses and sexual behavior, which are silently collected during the learning process. The findings of this study enable this proposed mobile application to be developed for real use in a distant target. Hence, this research aims to increase awareness of strengthening sexual health literacy for a better quality of lives in ethnicity.

In this study, the evaluation results reveal several interesting points to be discussed. First, sound perception and attitude towards an interactive learning story. It is due to the design of considering user's interaction, and chunking information into smaller portions to be learned and absorbed. More importantly, the local context of ethnicity has been employed in making learning more relevant to the users' environment. This makes learning more authentic and helps reduce the learning gap between the newly proposed learning and learners (Lombardi & Oblinger, 2007). Regarding the evaluation of mobile application on the prototyping platform, the results could not entirely reflect the actual learning experience due to the limitation of presentations with visuals, motions, and interactions, found no difference results between males and females. This may affect the mobile user experience while giving

an evaluation. Although this study has conducted a significant step of this research, it still needs more improvements and further investigations.

Acknowledgements

References

Apidechkul, T. (2016). A 20-year retrospective cohort study of TB infection among the Hill-tribe HIV/AIDS populations, Thailand. *BMC Infectious Diseases*, *16*(1), 1–14. https://doi.org/10.1186/s12879-016-1407-4

Bureau of Reproductive Health. (2019). *Annual report 2018*.

Dinaj-Koci, V., Deveaux, L., Wang, B., Lunn, S., Marshall, S., Li, X., & Stanton, B. (2015). Adolescent Sexual Health Education: Parents Benefit Too! *Health Education and Behavior*, *42*(5), 648–653.

Guse, K., Levine, D., Martins, S., Lira, A., Gaarde, J., Westmorland, W., & Gilliam, M. (2012). Interventions using new digital media to improve adolescent sexual health: A systematic review. *Journal of Adolescent Health*, *51*(6), 535–543.

Hwang, G.-J., & Wu, P.-H. (2014). Applications, impacts and trends of mobile technology-enhanced learning: a review of 2008–2012 publications in selected SSCI journals. *Int. J. Mobile Learning and Organisation J. Mobile Learning and Organisation*.

Hwang, G.-J., Yang, L.-H., & Wang, S.-Y. (2013). A concept map-embedded educational computer game for improving students' learning performance in natural science courses. *Computers and Education*, *69*, 121–130.

Liu, P. H. E., & Tsai, M. K. (2013). Using augmented-reality-based mobile learning material in EFL English composition: An exploratory case study. *British Journal of Educational Technology*, *44*(1), 1–4.

Lombardi, B. M. M., & Oblinger, D. G. (2007). Authentic Learning for the 21st Century : An Overview. *Educause Learning Initiative (ELI)*.

Ministry of Education. (2016). Review of Comprehensive Sexuality Education in Thailand. *Review of Comprehensive Sexuality Education in Thailand*.

UNESCO. (2018). *International technical guidance on sexuality education*. *Unesco*. https://doi.org/10.1523/JNEUROSCI.0529-04.2004

UNICEF Thailand. (2016). *Situation Analysis of Adolescent Pregnancy in Thailand. Synthesis report 2015*.

A Web-based Learning System for Myanmar Culture and Language Learning of Undergraduate Students in Thailand

Chanapa CHANOONAN[a], Nang Chit Su THEW[a], Charoenchai WONGWATKIT[a*], Waralak CHONGDARAKUL[a], Suphaphan CHANSIRI[b] & Chit Su Po Po[c]
[a]*School of Information Technology, Mae Fah Luang University, Thailand*
[b]*School of Nursing, Mae Fah Luang University, Thailand*
[c]*School of Liberal Arts, Mae Fah Luang University, Thailand*
*wongwatkit.c@gmail.com

Abstract: An efficient online learning system leads any education to increase overall performance and accomplish a specific course. Traditional learning of Myanmar language and culture makes infringingly the decrease of motivation in students and paperwork of the course. Therefore, the students need the system that can help them to review the content effectively in order to motivate them in the study and a system that provides better management of learning materials, exercises, and activities, including a more comfortable tool for lecturer and students, and provide online learning activities based on student's performance, promote understanding of Myanmar Culture Learning (MCL). In this study, an online web-based learning and exercising system has been developed by adopting the context of the course on Myanmar Culture and Language. The developed system embedded adaptive structured questions, assessment, and learning profiles that can help students to understand the content outside the classroom better. The system has been tested for system performance before use. To find the effectiveness of this system, the data analysis has been conducted. The results show that the students who were learning and practicing this system have a higher understanding of the content and better achievement in the exam. The findings of this study shed light on the significance of promoting the learning motivation of MCL and learning paths for each student.

Keywords: Technology-enhanced language learning, Myanmar culture, Myanmar language, learning information system, online learning

1. Introduction

Studying Burmese Language and Culture extends the power to unite people, which further triggers a sense of belonging to one community. People are well-connected if they can engage with the locals and their culture. In doing so, understanding Myanmar culture and language could help people adapt to a new environment, new culture, new policy and therefore, connecting people through language and culture will be necessary. By learning other regional cultures, it helps break down barriers and overcome stereotypes, and it creates an environment for understanding and perspective building. Despite, Myanmar is in the mean of developing the democratic country in ASEAN, which mean the country itself open much liberty to the world in other to welcome a lot of foreigner business companies, agencies, travelers, etc. Moreover, Myanmar has become a heart of attention paid between academics and observers alike among ASEAN members. According to Asian Socio-Culture and Community (ASCC), Blueprint ASEAN members must exchange of cultural performers and scholars among the Member States through the education system to provide further access and understanding of the different cultures of ASEAN Member States. It is a crucial thing to start to promote the learning of Myanmar culture learning in the country.

The current process of learning Myanmar language and culture for learners is based on the textbook, which is published by Myanmar cultural Organization. On the Other hand, the process of Myanmar culture learning for an international standard is weak in kind of technology uses in the

meanwhile of IoT (Internet of Things). On the contrary, there are also online learning for Myanmar language; all the lessons contain audio and are all offered for free and also can learn the alphabet together. Despite, Myanmar Culture and history can be studied through social media platforms. It still lessons in providing the digital learning system for the cultural part. However, it should be created some system with high quality for Myanmar culture learning to enhance the diversities of Myanmar itself and to promote the beauty of the country.

Recently, most classrooms need a system to promote the learning process. The accurate student's knowledge feedback is essential for maintaining the students and lecturer discipline. Traditionally, the classroom is manually used by the paper-based testing system to know the understanding of students. Despite, the existing cultural learning system tends to target on a content-based blog instead of providing a learning process such as exercising, test, and learning of the system.

From the existing problem with CMS and LMS, the system has only content and exercise for the student. This cause does nothing to bring the student to understand clearly or understand just only a few percent. Some student does the exercise for a pass, not genuinely learning. Cause of this motivate to develop the new system, PMLS system develops for control and coordinates for cover all of the problems. The system will progress of student's performance. The highlight is system planning and feedback for the student. PMLS is a system with learning systematic that starting with the learning material, exercise, quiz, including evaluation and summary for the student. Step of PMLS is learning from content and do exercise which their score must meet the criteria to be able to learn the next chapter. Lastly, the student must do the quiz, and they will know their performance for considering and analysis themselves. PMLS define that student does exercise until reaching the criteria. The system will analyze and feedback for students which point that they misunderstand, the system will show the suggestion which should be improved. From this point, PMLS system will bring the student to learning by understanding and can suitably develop themselves.

To address the above-mentioned issue, our group developed the online learning system for Burmese culture learning that provides better management of learning materials, exercises, and activities, including a more comfortable tool for lecturer and students, and provide learning activities based on student's performance., promote understanding of MCL (Myanmar Culture Learning). In fact, promote the learning motivation of MCL on the proposed system. Therefore, an online web-based Myanmar learning system (MLS) is a little more advanced than other regular cultural and language learning systems by giving learner feedback on their knowledge while working on quiz and exercise in the system, locked chapter and graphical feedback on different topics to motivate students. However, the system is focused on only one course in university; it still needs to add a more flexible learning process.

2. Related Study

2.1 Web-based Learning Environment

Web-based learning administration is proposed to improve the student's learning effectiveness. In this framework, the four most critical qualities are semantically itemized to portray each learning article and learner. At a similar time, students can adjust their very own learning substance amid the learning procedure. Exploratory outcomes demonstrate that the proposed framework can improve student learning proficiency and viability.

It focuses on lecturer need to build up an instructive situation that will offer to the distinctive learning styles of the student. It is likewise indispensable that understudies have a comprehension of their learning styles to improve the speed and nature of their learning. It likewise shows the significance of individual contrasts a factor in plan the educating furthermore, learning process, particularly in online guidance.

In a mixed learning condition that uses innovation, understudies are not bound by their homeroom dividers as far as access to data, information, and specialists. A carefully rich learning condition gives students the specific circumstance and significance for discovering that they need. Learning programs that offer a remunerating gaming condition that more youthful and more seasoned

student plays with without anyone else time is a suitable method to connect with students by making their learning work feel like play.

2.2 TELL and Myanmar Culture/Language Study

Technology-enhanced Language Learning (TELL) uses computer technology, including hardware, software, and the internet to enhance the teaching and learning of languages by using a hand-held electronic dictionary to look up a word in class Chatting with a friend on Instant Messenger using a little English Reading news website Participating in an online discussion board. This helps students develop vocabulary, comprehension, spelling and even pronunciation for software that includes voice. TELL improves motivation and develops better attitudes in students towards learning. The research indicates that students' attitudes and motivation tend to be better if they have control over their learning and that some students do learn more if given the opportunity to control the amount and sequence of their work." (Bush and Terry 1997).

There are also studies focusing on the positive influence of technologies on students' attitudes to language learning, including increasing students' interest motivation, confidence, and self-efficacy in the engagement of learning (Chen, 2007). Tamim, Bernard, Borokhovski, Abrami, and Schmid (2011) pointed out that the experimental studies here mostly focused on comparing technology with "no technology". Given there are various technological systems like virtual learning environments, conversational agents, mobile applications, etc., it can be said that there is a lack of specific research studies on technology-enhanced language learning. In this study, we have reviewed some of the theories and research related to technology-enhanced language learning, and the study is an attempt to point out some of the issues that seem to be absent in related literature. Researchers are suggested to take new alternatives regarding the use of brand-new technologies and conduct experimental studies in order not to lose actuality.

3. A Development of Web-based Learning System for Myanmar Culture and Language

3.1 Contextual Analysis

Analysis of the target audience is another crucial step. The learner's key characteristics will influence the design and delivery of e-learning (e.g., their previous knowledge and skills, learning context, and technology access background). Task analysis identifies the job tasks to be learned or improved by learners and the knowledge and skills to be developed or strengthened.

As mentioned in the previous learning style of Myanmar culture course, lecturers have not used any software to manage the learning process. The course materials, lesson exercises, score marks, and other class activities have been conveyed in the classroom, relying on paper-based and off-line learning style. Lacking online learning, teachers cannot handle many paper works, gather student assignments, take the examination, manage student score, and communicate outside the classroom. Meanwhile, the current traditional learning does not provide flexibility and convenience to the students who cannot attend the class on the schedule. Moreover, they also are unable to communicate with the lecturer and classmate out of the classroom effectively. We have obtained the teacher and student requirements for online learning as follows.

1) Functional requirement: The online learning system should enable teachers to create content and assessments, monitor the progress of their students, record student profiles, and manage to grade with standard scores. Students can learn and self-practice at any free time, do assessments, and view their scores. For more student motivation and personalization, we suggest that the system should provide flexible questions and different topic feedbacks for the individual student. Points or student test scores also arrange the topic organization.

2) Non-functional requirement: The qualification aspects of the system should be concerned. Therefore, several non-functional requirements are consisting of availability, security, authentication, learnability, and usability. The proposed system is internet based, and it is available anywhere and anytime not only on campus but outside of the campus. The database of the e-learning must be confidential and private. The system must authorize only valid users to access the e-learning system.

E-learning system should focus on learners, not just the contents. The interface of the proposed e-learning should be user-friendly and support personalization based on learner's preferences.

The functionalities of our web-based application are defined as follows. There are five primary features to be used in student account consisting of login authentication and date--stamped, learning process in suggested chapter, exercises for practice which can be locked for next chapter access if the learner cannot pass the current chapter, taking quiz, keeping and viewing score as historical log score (i.e., pass, fail, or pending). In the part of lecturer, there are five primary functions including login authentication, course management for posting lesson materials and resources, student assessment of each chapter.

3.2 Design

Our system structure is mainly designed into two modules. Firstly, Learning Activities module contains a database of all lesson materials and all learning functions. Secondly, the Adaptive Learning Unit performs the learning analysis, which allows some specific lessons and evaluates a student for "pass" or "fail." It provides a further suggestion of learning resources suitable for a student who fails in a particular lesson. The learner is required to pass the lesson test before moving to the next lesson. This part will be described in Section 3.2.1.

3.2.1 System Design

To produce the e-learning which can be dynamically adapted based on the learner's preference, we introduce the personalization process and algorithm as described below. The online web-based learning experiences building process consists of 2 main parts:

  1) E-learning topology model
   The educational domain is modeled using ontologies which is similar to Topic Map [1]. Therefore, our e-learning ontology is represented by a graph showing the relationship among relevant topics. Figure 3 shows the proposed modeling of our e-learning course. The basic relations of the model are HasPart (HP) being a part of relation and IsRequiredBy(IRB) being an order relation. Suppose that C represents domain of learning of the Myanmar Culture and Language. To complete this subject, learner needs to learn chapters C1,C2,C3 and so on. The relations HP(C,C1), HP(C,C2), HP(C,C3) represent the specific order to learn in the course. In the meantime, IRB(C1,C2), IRB(C2,C3) and IRB(C3,C4) state that student needs to learn and achieve passing score of C1 before learning C2, as same as learning C2 before C3, and C3 before C4 respectively.

   In our ontology design, the learning objects (LOs) are learning content design, development and reuse. They are provided as a material for a single lesson or topic. Example of learning objects consists of simulations, interactive learning content, exercises, assessment, associated media element and so forth. In the diagram, there are the connection namely, HasResource(HR) between the lesson and a LO. The relation HR(Cx, LOy) represents the learning object LOy packaged in lesson Cx. Some LOs can be used in multiple lessons i.e. LO1 is shared among Lessons C1 and C2.
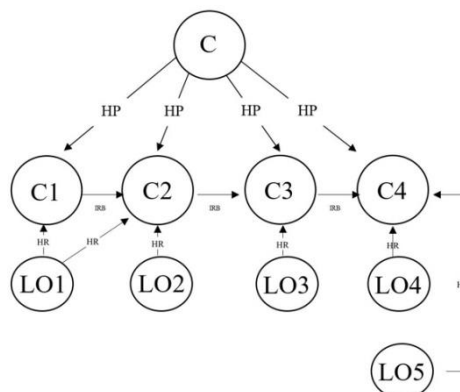
Figure 2. E-learning topology model of the MLS.

2) Learner model

The learner model mainly describes each learner characteristic by representing Subject State and a set of Learning Preferences. The subject state is defined based on the list of lessons in the e-learning topology. Each of them shows the grade range from 0 to 10, where 0 represents learner is totally failed, whereas 1 represents the learner can complete the lesson. A lesson learn can be considered as "pass" when the grade is greater than some fixed value. The learning preferences define the properties of the learning object or learning resource which is suitable for the learner's characteristics in particular. The properties are composed of Lesson required, Learning Resource Type, Level of Difficulty, Language and Learning Time.

To implement these 2 models above, we use Learning Path Algorithm (LP) to generate the right ordered list of Learning Object that the learner needs to acquire sufficient knowledge for each lesson and finally achieve the whole course objectives. The algorithm is described by simple example of a student to present the complete process as follows.

Step 1. The Learning Path is generated as fit to this student
   LP ={C2,C3,C4}

Since C1 has already learned and passed, it has been removed from the path.

Step 2. The Subject State and Learner's Preference State of this student is presented as
         Subject State: C1(8), C2(3)
         Learning Preference State:
Lesson required -> C2
Learning Resource Type-> Multimedia content
Level of Difficulty -> Medium
Learning Time -> 30 minutes
Language -> ENG

Step 3. Learning object is selected based on the metadata to satisfy the student's learning preferences.

LO1 (Explain(C1,C2), Multimedia, Easy, 1 Hr, ENG)
LO2 (Explain (C2), Multimedia, Medium, 30 M, ENG)
LO3 (Explain (C3), Multimedia, Medium, 45 M, ENG)
LO4 (Explain (C4), Multimedia, Hard, 1 Hr. ENG)
LO5 (Explain (C4), Multimedia, Hard, 1.30 Hrs ENG)

In the example, this student is suggested to learn with the set of {LO1, LO2} prior to the next lesson C3.

3.2.2 Content Design

In our web-based e-learning, the course content has been broken down into screens, modules, situations, visual and instructional elements. The content consists of a learning document, presentation, and multimedia, which respond interactively to the target learner. The Myanmar Culture course e-learning consists of 4 main chapters. Chapter 1 introduces politics, economics, and history of Myanmar, Chapter 2 presents people, weather and places of Myanmar, Chapter 3 presents Myanmar traditions, customs, religions, and festival, and Chapter 4 describes the entertainment show and art in Myanmar. Figure 3 shows the content structure of the proposed e-learning.
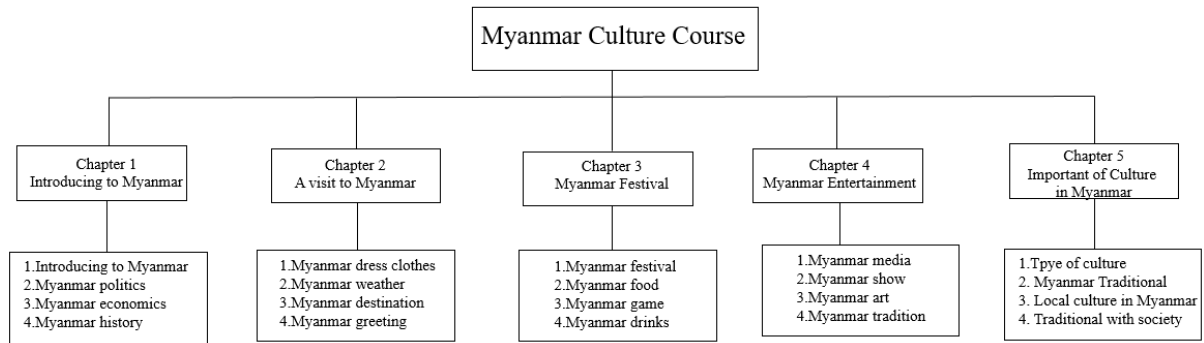
Figure 3. Myanmar culture course content structure.

3.3 Development

This stage is the third step, as shown in the ADDIE model. In this stage, the configuration archives from the second stage are utilized to implement the structure and produce creating of the framework which incorporates framework building, conveying, introducing, arranging, testing, and discovering blunders. The program was written in JavaScript programming language because there is a suitable cost server deal in Thailand as the client's craving, and there is open source accessibility. In building up, the venture system is in Model-View-Control (MVC) engineering because of its convenience of advancement and support. Moreover, the firebase as the database the board programming.

There are two types of assessments used in the MLS system Formative assessment for improving teaching and learning, and Summative assessment intend to capture what a student has learned, or the quality of the learning, and judge performance against some standards. Additionally, two types of activities take place during the assessment, which is taking exercise and taking the quiz to collect the assessment score for each student are presented in Figure 4. The resources of the content referenced on Myanmar Culture and learning Book. We used PDF as a lesson material to enhance the standard of concrete by adding a figure to explain the text and input exciting topics for students to motivate their study.
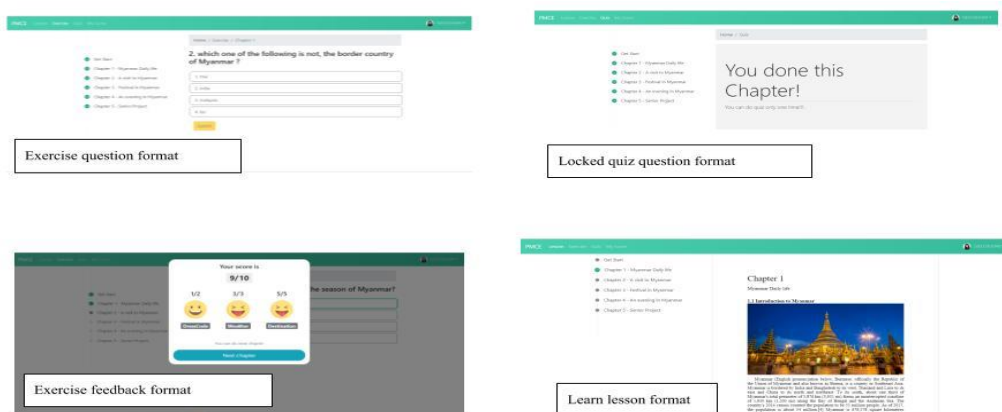
Figure 4. Content for each screen module.

4. Experimental Study

4.1 Experimental Design

In comparison to the traditional method, an experiment was conducted to evaluate the effectiveness of the online learning system. In this study, since the participants were not randomly assigned, a

quasi-experimental research design was used. The experiment was conducted with ten students with a simple drawing of the class's representatives from the Myanmar Culture course at Mae Fah Luang University in Thailand. The aims of the study were:

1. Examine students' related knowledge of online learning Myanmar Culture class.
2. Determine students' usefulness on online learning at the undergraduate level in Mae Fah Luang University.
3. Determine students; detailed feedback after using the system of MLS.

4.2 Participants

The selected representative came from a different educational background and different culture since three students from Thailand, four students from China, and three students from Myanmar. These students also from the different major of studies field. Therefore, it can be determined with confidence that this effect on the dependent variable is directly due to the independent variable manipulation. For these reasons, the best type of research design is often considered to be specific experimental designs. Their computer experiences, consisting of apparent self-use, gratification, and efficiency, and the application of online learning, play a dominant role.

4.3 Instrumentation

The research tools used in the experiment consisted of pretest, posttest, and satisfaction questionnaire. The pretest and the posttest were designed by Myanmar Culture class teacher who has at least five years of teaching experience. Each chapter test contained ten multiple-choice-question items, with one score per item. The pretest was done why taking the manual based test, and the posttest was done by using a systematic test. The questionnaire was intended to investigate students' attitudes toward the system, consisting of 8 items of 5-point Likert scale (3 items each for visual systematic learning, enjoyment, and motivation), ranging from "1" for lowest satisfaction to "5" for highest satisfaction. In collecting this data, we ran a simple activity to ask students to rate each question by answering on the paper; we also asked them and facilitators to provide feedback for the application.

5. Results

5.1 Learning Achievement

To break down Myanmar Culture learning improvement, enlightening measurements, and t-test was utilized. As appeared in Table 1, the outcomes demonstrate that the understudies have higher posttest scores than the pretest score. it was found that the exam scores of students before using MLS (Mean = 5.9, SD = 1.45) were significantly lower than those scores after using MLS (Mean = 9.2, SD = 0.78). To see the contrast between the two scores, a combined example of t-test was led, and the outcome demonstrates that the pretest and posttest scores are fundamentally extraordinary. It infers that the created, versatile diversion system can enable understudies to adapt progressively.

Table 1

Student's Pretest and Post Test Score

Test	N	M	SD	t	p
Pretest Score	10	5.9	1.45	6.32	0.00*
Post-test Score	10	9.2	0.78		

* $p < 0.05$

5.2 Satisfactions towards MLS

In-depth and thorough literature study indicated a significant and positive association between students' interest in online learning, computer usability, and ease of use. The research shows that students widely accepted e-learning because the internet network makes it easy for them to search, gain, and work independently on learning materials and resources in a short period. The finding on a quantitative study, using a structured questionnaire at the Mae Fah Luang University, School of Management, to explore attitudes towards web-based distance learning and to identify positive attitudes towards online learning due to feasibility and new ways of learning.

Table 2

Student's Satisfaction towards the Developed E-Learning System

Dimension	Satisfaction	Mean	SD	Remark
Systematic Learning	The system help improves student assessment score	4.10	1.66	High Satisfaction
	The system helps related lesson learn from the classroom	4.30	0.94	High Satisfaction
	Learning lesson in a systematic way make improve knowledge about the content	4.00	1.05	High Satisfaction
Enjoyment	I enjoy doing assessment through MLS system	4.80	0.63	High Satisfaction
	It's fun to recall your lesson learned while doing quiz	4.20	1.03	High Satisfaction
	I am excited to continue doing exercise after finish one chapter	4.70	1.63	High Satisfaction
Motivation & Challenge	I feel challenged to continue taking exercise until it finished	4.30	0.94	High Satisfaction
	The feedback of the system motivates me to study more?	4.20	0.91	High Satisfaction

6. Conclusion

The development of this system aims to improve the learning of Myanmar Culture Course in Mae Fah Luang University in Thailand. Our group had learned that the development of the E-learning system depends highly on the practical learning objective of its students. This study developed the system to be very helpful in the assessment management of lecturer and students to be able to improve the learning of the class and promote understanding of the lesson. Also, this system provides better management of learning materials, exercises, quiz including a more comfortable tool for lecturer and students, and provide learning activities based on student's performance. Promote understanding of MCL (Myanmar Culture Learning). The system will help them to review the content effectively in order to motivate them in the study and students can improve themselves from their misunderstanding, who afraid for answering questions or asking questions which also help them. The teacher can screen all of the student's problem and improve their learning material.

The finding of this study shown that Students must be provided time to address the demands of the activity; resources must be readily available and meet all safety standards. Students should have opportunities to draft stage work and practice. Developing the criteria and the rubric and sharing these with students before evaluating a dramatic performance is critical before assessing student effort. Students can take their experiences in performance-based learning to use at later points in their educational, personal, or professional lives. The goal of performance-based learning should be to enhance what the students have learned, not just have them recall facts.

For the future, we are planning to adopt the e-learning website with other subject or making to the course. Improving the content from racking to improve learning skills, adapt learning material for each person by their skill.

Acknowledgments

References

Anderson, R. E. (1992). *Social impacts of computing: Codes of professional ethics.* Social Science Computing Review.

Aung-Thwin, M. A. (2018, December 26). *Myanmar.* Retrieved from https://www.britannica.com/place/Myanmar

Bush, M. &. (1997). *Technology-enhanced language learning.* National Textbook Company: Illinois.

Chan, T. W. (2006). *One-to-one technology-enhanced learning: An opportunity for global research collaboration.* Research and Practice in Technology-Enhanced Learning.

Chen, C. (2007). *Intelligent Web-Based Learning System with Personalized Learning Path Guidance.* Retrieved from Eric.ed.gov: https://eric.ed.gov/?id=EJ795992.

Committee, B. A. (2006). Retrieved from Community Directory: People from Burma/Myanmar: https://static1.squarespace.com/static/571f0e412fe1317553071298/t/57282b6fe32140b80139e167/1462250 356854/burmese_directory.pdf

Conger, S. &. (1995). *Ethics and computer use.* Communications of the ACM.

Fahad, A. N. (2009). *Students' Attitudes and Perceptions towards the Effectiveness.* The Turkish Online Journal of Educational Technology – TOJET.

Johns, S. &. (2018, September 12). *https://www.edelements.com/blog/the-core-4-of-personalized-learning.* Retrieved from The Core 4 Elements of Personalized Learning: https://www.edelements.com/blog/the-core-4-of-personalized-learning

Jonassen, D. H. (1999). *Learning to Solve Problems with Technology: A Constructivist Perspective (2nd Edition).* Columbus, OH: Prentice Hall.

Mackay, W. E. (1995). *Ethics, lies and videotape. In I. R. Katz, R. Mark, L. Marks, M. B. Rosson, & J. Nielsen (Eds), Proceedings of CHI' 95.* Denver, Colorado: ACM Press. .

Rahimi, M. a. (2011). *The impact of computer based activities on Iranian high school students' attitudes towards computer assisted language learning.* Procedia Computer Science.

Schwartz, M. (1995). *Task Force on Bias-Free Language of the Association of American University Press.* IN: Indiana University Press.

Matteo Gaeta, S. M. (2013). *An Approach To Personalized e-Learning.* Retrieved from www.iiisci.org: http://www.iiisci.org/journal/cv$/sci/pdfs/heb785zu.pdf

Education Elements. (2010). *edelements.* https://www.edelements.com: https://www.edelements.com/hubfs/Core_Four/Education_Elements_Core_Four_White_Paper.pdf

An Integrated Inquiry-based BYOD Approach for Supporting Social Studies Learning Abilities in Museums

Chitphon YACHULAWETKUNAKORN[a]*, Ratthakarn NA PHATTHALUNG[b], Charoenchai WONGWATKIT[c], Jintana WONGTA[d] & Chayanuch WATTHANA[e]

[a,b,d,e]*Engineering Science Classroom, King Mongkut's University of Technology Thonburi, Thailand*
[c]*School of Information Technology, Mae Fah Luang University, Thailand*
*chitphon.yac@kmutt.ac.th

Abstract: History is an important required subject on every level and every country. In particularly Thailand has prioritized to study history. Nevertheless, there has a limitation in studying history. Especially teaching and learning approach that still mostly be taught through lecture-based learning, and memorization skill. In this study, the author designed the historical learning approach that integrating inquiry-based BYOD approach to learning and experiencing in the historical museum. 62 grade 12 participants were assigned the mission through the communication gadget. In the mission, participants were anticipated to trained Collaboration, Communication, Creativity, and Critical Thinking skill in the 21st century through the mission associated with historical, architectural, and cultural knowledge's content. From the experiment, it founded that participants mostly developed and increase Collaboration, Communication, Creativity, and Critical Thinking skills after experienced this museum education approach. The findings of this study could serve as a model in adopting blended learning with museum learning activities for social science and other subject.

Keywords: History Study, museum education, BYOD, experiential learning, inquiry-based learning, 4Cs skill in 21st century

1. Introduction

Social Studies course in the secondary school level of Thailand consists of many disciplines such as Political Science, Law, History, Economics, etc. In particular, the history course, Thai Ministry of Education has significantly prioritized to study Thai history. Owing to Thai history has faced with many severe crisis. For instance, the diversity issue among people within these country in the context of religion, ethnicity, culture, poverty, corruption, etc. These problems exactly affected to the political, and economic stability. Therefore, Government agreed that the main causes caused by National History misunderstanding.

Teaching History in Thailand mostly remain to teach in classroom through lecture-based learning by using instructional media such as ancient pictures, videos, historical documentaries, etc. According to those learning processes mentioned, students were trained to apply knowledge in ordered to memorize the historical incident but they weren't trained to construct and comprehend the content of history logically by themselves. Furthermore, they couldn't apply knowledge content to real life. Therefore, learning the history beyond the classroom; the historical sites, the national museum would accelerate the self-learning process through Inquiry-based learning.

Historical museums are increasingly positioning themselves in the market as places for rich learning and experiences. Many study has shown that people visited museums for learning and experience (Ahmad, 2013). Learning process and experiences from the historical museum could encourage students having an ability to interest the history course through ancient artifacts in the museum.

Bring Your Own Device remained as an effective approach, in particular, to support mobile learning. BYOD concept is used to describe the students using personally owned devices in education

settings. Besides, it was considered as a significant technique of learning encouraged learners to compare knowledge content through traditional learning and online learning.

According to the current phenomenon of the historical education that is always be challenging topic for Thai education sector. Therefore, blending both traditional with mobile learning in the approach of BYOD in ordered to learn history in the museum could be an interesting learning process. Hence, this research mainly aimed to study the effectiveness of an approach that integrating an inquiry-based BYOD for learning the history through the historical museum by analyzing with 4Cs skill of the 21st century that learner could derive and construct. 4Cs's considered as the most popular learning strategies in today's environment. It's a necessary skills for students so that they could learn and apply knowledge's content both in the context of Education, and the future occupation.

2. Related Studies

2.1 Museum Education and History Learning

Museum education considered as a field devoted to developing the education role of education spaces. It aimed to engage visitors in learning experiences to enhance their curiosity and interest through objects and collections (Griffin & Paroissien, n.d.). Ohatsuka defined museum education as the public service of education that broadest sense includes exploration, study, observation, critical thinking, contemplation and dialogue (Paper, Ohtsuka, Biwa, Biwa, & Ohtsuka, 2016). Hence museum education defined as the public space for learning through objects, collections, and others channel. Nevertheless, Ahmad prioritized to study the infected agenda in National Museum because it could be expressed to overall national history (Ahmad, 2013). Nevertheless, nowadays the interactive technology rapidly influences to traditional museum inevitably (Bourke, 2013).

Currently, National museum considered as the most effective place for learning national agenda inevitably. In the same time, interactive technologies were gradually applied in the museum. Jornet divided the process of learning in the museum into the main two approaches (Jornet & Jahreie, 2013). First, traditional museum, the physical, conceptual artifact, tool. Visitor could get the knowledge's content but rarely interact with any interactive multimedia (Vartiainen & Enkenberg, 2013). Second, the interactive virtual museum, the multimedia, tool, the artificial artifact (Huei-Tse Hou & Sheng-Yi Wu, 2014). It represented through both tangible and intangible cultural heritage.

The concept of museum learning was currently applied to many sector. In particular, Science, and Business. Chalas studied the comparison between the Art Museum and Art Gallery to improve the exhibition's approach (Chalas, 2017). Similar to Yi studied the behavior of Museum visitor in the Art Museum in ordered to improve and develop their exhibition to be Contemporary Art (Yi, 2019). Achiam designed astronomy's education in the space museum (Achiam, 2015). She concluded that it could accelerate learning behavior. Similar to Chang, a science museum could encourage student learning behavior more than the classroom (Chang, Huang, & Chen, 2005).

According to the literature review associated, In the context of Museum education, authors used the Ohatsuka as the overall concept of museum education's definition. From these concepts, we adopted both Ahmad, and Bourke's idea blending the interactive technology to be the contemporary museum of learning which according to Chang's ideas.

2.2 BYOD and the 4Cs skill

Nowadays, technology rapidly has an important role in broad sector. Such as Manufacture, and Education. Bring Your Own Device currently remained as an effective learning technique that particular support mobile learning. It is used to describe the students using personally owned devices in education settings (Burns-sardone, 2014). In the past decade, many research studies have applied BYOD strategy to promote in-field learning. For example, Handfield created Google Art Project allowing the students to see the artworks from famous museums (Handfield, 2014). Similar to Jang and Lien founded that graphic-user-interface and mobile computing technology could improve exhibition form in the museum to enhances the learning experience (Jang & Lien, n.d.).

The 4Cs considered as a significant skill which deserved for the student at every level. It comprised of Collaboration, Communication, Creativity, and Critical Thinking. There are many studies applied the 4Cs concept to conform to social studies, in particular, field activity. Mhlauli applied the 4Cs among the social studies teacher in order to develop a school curriculum (Mhlauli, 2017). Orly assessed student learning's efficiency through the field trip 4Cs activity (Orly, 2011). Similar to Reynolds, he also used TPACK (Technological Pedagogical Content Knowledge as an appropriate model for Social Studies curriculum. In addition, each 4Cs skill associated to connect with history study. For example, Collaboration could promote teamwork, and brainstorming. Communication could be represented through presentation, and debate skill. Creativity also created a continuous skill from knowledge content. Lastly, the critical thinking could be assessed from the assignment, lectured-based approach (Reynolds, Tavares, & Notari, 2017).

According to the literature review associated, the author adopted many ideas which could be applied to this study. In the concept of BYOD, the author used Burn-sardone as the overall concept of BYOD. In addition, Handfield's idea also considered as a modern learning approach through BYOD's concept which is similar to Jang and Lien's idea. From the BYOD conceptual idea, we could collaboratively evaluate to blend with the 4Cs skill, in particular Reynold's idea in order to consort with history and other social science in this study.

3. Approach and Design Development

The Museum learning field-trip is a required activity that Grade 12th students must join to comprehend Contemporary Thai History (1850-1932), and understand the concept of National Museum in Asia after World War II. According to the course's regulation, students have to study the Four Reign Course (The Reign of King Rama V-King Rama VIII) in the context of history, society, politics, and economy. Hence the teacher created the active learning activities in the most important historical museum in Bangkok; The national museum, and Museum Siam to consort with this course's regulation.
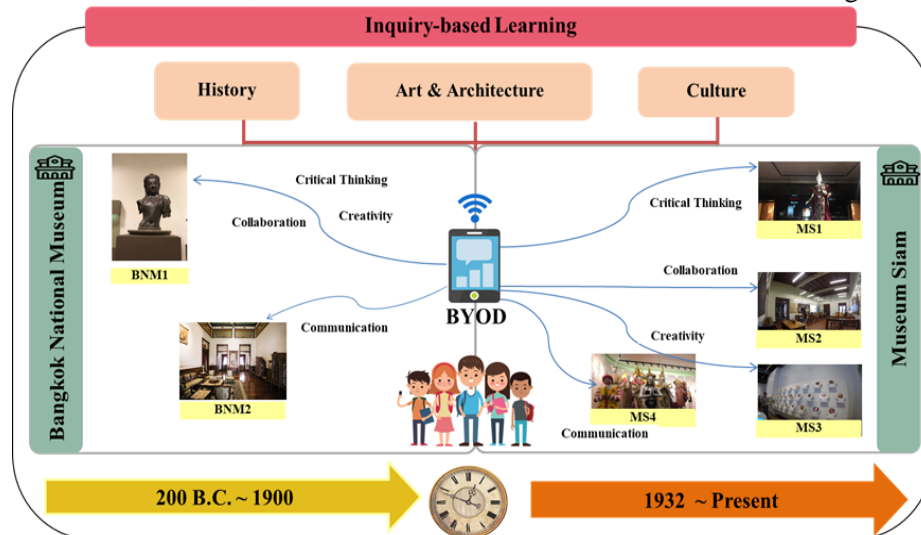
Figure 1. Overall Framework.

In this study, the learning approach was divided into two museums by using the historical timeline as criteria. Bangkok National Museum exhibited the artifact since the origin of Thai historical period-1900. In the case of Museum Siam is the contemporary interactive museum which mostly exhibited the duplicate artifact that represented to Thainess after 1932, the Siamese revolution of 1932. From the figure, students applied BYOD as the learning approach to inquire knowledge increasing the 4Cs skill through the mission that the teacher assigned.

According to figure 1, it showed the overall framework of this museum learning which was integrating main three social science knowledge content, such as, History, Art & Architecture, and Culture. From these contents, it was integrated into the assignment. The first location is Bangkok

National Museum (BNM). In this place, students were assigned to do the mission in two exhibition's room. First, BNM1, Sivamokpiman Exhibition room comprised of 3 missions which's trained Collaboration, Critical Thinking, and Creativity skill. Second, BNM2, another exhibition room where're chosen by students to make tourism VDO. For the second location is Museum Siam (MS). In this place, students were also assigned to do the four missions in four exhibition room. They were required to do the mission in 3 exhibition room which's trained Collaboration, Critical Thinking, and Creativity skill. In the case of Communication skill, students had to choose the other room to make VDO Clip to recommend that exhibition room.

Table 1

An Integrated BYOD Learning Activity

Activity	Descriptions	Expected Result
Pre-field learning (15 minutes)	Students were assigned the mission through Google Form. In this activity, students had to comprehend the mission in their group.	Critical Thinking (Analyzing the mission)
Brainstorming activity (30 minutes)	Students brainstormed in their group to share and work collaboratively. In this activity was directly trained the Collaboration skill to do group work.	Collaboration (Teamwork, Working toward a shared goal)
In-field learning (2 hours)	Students did the mission through inquiry-based BYOD approach in the exhibition room. Each mission was interpolated 4Cs skill. They could use mobile phone to inquire knowledge's content through a credible online database in ordered that they could construct knowledge from critical thinking, creativity, and communication skill because from each question, students could relate their previous, new knowledge through those mission. The assignment of both Bangkok National Museum and Museum Siam comprised of 4 questions in each place. For instance, Making tourism VDO in both two museums. This is the Communication mission.	Critical Thinking Collaboration Creativity Communication
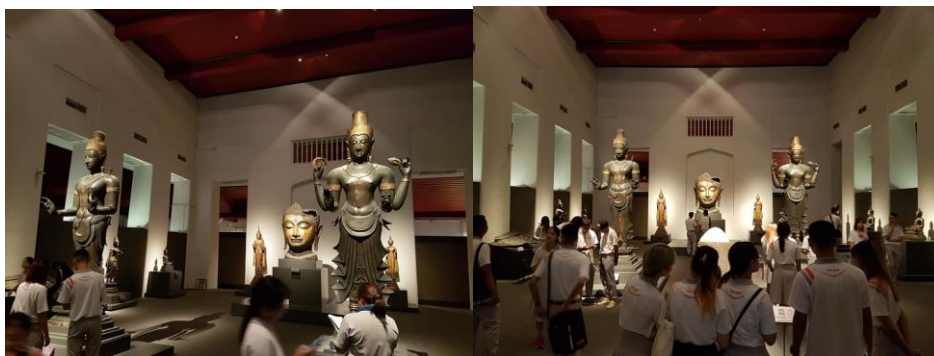
Figure 2. Students joined the museum learning through Brainstorming Activity.
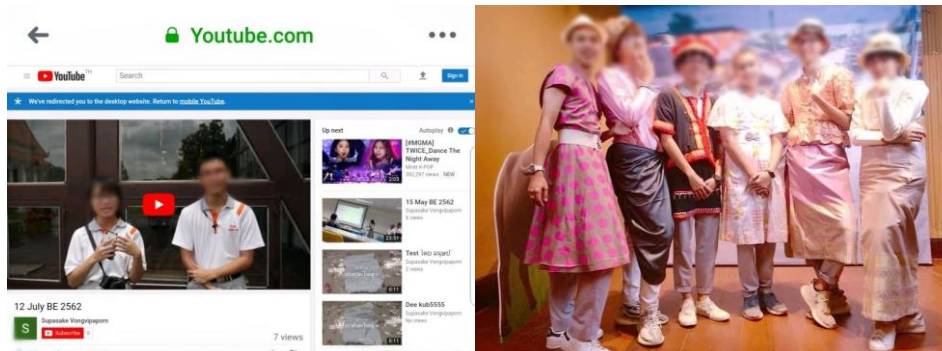
Figure 3. Students did the mission through Inquiry-based BYOD approach.

According to Figure 2, was the photos of museum learning's activities during students were learning in the field. The first above photo is the Brainstorming activity, students discussed and analyze artifact's configuration in BNM1 in ordered to analyze the criteria of BNM1 design. In this mission expressed to the critical thinking skill. For the second photo is the process of an exhibition's design, students discussed and analyze artifact's configuration in BNM1 in ordered to create new artifact's configuration in that room. It expressed to develop the creativity skill. The third photo is the process of Tourism VDO making; students were assigned to make VDO for recommending the other exhibition room. Students could be assessed the communication skill through online approach. From all those processes of learning mentioned, it's necessary to use BYOD as the approach to facilitate learning.

4. Method

4.1 Research Design

This study was designed to describe the overall museum learning approach which could be assessed the 4Cs skill. Authors used historical knowledge content as the criteria evaluating all of 4Cs skills. Therefore, authors evaluated the comparative result by using self-evaluated questionnaire before and after joining the field trip. In case of learning's objective, students were required to comprehend the historical knowledge's content in the period since 1850-1932 logically.

4.2 Participants

There were 62 students in grade twelve participating in this research study (male = 26, female = 36). All students learned the contemporary Thai history through the traditional and interactive museum which's consort with the required course, ESC 615 Four Reigns. Students were required to experience the museum learning activity within 1 day. The first museum is in the Bangkok National Museum, students joined the activity since 9.00 AM.-12.00 PM. The second museum is Museum Siam; they joined this learning approach since 1.00 PM.-4.00 PM.

4.3 Research Tool

There were the main instruments used in this study in order to evaluate 4Cs skills. They were used to assess the 4Cs skills by comparing before & after exploring the museum learning activity in the method of rating scale. In these questionnaire, it comprised of 12 self-evaluation question: 3 self-evaluation question for assess each skill. The data used in this study was collected from the self-evaluation from Google form. This instrument was adapted from Abdallah (2010) with self-assessment, and adapted from Likert Rating Scale self-assessment to evaluate the 4Cs skill development through an inquiry-based BYOD activity. For example, of the answer's meaning, 5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, and 1 = Strongly Disagree.

271

5. Results

5.1 4Cs Skill of 21st Century

Based on the evaluation result of the 4Cs skill, most students performed at the higher score of learning achievement after exploring the museum learning, as shown in Table 2. This implies that student can develop their 4Cs skill, particularly Collaboration, and Creativity skill.

Table 2
Result of 4Cs Skill

Skill	*n*	Experiment	Mean+SD	*t*	*p*
Collaboration	62	Before	3.98 ±0.84	1.99	0.025*
		After	4.23 ±0.61		
Communication	62	Before	4.31 ±0.80	-1.09	0.14
		After	4.18 ±0.56		
Creativity	62	Before	3.76 ±0.90	2.46	0.004*
		After	4.05 ±0.58		
Critical Thinking	62	Before	4.05 ±0.95	0.96	0.17
		After	4.16 ±0.52		

* p<0.05

According to the result above, it founded that students can develop Collaboration, Creativity, and Critical Thinking. In particular Creativity, Collaboration students obviously increase this skill. It implied that student increased this skill through the attitude toward teamwork, working collaboratively. In contrast to other skills, for instance, critical thinking result slightly increases after exploring in the field. On the other hand, the communication skill, it slightly decreased. Due to some limitation of the museum's regulation didn't allow visitor making VDO clip inside the museum. Therefore, attitude tends to decrease.

6. Discussion and Conclusion

This study investigated the development result of 4Cs skills through an inquiry-based BYOD approach for study Social Studies in Museum. In this study, we reported the latest several museum learning activity and findings. Collaboration, and Creativity is the skill that students obviously developed.

In contrast to communication skill, it showed that it slightly decreased after they did the museum learning activity. From those result, it implied to these study's limitation associated with the museum regulation. Therefore, it tended to affect to the student's attitude toward the communication skill in this activity. Similar to critical thinking skill, it slightly increased after they did the activity. From the result, it assumed that students generally accustomed to the critical activity in the social studies class. Hence it is not too different from the museum learning activity.

However, the current study has some limitations that should be resolved and improved. First, the number of participants in this study was relatively small; therefore, many participants across different contexts and background would be challenged to study for further generalization of this proposed approach. Second, there are some limitations on activity that didn't consort with the museum regulation.

References

Achiam, M. (2015). Analysis of the Educational Potential of a Science Museum Learning Environment : Visitors ' experience with and understanding of immersion exhibit Analysis: visitors ' experience with and understanding of an immersion exhibit, (February).

Ahmad, S. (2013). Museum Learning : Using Research Creating Future Museum Exhibition Museum Learning : Using research as best practice. *Procedia - Social and Behavioral Sciences*, *105*(December), 370–382.

Bourke, M. (2013). *New trends in museums of the 21 st century Table of contents Table of Contents Emerging new trends in the European museum panorama*.

Burns-sardone, N. (2014). Making the Case for BYOD Instruction in Teacher Education. *Issues in Informing Science and Information Technology*, *11*, 191–201.

Chalas, A. (2017). Toward Evaluating Art Museum Education at the Art Gallery of Ontario, (June).

Chang, C., Huang, Y., & Chen, C. (2005). THE IMPACT OF A SCIENCE MUSEUM INVOKED (SMILE) ON STUDENTS, 357–366.

Griffin, D., & Paroissien, L. (n.d.). Understanding Museums : Australian museums and museology Des Griffin and Leon Paroissien (eds).

Handfield, A. (2014). Art History Gone Mobile: B.Y.O.D. and Google Art Project.

Huei-Tse Hou, & Sheng-Yi Wu. (2014). A blended mobile learning for museum learning. Educational Technology and Society, 17(2), 207-218. *Educational Technology and Society*, *17*(2), 207–208.

Jang, H., & Lien, Y. (n.d.). Educational Exhibition System and the Application of APP on Museum Mobile Learning – National Palace Museum as an Example, 1–18.

Mhlauli, M. B. (2017). Social ' Studies ' Teachers '' Conceptualizations ' and ' Practices ' of ' Democracy) in) Upper) Classes) in) Primary) Schools) in # Botswana), (January 2016).

Orly, M. (2011). Assessing Learning in the Outdoors with the Field Trip in Natural International Journal of Science Assessing Learning in the Outdoors with the Field Trip in Natural Environments (FiNE) Framework, (May 2014).

Paper, C., Ohtsuka, T., Biwa, L., Biwa, L., & Ohtsuka, T. (2016). Museum learning / studying toward a better relationship between humans and lakes, (January).

Reynolds, R., Tavares, N. J., & Notari, M. (2017). Twenty-First Century Skills and Education Roadmaps Chu , S ., Reynolds , R ., Notari , M ., Taveres , N ., & Lee , C . (2016). 21st Century Skills Development (January)

Vartiainen, H., & Enkenberg, J. (2013). Learning from and with museum objects: Design perspectives, environment, and emerging learning systems, (January 2014).

Yi, T. (2019). The Process of Visitor Studies in Art Museum the Behavior of Museum Visitors, (February).

Personality Traits of Future Nurses and Cyberchondria: Findings from an Emerging Economy

Josephine DE LA CUESTA*[a], **Jypzie CATEDRILLA**[b], **Ryan EBARDO**[c], **Laiza LIMPIN**[b], **Cecilia LEAÑO**[d] **& Hazel TRAPERO**[e]
[a]*Asia Pacific College, Philippines*
[b]*Mindanao State University – General Santos, Philippines*
[c]*Jose Rizal University, Philippines*
[d]*De La Salle University-Manila, Philippines*
[e]*University of the Philippines - Cebu, Philippines*
*joannec@apc.edu.ph

Abstract: The Internet is intricately embedded in our everyday lives and has become a valuable source of information to support learning due to its accessibility and decreasing costs. However, the rising costs of healthcare resulted in students seeking medical information from online health websites contributing unnecessary stress to their academic lives. In developing economies, however, the overloaded information from the Internet brings forth severe risks to these individuals by exposing themselves to inaccurate and inappropriate information in addressing their perceived conditions and symptoms. Cyberchondria is the speculative escalation of anxieties about common health issues which is grounded on the assessment of online information to satisfy medical curiosity. The personality traits of nursing students in higher education are utilized to identify which among these traits can lead to cyberchondria by examining 207 responses through a structural equation model technique. Analysis of data reveals that the individual personality traits of conscientiousness and neuroticism are positively associated with cyberchondria. Practical and academic implications are discussed in relation to the role of technology in nursing education.

Keywords: Nursing education, online health information, individual personality traits, structural equation model, cyberchondria

1. Introduction

The profession of nursing is vital to sustain national healthcare systems and educational institutions play a pivotal role in molding the nurses of tomorrow. In the Philippines, the nursing profession remains to be one of the top skilled migration exports and is one of the top choices of students in their pursuit of higher education qualifications (Castro-Palaganas et al., 2017). Recent reforms in the Philippine ICT and healthcare sectors created a multitude of opportunities for Filipinos to conveniently access online information making them more knowledgeable on their health-related issues (Camus, 2018; Ranada, 2019). In addition, the availability of vast medical information online resulted in people spending countless hours searching for possible diagnosis of their symptoms. For example, a Pew Research (2013) study revealed that 35% of individuals in Northern America are taking advantage of the availability of health information on the Internet prompting them to self-diagnose their conditions using the popular online health websites of WebMD, Mayo Clinic and Health Line. The abundance of health information on the Internet has allowed people to explore and research about their health from the comfort of their homes. Although the use of online information will enable making informed decisions, it has the possibility of intensifying the anxiety in people who have no background in health and medical training when employed as a diagnostic practice.

Prior studies argue that the self-diagnosis behavior of individuals invites unnecessary psychological stress, largely attributed to possible exaggeration of fears about their health conditions. The proliferation of medical information online increases the risk of acquiring information that are misleading, unreliable, and susceptible to misinterpretation (Gass, 2016). This phenomenon, as coined

by White and Horvitz (2002), is known in cyberpsychology as cyberchondria which is the repetitive utilization of Internet resources for information on the individual's health leading to heightened paranoia. Cyberchondria is a relatively emerging issue, but with the advancement of high-speed internet and mobile phones, it has become a public health issue in developing economies (Inthiran, 2016). Susceptibility to cyberchondria varies and a prior study established a linkage between increased availability of information on the Internet as well as the influence of individual personality attributes (Baumgartner et al. 2011).

In higher education, students are faced with meeting their academic requirements in addition to varied personal issues of adolescent life such as health. As such, the Internet has become a constant resource in trying to address these health issues which may heighten cyberchondria (Bati, Mandiracioglu, Govsa, & Çam, 2018). As nurses are important stakeholders in the healthcare system, a more profound understanding of the relationship between individual characteristics and escalations of Internet anxiety among nursing students will be beneficial to higher educational institutions and regulatory bodies, to enable the production of the next generation of nurses. In this study, the authors propose to examine the relationship between cyberchondria and the Big Five individual personality traits in the context of nursing students from higher education in a developing economy.

2. Related Literature

The proliferation of online websites providing health-related information is driven by the desire of individuals to have an initial understanding of their health concerns. However, numerous studies suggested that excessive exposure and interaction with online medical content may intensify anxiety (White & Horvitz, 2012). The anxiety induced by these health-related searches online may lead to uncontrolled risky behavior leading to cyberchondria (Aiken & Kirwan, 2012). The study of Baumgartner & Hartmann (2011) explored the relationship between health anxiety and online search behavior, which revealed that anxious individuals experience negative consequences from the use of the Internet for searching health information. In another study, the information-seeking behavior of an individual can be attributed to the factors of individual personality traits (Halder et al. 2010). As a result, individual characteristics play a crucial role in determining the anxiety behavior of individuals toward Internet use for online health searches. In higher education, access to the Internet appears to have a positive relationship with cyberchondria. The study by Bati et al. (2018), revealed that frequent Internet search on health-related issues increase cyberchondria and that this effect is heightened in those who are suffering medical conditions. The findings of this study are aligned with a prior investigation by Singh & Brown (2014) which revealed that university students tend to utilize the Internet in searching for related information on their health issues.

The theory of personality traits has been used in many Information Systems (IS) and Information Technology (IT) researches to understand the influence of individual behaviors in different technological and societal contexts (Maier, 2012). The Theory of Personality Traits describes an individual's traits as a set of "*dispositions leading to constant patterns of thoughts, feelings, and behaviors across diverse situations that distinguish individuals from each other*" (Costa & McCrae, 2006, p.3). These stable elements of an individual's personality include extraversion, neuroticism, openness to experience, agreeableness, and conscientiousness (Costa & McCrae, 2001). Krishnan et al. (2010) examined the influence of personality traits on cyberloafing to describe the intended acts of employees in using their organizations' Internet resources during working hours for personal purposes. In the study of Maier et al., (2017), the individual perception of technology use and how it adds to stress is influenced by personality. Also, other studies revealed that different personality traits could be a predictor of individual unethical behavior with Internet addiction and cyberplagiarism (Ramírez-Correa, 2017; Ayar et al. 2015). The study of Karabeliova & Ivanova (2014) explored the linkages between cyberchondria, Internet addiction, and individual personality traits and results show that high levels of neuroticism influences health anxiety and a low level of conscientiousness predicts Internet addiction. For this study, the five personality traits of nursing students and their relationships to cyberchondria are operationalized in five hypotheses as shown in Figure 1 – Theoretical Framework
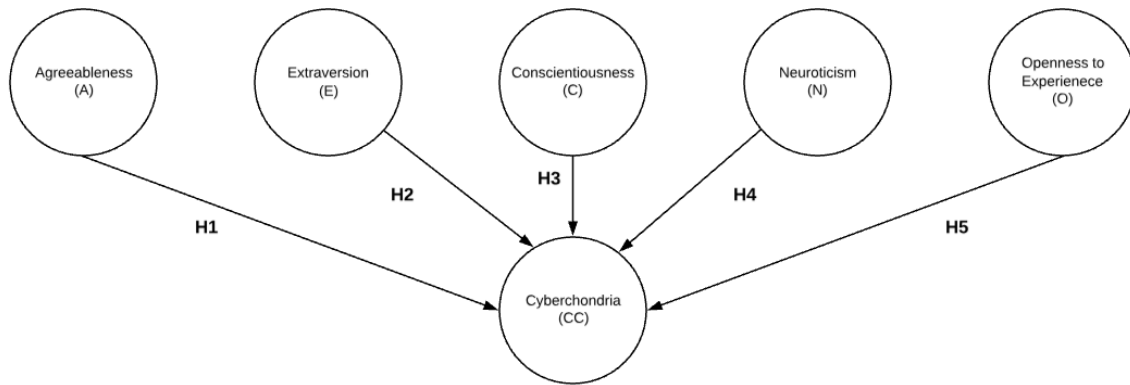
Figure 4. Theoretical Framework

3. Methodology

The study used a cross-sectional method to investigate the relationship between individual personality traits and cyberchondria using an online survey. Students enrolled in the Bachelor of Science in Nursing program from two Philippine universities were invited to participate in an online survey. The rationale behind the research, sections of the instrument and privacy protocols were explicitly stated at the start of the survey process. The authors ensured that ethical standards are upheld through informed consent from students who are at least 18 years old. A total of 207 responses were recorded and analyzed for construct validation and hypothesis testing. The demographic profile of the respondents revealed that most of them are active online consumers of health information. Majority of the respondents are female nursing students, accounting for 65% or 134 of those who participated in the study. The rest are male nursing students with a total of 73 or 35% of the total recorded responses.

A concise version of the International Personality Item Pool (IPIP) survey instrument from Donnellan, Oswald, Baird and Lucas (2006) was used for this study to measure the individual's personality traits. On the other hand, the questions concerning cyberchondria were taken from Selvi et al. (2017). The final version of the instrument consists of 33 items about the individual's perceptions on the Internet's health information, their practices with the use of the Internet to search for health-related information, and how the Internet influences their health concerns. Participants answered using a five-point Likert scale ranging from 1 – "Never" to 5 - "Always". Some items were modified to ensure its appropriateness to the context of the study. Indicators that failed to meet the minimum threshold for Cronbach Alpha (0.70), Composite Reliability (0.70) and Average Variance Extracted (0.50) were discarded resulting in a final version of the questionnaire.

4. Results and Discussion

Validity of the research model was tested by performing a multiple regression analysis using a Structural Equation Model as proposed by Hair et. al. (2014). This technique was used in another study investigating personality traits and its relationship with deviant behavior (Ramírez-Correa, 2017). The data was analyzed using SmartPLS 3.0 and the results are shown in Table 1 - Results.

Table 1
Results

Hypothesis	Statement	T-Statistics	Decision
H1	A high level of agreeableness is positively related to cyberchondria	1.470	Reject
H2	A high level of conscientiousness is positively related to cyberchondria	2.197	Accept
H3	A high level of extraversion is positively related to cyberchondria	0.978	Reject
H4	A high level of neuroticism is positively related to cyberchondria	2.786	Accept
H5	A high level of openness to experience is positively related to cyberchondria	0.895	Reject

Based on T-statistics, high levels of conscientiousness and neuroticism are positively related to cyberchondria. The values of 2.197 (conscientiousness) and 2.786 (neuroticism) are above the acceptable values of 1.96 resulting to a positive relationship to cyberchondria. Although the values of 1.470 (agreeableness), 0.978 (extraversion) and 0.895 (openness) demonstrate positive relationship towards cyberchondria, their relationships cannot be supported in the context of this investigation (Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, 2014).

Based on the results, the authors infer that neuroticism and conscientiousness have a considerable impact on the escalation of individual health anxiety through a consistent Internet search for health information. On the contrary, the traits of extraversion, agreeableness, and openness do not positively influence cyberchondria. As revealed in the study of Karabeliova and Ivanova (2014), increased levels of neuroticism and conscientiousness of an individual can be positively associated with cyberchondria. Conscientiousness is associated with being reliable, responsible, organized, and hardworking (Goldberg, 1990). As such, people who have this trait exhibit a consistent desire for success through purposeful planning and persistence. These people can be compulsive perfectionists with a tendency to hoard vast amounts of online information to guide their decision making (Ozowa, 2017). On the other hand, people with high levels of neuroticism are anxious, depressed, embarrassed, emotional, angry, worried and insecure (Costa & McCrae, 2001). In education, students demonstrating neurotic tendencies are at high risk to commit academic dishonesty or other deviant behaviors (Ramírez-Correa, 2017).

To mitigate the negative impact of cyberchondria on public health, the authors highlight several recommendations. The study of White & Horvitz (2012) provided a framework for search engines to monitor the long-term search behavior of individuals by analyzing Internet search logs, to offer better support and prevent escalation of unethical online behavior. A predictive model was proposed to accurately predict when concerns are expected to escalate and the assessment of these impacts for any individual suffering from anxiety behavior. In another study, Starcevic (2017) argued for the reinforcement of online health information literacy in educational institutions by identifying the limitations of Internet usage, recognizing the credibility of various medical websites and assessing online health searches critically.

5. Conclusion, Limitations and Recommendations

While this study attempts to identify the relationship of personality traits to cyberchondria, the findings are limited by the number of respondents and the sampling technique used by the researchers. The limitations of the study created opportunities for future research. First, there is a need to enrich the collection of data to cover the equal representation of the overall locality in the Philippines. Therefore, the authors recommend replication of the study with larger samples to better demonstrate the relationship between cyberchondria and other personality traits. Second, a thorough study of the different age groups will capture various factors with regard to Internet user behavior and cyberchondria. Lastly, to complement and further improve the general lack of adequate survey methods that allow researchers to make strong and reliable inferences, future research should apply other methodologies such as qualitative interviews, content analysis or other emerging techniques to discover the most commonly recurring types of individual online behaviors in relation to their health issues.

In conclusion, this study identified which among the personality traits of nursing students as proposed by Goldberg (1990) are susceptible to cyberchondria. The structural model indicated that a high level of conscientiousness and neuroticism has a positive relationship to cyberchondria at a significant level. This result is consistent with the findings of Heiman, et al., (2018) in Germany, which revealed that individuals with a higher score for conscientiousness and neuroticism are likely to seek information about the illness on the Internet. Several recommendations can be inferred from the findings of this study. First, as future medical professionals, nursing students have the moral obligation to develop critical appraisal skills to identify which information is valid and reliable (O'Mathúna, 2018). These skills will be valuable as they will be interacting with patients in the future who may have a prior diagnosis of their health conditions from Internet sources. Second, while the Internet is an important tool in supporting education, universities should incorporate curricular adjustments to inculcate the value of accurate and reliable Internet information to mitigate cyberchondria among university students. Such interventions will enable nursing students to cope with the challenges of their academic lives and prepare them for their future roles in the healthcare industry (Bati et al., 2018). This can be accomplished by integrating cyberchondria in ethics or technology courses specifically designed for

medical students. Lastly, Internet stakeholders need to collaborate to ensure that medical information available are those that are scientifically proven to alleviate the negative effects of cyberchondria to its users (O'Mathúna, 2018).

References:

Aiken, M., & Kirwan, G. (2012). Prognoses for diagnoses: medical search online and "cyberchondria." *BMC Proceedings*, *6*(Suppl 4), P30. https://doi.org/10.1186/1753-6561-6-S4-P30

Bati, A. H., Mandiracioglu, A., Govsa, F., & Çam, O. (2018). Health anxiety and cyberchondria among Ege University health science students. *Nurse Education Today*, *71*(March), 169–173. https://doi.org/10.1016/j.nedt.2018.09.029

Baumgartner, S. E., & Hartmann, T. (2011). The Role of Health Anxiety in Online Health Information Search. *Cyberpsychology, Behavior, and Social Networking*, *14*(10), 613–618. https://doi.org/10.1089/cyber.2010.0425

Camus, M. (2018). Metro Manila to benefit from 3rd telco service | Inquirer Business. Retrieved February 28, 2019, from https://business.inquirer.net/261714/metro-manila-to-benefit-from-3rd-telco-service?utm_expid=.XqNwT ug2W6nwDVUSgFJXed.1

Castro-Palaganas, E., Spitzer, D. L., Kabamalan, M. M. M., Sanchez, M. C., Caricativo, R., Runnels, V., … Bourgeault, I. L. (2017). An examination of the causes, consequences, and policy responses to the migration of highly trained health personnel from the Philippines: the high cost of living/leaving—a mixed method study. *Human Resources for Health*, *15*(1), 25. https://doi.org/10.1186/s12960-017-0198-z

Donnellan, M. B., Oswald, F. L., Baird, B. M., & Lucas, R. E. (2006). The Mini-IPIP scales: Tiny-yet-effective measures of the Big Five factors of personality. *Psychological Assessment*, *18*(2), 192–203. https://doi.org/10.1037/1040-3590.18.2.192

Gass, M. A., & Gass, M. (2016). Risks and Benefits of Self-Diagnosis Using the Internet By.

Goldberg, L. R. (1990). An Alternative 'Description of Personality': The Big Five Factor Structure. *Journal of Psychology and Social Psychology*, *59*(6), 1216–1229. https://doi.org/10.1037//0022-3514.59.6.1216

Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2014). Partial least squares structural equation modeling (PLS-SEM). *Sage Publisher*. https://doi.org/10.1108/EBR-10-2013-0128

Hair, J., Hult, G., Ringle, C., & Sarstedt, M. (2014). Partial least squares structural equation modeling (PLS-SEM). *Sage Publisher*. https://doi.org/10.1108/EBR-10-2013-0128

Halder, S., Roy, A., & Chakraborty, P. K. (2010). The influence of personality traits on information seeking behaviour of students. *Malaysian of Library & Information Science*, *15*(1), 41–53. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&profile=ehost&scope=site&authtype=crawler&jrnl=1 3946234&AN=50567756&h=G69OOo2Pf3oWrXTV3xzWD/xN8m4SZKdoCHogFM5Kn50EVKzyEIcZ Z/GRHzo4d58X2/8qPGVYLLsiLN09G53RLg==&crl=c

Heiman, H., Keinki, C., & Huebner, J. (2018). EHealth literacy in patients with cancer and their usage of web-based information. *Journal of Cancer Research and Clinical Oncology*, *144*(9), 1843–1850. https://doi.org/10.1007/s00432-018-2703-8

Inthiran, A. (2016). Online Health Search Experience: Sentiments from South East Asia. *International Journal of Knowledge Content Development & Technology*, *6*(2), 29–42. https://doi.org/10.5865/ijkct.2016.6.2.029

Karabeliova, S., & Ivanova, E. (2014). Elaborating on Internet addiction and cyberchondria–relationships, direct and mediated effects. *The Journal of Education Culture and Society*, (1), 127–144. https://doi.org/10.15503/jecs20141-127-144

Krishnan, S., Lim, V. K. G., & Teo, T. S. . (2010). How does personality Matter? Investigating the impact of Big-Five personality traits on Cyberloafing. *International Conference on Information Systems 2010 Proceedings*, 1–16.

Maier, C. (2012). Personality within information systems research: A literature analysis. *ECIS 2012 - Proceedings of the 20th European Conference on Information Systems*. Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-84905734768&partnerID=40&md5=40e8a556937f e3bdeec1319379017af2

Maier, C., Weberei, A. Der, Laumer, S., Weberei, A. Der, Wirth, J., Weberei, A. Der, … Weberei, A. Der. (2017). Personality and Technostress : Theorizing the Influence of IT Mindfulness. *ICIS 2017 Proceedings*, 1–11.

O'Mathúna, D. P. (2018). How should clinicians engage with online health information? *AMA Journal of Ethics*, *20*(11), 1059–1066. https://doi.org/10.1001/amajethics.2018.1059

Ozowa, V. (2017). Perceived Effect of Personality Traits on Information Seeking Behaviour of Postgraduate Students in Universities in Benue State , Nigeria.

Ramírez-Correa, P. E. (2017). Relationship Between Cyber Plagiarism and the Big Five Personality Traits: an Empirical Study in a Chilean University. *Holos*, *5*, 125. https://doi.org/10.15628/holos.2017.5191

Ranada, P. (2019). Duterte signs universal health care law. Retrieved February 26, 2019, from https://www.rappler.com/nation/223942-duterte-signs-universal-health-care-law

Selvi, Y., Turan, S. G., Sayin, A. A., Boysan, M., & Kandeger, A. (2018). The Cyberchondria Severity Scale (CSS): Validity and Reliability Study of the Turkish Version, *20*(4), 241–246.

Singh, K., & Brown, R. J. (2014). Health-related Internet habits and health anxiety in university students. *Anxiety, Stress, & Coping*, *27*(5), 542–554. https://doi.org/10.1080/10615806.2014.888061

Starcevic, V. (2017). Cyberchondria: Challenges of Problematic Online Searches for Health-Related Information. *Psychotherapy and Psychosomatics*, *86*(3), 129–133. https://doi.org/10.1159/000465525

White, R. W., & Horvitz, E. (2002). Cyberchondria : Studies of the Escalation of Medical Concerns in Web Search.

White, R. W., & Horvitz, E. (2012). Studies of the onset and persistence of medical concerns in search logs. *Proceedings of the 35th International ACM SIGIR Conference on Research and Development in Information Retrieval - SIGIR '12*, 265. https://doi.org/10.1145/2348283.2348322

Digital Learning Transformation for One-room Schoolhouses in Rural Pakistan

Faisal BADAR* & Jon MASON
Charles Darwin University, Australia
*faisal.badar@students.cdu.edu.au
jon.mason@cdu.edu.au

Abstract: Despite extensive global efforts to make education accessible for all, one out of every five children are out-of-school. The situation demands re-thinking of learning strategies particularly in underprivileged contexts. Continued advancements in learning technologies may offer novel solutions and this paper reports on a study that explores such opportunities. Opportunities to think laterally also reveal that the centuries old one-room schoolhouse is a proven educational system that has yielded promising results for rural areas all around the world. Using a contemporary multi-grade teaching method, the one-room schoolhouse provides a resilient model educating children at locations, which lack quality teachers and resources. This paper reports a case study of an integrated approach to teach out-of-school children in rural Pakistan using education technology in a one-room schoolhouse. A synthesis of knowledge and practices associated with one-room schoolhouses is presented together with an analysis of education technology developments that look promising. A digital transformation roadmap to implement and scale this method to educate out-of-school children in other underprivileged communities is summarised.

Keywords: rural education, out-of-school, educational technology, ICT, one-room schoolhouses, multi-grade teaching, underprivileged

1. Introduction

At the change of millennium, global initiatives such as 'Education for All' (EFA) and the 'Millennium Development Goals' (MDGs) enlisted the support of many nations in pursuing the provision of primary education to all children of the world (UNESCO, 2015). In 2015, the member states of the UN renewed and reframed the commitment into 17 Sustainable Development Goals (SDGs), as part of the UN's sustainable development agenda 2030, in which SDG 4 refers to inclusive and equitable education lifelong learning opportunities for all. Despite such initiatives, global statistics show that one out of five children is out-of-school. Furthermore, due to a decline in efforts from participating governments, progress in decreasing the number of out-of-school children, adolescents, and youth has significantly reduced in recent years (UNESCO Institute of Statistics [UIS], 2018).

Meanwhile, mobile and wireless based Information and Communication Technologies (ICT) have enabled new ways to teach and learn where learners are not as dependent on specific time, place, or teachers (Hussain, Wang, & Rahim, 2013). Innovative e-learning solutions are also emerging in remote and rural areas in developing countries; however, sustainability of these disruptive innovations creates a challenge for governments and policy makers (Badar, Mason, & Khan, 2018). Within this complex environment, the one-room schoolhouse offers a practical and adaptable approach for 21st century learning where student centric learning is focused within a multi-grade student class (Goodlad, 1996).

This paper highlights key aspects of a study that examines the effectiveness of Raunaq-e-Islam Neighbourhood Schools (RINHS), operating as digital one-room schoolhouses in underprivileged communities in Sindh, Pakistan. It also proposes a draft roadmap to transform learning in these schools using ICT tools in education for these underprivileged communities. Data for the study was collected during field visits and transcribed from notes gathered from on-site observations and unstructured interviews with the RINHS stakeholders. Thus, the aim of this study is to explore the learning effectiveness of

one-room schoolhouses in underprivileged contexts and to present digital transformation of school learning strategies for implementation and improving quality of education with a focus towards development of innovative learning environment.

2. Out-of-school children and role of ICT in education

263 million children and youth of the world are out-of-school (UIS, 2017). Moreover, "the world's poorest children are four times more likely not to go to school than the world's richest ones" (UNESCO, 2015). Systemic integration of ICT in education is an opportunity for improving the quality of teaching and learning as well as expanding access to learning opportunities (Mitra, 2005). The main reasons behind out-of-school secondary level children are poverty, location, and gender; learning models based on mobile technology can provide access to people living in a remote location where there are no schools, teachers and libraries (Porter, 2016).

2.1   *Pakistan; education and out-of-school children's status*

Pakistan is the sixth most populated country in the world, having the fourth largest pool of out-of-school children (UNESCO, 2017). Most of the out-of-school children are residing in remote, rural or underprivileged city areas with prevailing challenges in providing quality education including shortage of good teachers, the hidden child labour challenge, affordability and cultural barriers to pursue educational goals (Titola-Meskanen, 2014). Education quality and standards are also declining in rural areas and increasing urban/rural disparities and inequalities, which is creating a learning crisis in low-income rural areas (Agarwal, 2014).

There is a serious inequality in educational attainment levels in Pakistan where more than twice individuals aged 15 years or above are illiterate in rural areas compared to that in urban areas (61.2% in rural areas and 29.74% in urban areas) (Pakistan Bureau of Statistics [PBS], 2015). In Karachi alone, there is huge disparity in education between the urban and rural areas. The Gini index of Education in Karachi shows the value of 0.611 in rural areas and 0.346 in urban areas (Saeed & Fatima, 2017).

2.2   *Role of ICT in spreading education*

Education in developing countries could be transformed by and benefit from e-learning through effective and innovative application of ICT (Badar, et al., 2018). Contemporary educational technology approaches such as distance learning, Open Educational Resources (OERs), Massive Open Online Courses (MOOCs), and open Learning Management Systems (LMS) like Moodle have all transformed learning environments (Ali, 2011). With mobile/ubiquitous learning, learners have more flexibility and opportunity for individualized, personalized and highly interactive learning (Cobcraft, Towers, Smith, & Bruns, 2006). Mobile phones are widely considered as the optimal solution for delivering education in developing countries, because of their usability, accessibility, and affordability (Grimus, et al., 2013; Ford & Leinonen, 2009). Mobile technology has the natural affordance to shift the teaching focus to the learner (Grimus, et al., 2013).

Distance education is a well-established methodology where students and teachers are separated physically or by time domain. The learning and assessment content is also designed specifically to suit the ease of distant learners. Research revealed a positive association among students engaged in distance learning in terms of self-regulation, self-efficacy and interaction (Yu,2015; Garrison, 2011; Harasim, 2012). Studies surfaced other advantages such as reduced travel cost and time, access to wider community of experts and flexible learning approach (Finch & Jacobs, 2012).

3. One-room Schoolhouses in rural Pakistan

3.1   *History of One-room Schoolhouses*

One-room schoolhouses have been common all around the world and operating for at least the last 300 years (Williams, 2005). Parents considered these schoolhouses a proper place for their children's education. After completing the school year, students were examined orally covering their spelling, arithmetic problem-solving competence, and other subjects, based on which teachers determine the students' future level of studies (America's one-room schools of the 1890s, 2005).

The one-room schoolhouse has traditionally provided a means for an integrated approach to the curriculum, often mixing age and aptitude. As a 'method' for 21st century education, it is distinguished from conventional curriculum design because it 'revisits' this older integrated approach. Interestingly, recent research indicates it improves the non-cognitive abilities of the students, giving them opportunity to mentor relatively less advanced students in that domain (Cundra, Benzel, & Schwebach, 2017). This pedagogical approach helps students to access challenging course material and research methodologies when someone among them have more relevant knowledge and provided the opportunity to educate the less knowledgeable ones (Bhuiyan, Supe, & Rege, 2015).

3.2   One-room Schoolhouses in rural Pakistan (RINH Schools)

One-room schoolhouses in rural Pakistan have been adopted by Raunaq-e-Islam Neighbourhood Schools (RINHS) that utilise centuries old practices to educate rural and remote communities. RINHS are operated by the Pakistan Memon Women Educational Society and serving out-of-school children in underprivileged communities since 2010. Demographically, RINHS are operating in rural and low-socio economic areas with limited access to educational institutions. Most households in these areas live below the poverty line and cannot afford to send their children to the private schools in the vicinity. Moreover, cultural and traditional norms also restrict transportation of female students to far-away areas for educational purposes.

RINHS utilise the multi-grade one-room schoolhouse practices in all their 20 schools. Students from pre-primary to grade 7 are taught by locally developed teachers. Many teachers are also owners of the houses where these schools are established. These schools are equipped with basic necessities such as ventilation, electricity, course books and writing material, make-shift arrangement for digital learning environment, drinking water and access to clean toilets.

RINHS represent an alternative learning environment with suitable hygienic conditions for students not going to schools elsewhere. Students are taught in a multi-grade environment with considerable range of age cohorts within one classroom. Instructions in these classrooms follow weekly plans developed using government curriculum and books. However, extra-curricular activities are also regularly conducted to develop these students' cognitive, non-cognitive and social skills and abilities. The learning atmosphere also sits well with the local socio-cultural context. Parents are happy with the dedication of teachers and the outcomes for children with varied capacities and needs.

Teachers are trained to handle multi-age students in their classrooms and use instructional formats which combine learning for the whole class, individualized/small group learning, and peer mentoring by advanced students. Weak students are given additional instructions so they may get along with the pace of other students. Daily homework is also required.

Despite the best efforts of RINHS management, they have observed that they are unable to reach beyond a certain limit in terms of scaling up and improving the quality of teaching in their schools.

4. Roadmap to Digital learning transformation at RINH One-room Schools

RINHS has successfully penetrated the isolated communities in rural and remote areas around the Karachi region through their one-room schoolhouse educational model. The model offers a sense of security to these communities as their own community member/s teach the children. Moreover, RINHS provides financial support to interested students through philanthropic activities where appropriate. However, quality of teachers is the weakest link. As these schools are in far-away remote areas, good quality teachers from urban areas do not prefer to join these schools. Locally trained teachers have limitations in terms of their educational backgrounds, exposure to latest teaching techniques and technology related developments. To overcome these issues, RINHS are exploring the possibility of technology based-learning solutions for these neighbourhood schools. Digital transformation of RINHS

according to the 21st learning techniques which shift the role of local teacher to a trained facilitator supported by remote qualified academic teams looks promising.

4.1 Moodle-Learning Management System and e-learning policies development

A Learning Management System is now typically a cloud service that provides a teaching and learning environment independent of time and location. An LMS now plays a pivotal role in online and distance learning as it enables a mix of teacher-led courses, and interaction between the teachers and students. (Sharma, 2013).

Because it is freely available with a proven capability to enhance learning, Moodle was selected as the LMS for the digital transformation process at RINHS (Stanley, 2014). Due to its open source architecture, Moodle can be utilized in many environments, which can help developers to create and edit the features according to RINHS needs and desires. A basic framework of e-learning policies for RINHS was developed involving all stakeholders.

4.2 Digital content development, teachers training, and use of OERs and MOOCs

Digital learning transformation of RINHS needs a complete revival of learning strategies, where the traditional learning pedagogies needs to be augmented with digitally suitable pedagogies. Similarly, the traditional learning content also needs to become digitally compatible for seamless delivery at the school's level. Moreover, teachers and facilitators' training was also a major challenge, as without motivated and capable teaching team, the digital transformation may not bring the desired outcomes.

Another challenge for the digital transformation team at RINHS was to gain confidence of the stakeholders about the myths related to e-learning environments such as digital learning is not effective learning method particularly for underprivileged population due to their lack of technology adoption; implementing ICT systems in the underprivileged areas will not bring positive outcomes as these tools suit to the tech-savvy children; teachers' training in digital environment is similar as of traditional classroom teaching; digital pedagogies may distract children from real learning towards technology fascination. Series of awareness forums were conducted with RINHS stakeholders to discuss these myths and address their concerns.

The project team comprising members from RINHS academic team, RINHS Technology team and consultant's team members having expertise on digital learning content, pedagogies and training., and was responsible to study the existing learning content in use at RINHS, and analyse the possibility of using it in digital environment. The team also studied the OERs and MOOCs available and the possibility to utilise them in place of, or in conjunction with the existing content, in the new environment.

The team emphasised on minimising the teachers, facilitators and learners' discomfort during the digital transition period and proposed blended digital content for the learners comprising digitised version of existing content augmented with OERs. The aim was to provide smooth adoption of existing content in digital environment among the learners in the beginning, and subsequently exposing to improved quality OERs based learning content developed after extensive global efforts. A sample blended learning material on selected topics was developed to be implemented during the pilot testing phase.

In the next step, the project team studied the existing pedagogies implemented at RINHS campuses, their effectiveness and possibility of using same pedagogies in digital environment. The team also researched on the contemporary learning strategies in use in various digital environments. Furthermore, the team also deliberated the capacity of present in-school staff to adopt new learning pedagogies, to provide a fairly challenging but realistically implementable pedagogical solution for these underprivileged areas. The team developed a pedagogical approach where the in-school staff will facilitate the learning process, and qualified and well-trained teachers will control remotely the learning environment of the classrooms with the help of pre-selected learning material and activities. The facilitators and remotely operating teachers will be provided the learning material and pedagogical details reasonably before the class activity so they are well-aware of the learning content and strategies before engaging the learners. Moreover, certain activities will also be designed to be conducted for the learners by the in-class facilitators to keep their effective control and authority on the learners. A fine

balance between remotely operating teachers and in-class facilitators was foreseen to bring optimum and most effective learning outcomes.

The digital transformation roadmap proposed redefining the role of local teachers into in-class facilitators as defined in 21st century teaching and learning methods and digital learning environments. This transformation will overcome the continued challenge faced by RINH management to provide well-qualified and experienced teaching resource for their school, as most of these schools are situated in remote locations, far away from the urban areas of the city.

To implement this transformation effectively, strong and comprehensive in-class and remotely operating teachers' technological, motivational and academic training is considered prudential. The team designed sample trainings to cover all the three aspects for the pilot project. In addition to the face-to-face lectures, online training component is also added including video lecture, digitally executed assessments, and online academic and communication activities, to make the training participants realise the real online learning atmosphere as students, and to prepare them understand empathetically in real-class digital environment.

A complete package of sample digital learning content, digital pedagogies and training components was provided to RINHS management to be implemented during the pilot project.

4.3 *Project pilot testing and future roadmap for digital learning at RINHS*

The project's pilot testing was planned on a selected sample of teachers and student for the duration of six months, starting from Jan 2020. During the pilot testing phase, the implementation of developed digital content will be taught to the selected group of students in a controlled environment through the developed pedagogical approach. The basic one-week teachers' professional development training initiated the pilot project which will be followed by subsequent one-day sessions every fortnight during the whole testing phase. The feedback from the teachers in the initial and subsequent trainings will help the designers understand the real-life learning dynamics and challenges in the digital environment, and amend the digital learning structure before implementing on the complete RINHS educational system.

5. Conclusion

Because the global efforts to educate children of the world have not yet been able to yield desired outcomes in many parts of the world and one out of every five children are out of school, there is a need to re-think strategies for teaching and learning for disadvantaged children. This study has investigated the centuries old one-room schoolhouses practices as a key part of a new solution. Together with the use of contemporary educational technology, a proposed roadmap to transform learning underprivileged context is discussed. The proposed approach is generic enough to also be implemented in other communities or in similar contexts. Several steps towards digital transformation of one-room schoolhouses operating in underprivileged communities discussed here are at the institutional level rather than at the level of individual learning unit or course to provide a bird's eye views of the digital transformation implementation roadmap. Keeping in view the urgency to effectively handle the need to educate these out-of-school children and the inability of traditional efforts to bring desired results, adopting the concept of Digital One-room Schoolhouses for the rural and remote communities around the world may create a positive and meaningful impact in the global arena in near future.

Acknowledgements

References

Agarwal, T. (2014). Educational Inequality In Rural And Urban India. *International Journal Of Educational Development, 34*, 11-19.

Ali, A. (2011). Key factors for determining students' satisfaction in distance learning courses. A study of Allama Iqbal Open University. Turkish Online journal of Distance Education. 12(2), 114-127

Hertage Alliance (2015). *America's one-room schools of the 1890s.* Retrieved from Heritage alliance: www.heritageall.org

Badar, F., Mason, J., & Khan, K. (2018). Re-thinking out-of-school learning in rural Pakistan. *Proceedings of the 26th International Conference on Computers in Education. Philippines: Asia-Pacific Society for Computers in Education*. 440-445

Bhuiyan, P., Supe, A., & Rege, N. (2015). *The art of teaching medical students.* Delhi: Elsevier India.

Cobcraft, R., Towers, S., Smith, J., & Bruns, A. (2006). Mobile learning in review: Opportunities and challenges for. *Proceedings. Online Learning and Teaching (OLT) Conference* (pp. 21-30). Brisbane: Queensland University of Technology.

Finch, D., & Jacobs, K. (2012). Online education : Best practices to promote learning. Proceedings of the Human Factor and Ergonomics, 56th annual meeting.

Ford, M., & Leinonen, T. (2009). MobilED: a mobile tools and services platform for formal and informal learning. *5th World Conference on Mobile Learning*. Banff.

- Garrison, D. R. (2011). *E-learning in 21st Century: A framework for research and practice* (2nd ed.). New York, NY:Routledge.

Goodlad, J. I. (1996). *Schools, curriculum and the individual.* Waltham MA: Blaisdell Publishing

Grimus, M., Ebner, M., & Holzinger, A. (2013). Mobile Learning as a Chance to Enhance Education in Developing Countries-on the Example of Ghana. *CEUR Workshop Proceedings*, *955*, pp. 340-345. Helsinki.

Harasim, L. (2012). *Learning theory and online technologies*. New York, NY:Routledge.

Hussain, S., Wang, Z., & Rahim, S. (2013). E-learning services for rural communities. *International Journal of Computer Applications, 68*(5), 15-20.

Mitra, S. (2005). Self organising systems for mass computer literacy: Findings from the 'hole in the wall' experiments. *International Journal of Development Issues, 4*(1), 71-81.

Pakistan Bureau of Statistics, (2015). *Pakistan social and living standards for individuals aged 15 and above* . Karachi: Pakistan Bureau of Statistics.

UNESCO Institute of Statistics, (2017). Global Education Montoring Report – UNESDOC Digital Library code ED/GEMR/MRT/2016/PP/27 REV. 4

Stanley, A (2014). Technology that puts the classroom in students' laptop. Retrieved from https://www.theglobeandmail.com/news/national/education/technology-that-puts-the-classroom-in-students-laptops/article21627186/

Titola-Meskanen, T. (2014). A mobile school in digital era: Learning environment ecosystem strategies for challenging locations and extreme poverty contexts. *Proceedings of 6th Annual Architectural Research Symposium*, (pp. 292-304). Finland.

UNESCO. (2015). *Global Monitoring Report 2015: Education for All 2000-2015: Achievements and Challenges.* UNESCO.

UNESCO Institute of Statistics, (2018). *UIS Fact Sheet No 48.* UNESCO.

Williams, F. K. (2005). Inside the one-room schoolhouse: A look at nongraded classrooms from the inside out. *National forum of applied educational research Journal, 18*(3), 2.

Yu, Z. (2015). Indicators of satisfaction in clickers-aided EFL class. *Frontiers in Psychology, 6, 57*

Teaching English with Science: A Result of Content and Language Integrated Learning Approach and Mobile-assisted Inquiry Pedagogy

Apiraporn THUMTATHONG[a], Sasivimol PREMTHAISONG[a], & Niwat SRISAWASDI[b*]
[a]*Demonstration School of Khon Kaen University Nong Khai Campus, Khon Kaen University, Thailand*
[b]*Faculty of Education, Khon Kaen University, Thailand*
*niwsri@kku.ac.th

Abstract: To improve meaningful learning for today's students, Content and Language Integrated Learning (CLIL) approach has been adopted to design positive learning environments in which both content and foreign language can be taught and learned together. This study presents an examination of students' learning motivations, and their perceptions toward the teaching English with Science in Content and Language Integrated Learning (CLIL) approach and Mobile-assisted Inquiry pedagogy through pre-test and post-test design. The study was conducted with 20 eighth grade students in northeastern region of Thailand. They were recruited to participate in the teaching English with Science in Content and Language Integrated Learning (CLIL) approach and Mobile-assisted Inquiry pedagogy. Students were examined their learning motivations and perceptions using 25 and 21 items of 5-points Likert-scales questionnaires. The results revealed that the students increased their learning motivations and perceptions toward the teaching English with Science in Content and Language Integrated Learning (CLIL) approach and Mobile-assisted Inquiry pedagogy. This finding implied that the teaching English with Science toward Content and Language Integrated Learning (CLIL) approach and Mobile-assisted Inquiry pedagogy had an influence on students' learning motivations and their perceptions. This finding suggest that teaching English with Science in Content and Language Integrated Learning (CLIL) approach and Mobile-assisted Inquiry pedagogy could be a promising way of enhancing secondary school students' learning motivations and their perceptions in English with Science class.

Keywords: Teaching English with Science, Content and Language Integrated Learning (CLIL), Mobile Technology Inquiry Based Learning

1. Introduction

With the globalization of an English language as a communication tool and the use of technology is increasing, the characteristics of the learners and teachers are changing. The part of English language teaching in the classroom is changed, the role of teaching is not only focused on the language itself but the teachers should apply English language with the content subjects. To this view, it is called "Content and Language Integrated Learning" (CLIL) approach which widely advertised as a "dual-focused approach" that gives equal attention to language and content (e.g., Mehisto, Marsh, and Frigols, 2008, p.9), CLIL can be described as an educational approach where curricular content is taught through the medium of a foreign language (Dalton-Puffer, 2011). In addition, CLIL as a solution for improving the effectiveness of language learning as well as students' motivation (Scott & Beadle, 2014).

The first CLIL English class in Thailand was occurred in 2006, the cooperation between the Thai Ministry of Education and the British Council in attempting to enhance Thai educational outcomes (MacKenzie, 2008). The first CLIL project showed that the CLIL approach was beneficial for language learning in the Thai context. The students' English skills were improve in this project, and they had positive attitudes toward learning language. Therefore the main part of the teacher in the CLIL classroom was a facilitator who help the students learning both individual and group learning processes to acquire knowledge, potential of perception, communication, and reasoning would be shown to work effectively in CLIL English classroom for Thai students (Dalton-Puffer, 2011).

Recently, mobile devices such as smartphones and tablets PC were changing how teachers teach and students learn. Mobile devices are recognized as an emerging technology with the potential to facilitate teaching and learning strategies (Jeng, Wu, Huang, Tan, & Yang, 2010). In addition, Hwang, Wu, and Ke (2011) reported that the use of an interactive concepts map with mobile learning can promote learning attitude and achievement for students. Furthermore, Hwang and Chang (2011) suggested that integration of mobile devices into learning environments can encourage students' learning interest and their motivation. Moreover, Panjaburee and Srisawasdi (2018) mentioned that the dynamic growth of mobile technology and the spread of the internet, there have created numerous new opportunities for the education in the next decades. To improve the quality of education in developing countries such as Thailand, new tools must be used both in terms of pedagogical methodology and technical devices. Additionally, mobile-assisted inquiry pedagogy were apply in KKU Smart Learning Academy Project, a project that initiated by Khon Kaen University since 2016 to develop knowledge and understanding for students in the three subject fundamentals: Science, Mathematics, and English, basically promote skills by KKU smart learning innovation, media skills, develop skill of information and technology and life skills and profession skills. Thus, to improve meaningful learning for students, the purpose of this study was examining students' learning motivations and their perceptions toward the teaching English with Science in Content and Language Integrated Learning (CLIL) approach and Mobile-assisted Inquiry pedagogy.

2. Literature Review

2.1 Content and Language Integrated Learning (CLIL)

The rapid changes and increases complexity of today's world present new challenges and put new demands on our education system. The role of English language teaching in the classroom is changed, the language may not directly taught but it may be taught English in learning content. At the present, Content and Language Integrated Learning (CLIL) approach is a worldwide increasing phenomenon. During the last decade it had speedily growth especially throughout Europe and Asia, where it was often being established as a special educational approach (Coyle et al., 2010; Yang, 2014). CLIL is a dual-focused approach which additional language is used for the learning and teaching of both content and language (Coyle, Hood, & Marsh, 2010, p.1; Marsh, 2012). In addition, CLIL is a content-driven because it implicated learning content through an additional language (Coyle et al.,2010; Dalton-Puffer & Smit, 2007; Eurydice, 2006) that also associated to culture, environment, and learning (Dalton-Puffer, 2011; Jappinen, 2005) based on connected pedagogies and using contextual methodologies (Coyle et al., 2010). Furthermore, the term of CLIL included a lot of educational approaches of bilingual education and CLIL programs vary as much as European sociolinguistic and socio-educational contexts did. The purpose of teaching and learning process were not only on language but also on content.

Additionally, history and science were two of the subjects which may cause most concern or lack of interest in students in CLIL programs. Essentially, this was due to the amount of contents and the comprehension of chronological events or scientific principles and formulas in a language which differed from the mother tongue. In science content relation, it was essential to take an interest in the areas of "biology, mathematics, Earth's science, physics, astronomy and chemistry" (Linares, 2016, p. 24) are consisted in one subject. Likewise, the subjects in which CLIL is utilized vary across the different situations, but the social studies (e.g. politics, history, and geography) dominate the landscape of bilingual instruction due to historical reasons. It should be examined that a recent trend towards the natural sciences and math in bilingual programs is slowly improvement. In the same way, Science provision through Content and Language Integrated Learning (CLIL) is still rather low. This study, we implemented a newly developed the integration of language and content in scientific English classroom towards Content and Language Integrated Learning (CLIL) approach enhancing both students' learning motivations and students' perceptions.

2.2 Mobile Technology Inquiry Based Learning

At the present time, digital technologies and learning resources have important roles in education, students are digital natives because they have grown up with technologies; it woven into their lives. Mobile devices such as smartphones and tablets PC became more accessible and affordable, mobile devices had become a learning tools with great potential in both classrooms and outdoor learnings. Regarding, Lai and Hwang (2015)'s idea, the blended mobile learning model is used to bridge the traditional, in-class, and outdoor instruction through a set of effective and possible teaching strategies related to mobile and ubiquitous learning, where the two mobile learning modes help learners to connect the content of their textbooks or what they have learned in the traditional instruction to the digital resources and real-world learning targets. Therefore, there are pedagogical possibilities to transform traditional or conventional instruction into innovative and creative learning environment with the technological affordances of mobile technology with regarding particular context of school classes or courses. In particular, research and development on the possible uses and potentialities of mobile technologies were continuously growing in developed countries and some of developing countries, but in Thailand, the implementation of technologies as a pedagogical tool to support inquiry-based learning science was still limited, terms of curriculum coverage and alignment in national curriculum (Srisawasdi, 2015). So that it can bring some challenges to overwhelm the limited practice of mobile and ubiquitous learning in Thailand, a developing country, but the same time it can bring some opportunities too.

Over recent years, the amount of studied about mobile technology have been increased. Many mobile devices were used in-class and outdoor instruction for enhance students' learning and their effect related to attitude and affective goals in different environments. Most of the findings of the studies pointed the added mobile learning is promoting students' affective (e.g. interest, attitudes) and cognitive domain. The findings from the inquiry-based learning with mobility (FILM), comparing the results with hands-on inquiry-based learning (HIL) and traditional learning (TL) showed that better outcomes were achieved and help students to comprehend conceptual understanding about liquid pressure both observable and unobservable level of phenomena (Chaipidech & Srisawasdi, 2017). In addition, Kamalawardhana & Panjaburee (2018) also mentioned the fact that students' perceptions towards the digital game were not influenced by the students' gender and learning style, and their gender learning styles were not significant different with the average of the learning interest levels according to the science learning with the digital game. Furthermore, the study of Answer me for learning: Development of ubiquitous learning system for conducting context-aware learning experience (Meuansechai, Feungchan, & Srisawasdi, 2015; Srisawasdi et al., 2016) showed a positive effect on the improvement of conceptual learning outcomes on sound wave phenomena and also promoting better science motivation. These positive outcomes could be improving students' attitude and enhancing students' conceptual learning with mobile-assisted inquiry pedagogy.

3. Methods

In this study, the researchers conducted an examination students' learning motivations and their perceptions toward teaching English with Science in Content and Language Integrated Learning (CLIL) approach and Mobile-assisted Inquiry pedagogy. The findings of the examination provided us as a basis in order to design a novel learning experience for teaching English with Science.

3.1 Participants

The participants of this study were 20 students who are studying in eighth grade and range of age is between 14 and 15 years in a public school located in northeast region of Thailand. They have no experience yet in learning English with Science toward Content and Language Integrated Learning approach and Mobile-assisted Inquiry pedagogy. In addition, they were taught on the concepts of respiratory system in regular science class before participating in this study.

3.2 Research Instruments

This study used two instruments for determining students' learning motivations and their perceptions toward teaching English with Science in Content and Language Integrated Learning (CLIL) approach

and Mobile-assisted Inquiry pedagogy and questionnaires were administered in pre-test/post-test design. First, the students' motivation questionnaire was developed form Science Motivation Questionnaire consisting of 25 items. This instrument was a Likert-scale putting items with five motivation components, including Intrinsic Motivation (IM) consisting of five items, Career Motivation (CM) consisting of five items, Self-determination (SD) consisting of five items, Self-efficacy (SE) consisting of five items and Grade Motivation (GM) consisting of five items (Glynn et al., 2011). Students answered the questionnaire to each item on a five-point-scales of ranging from "never" (1 point) to "always" (5 point). Second, the students' perception questionnaire consisting of 21 items of 5 points rating scale (Peng et al., 2009) that focusing on two perceptual constructs consisting; (i)learning experience (12 items) and (ii) overall impression (9 items), with a perfect score of 60 and 45 points respectively. For each item, respondents were assigned to rate how much the respondent agree of five scales, from 1-strongly disagree to 5-strongly agree.

3.3 Learning Materials

In this study, technology materials which bring to support learning process are interactive video from Lifesaver application, digital tools for science from iStyle Science Note Science Note application, and interactive presentation from Nearpod application. Students could also use all applications on their mobile devices. First, interactive video from Lifesaver application came with a movie that students could play like a game, it took students into situation where people were choking and students had to make the right choices to save people life. Students learned by doing activities: Did it wrong, and saw the consequences or did it right, and sensed the thrill of saving life. Second, digital tool for science from iStyle Science Note application is used as a digital tool for practitioners to learn and reflect fully the integrated (Integrated STEM Education) through context by focusing on the ability to create a scientific explanation. Students answered an inquiry questions through iStyle Science Note application by using CER methods: claim, evidence and reasoning. Students made their claims in the beginning. Next, students provided evidences supporting their claims. Then students explained how the evidences answering the questions or solving the problems. Third, Nearpod application was an interactive classroom tool that enabling teachers to create engaging learning experiences by providing interactive presentations, collaboration, and real-time assessment tools into one integrated solution. Including interactive features such as quizzes, open-ended questions, videos, polls, and drawing tools. Students joined respiratory system drawing activity through Nearpod application. Then students shared each of the students' drawing to the rest of the class and discussed together.
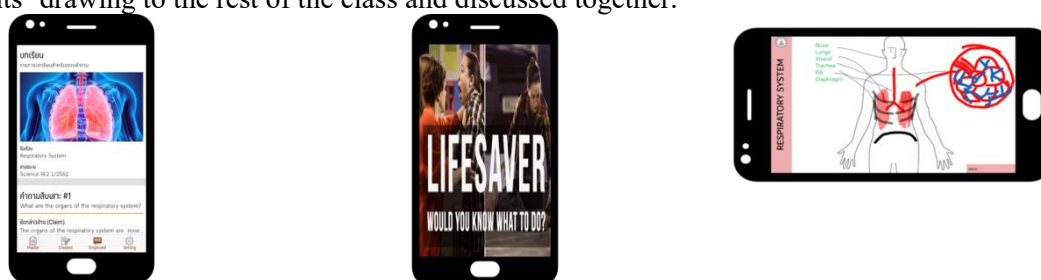
Figure 1. Illustrate of learning materials: Lifesaver, iStyle Science Note, and Nearpod application (Left to right).

3.4 An example of Teaching English with Science: A Result of Content and Language Integrated Learning Approach and Mobile-assisted Inquiry Pedagogy on respiratory system

In presentation, teacher oriented respiratory system concepts and provided interactive video from Lifesaver application about people were choking situation and then students watched video and made the right choices to save people life and recognized the choking first aid knowledge. For practicing, teacher introduced inquiry questions of respiratory system on iStyle Science Note application to the students. Then students answered an inquiry questions by using CER methods: claim, evidence and reasoning. First, students made their claims. Next, students provided evidences supporting their claims. Finally, students explained their reasoning. Classroom assessment, teacher asked students summarizing

the concepts of respiratory system through Nearpod application by drawing and labeling the organs of respiratory system and shared each of the students' drawing to the rest of the class. Finally, teacher discussed with the students about respiratory system and tried to connect the content to choking situation interactive video.

3.5 Data Collection and Analysis

The students were given 15 minutes to fill out questionnaires on students' learning motivations and their perceptions to determining their attitude toward teaching English with Science in Content and Language Integrated Learning (CLIL) approach and Mobile-assisted Inquiry pedagogy. After completing the instruments, they were explored to interact with the assigned of teaching English with Science in Content and Language Integrated Learning (CLIL) approach and Mobile-assisted Inquiry pedagogy. After finishing the learning process, students were administered by the same questionnaires again for 15 minutes to determining their pedagogy attitude. Before interaction with teaching English with Science in Content and Language Integrated Learning (CLIL) approach and Mobile-assisted Inquiry pedagogy, teacher provided an introduction of respiratory system concepts and learning process toward Content and Language Integrated Learning approach and Mobile-assisted Inquiry pedagogy.

Figure 2. Illustrate of Teaching English with Science: A Result of Content and Language Integrated Learning approach and Mobile-assisted Inquiry pedagogy on respiratory system.

The statistical data techniques selected for analyzing students' motivations and perceptions were performed by repeated measure MANOVA in IBM SPSS 19.0 to compare the effect of teaching English with Science in Content and Language Integrated Learning (CLIL) approach and Mobile-assisted Inquiry pedagogy.

4. Results and discussion

4.1 Effect of Teaching English with Science: A Result of Content and Language Integrated Learning Approach and Mobile-assisted Inquiry Pedagogy on students' science motivations

The results for the repeated measures MANOVA from pre- to post- questionnaires were conducted to determine students' learning motivation scores on the five subscales. In Table 1, the repeated measures MANOVA indicted a significant main effect for time (Wilks' lamda = .287, $F_{(1,14)}$ = 4.977, p = .015, partial $\eta^2 = .713$). Regarding the repeated measures MANOVA analysis of students' learning motivation scores on the five subscales, Intrinsic Motivation (IM), Career Motivation (CM), Self-determination (SD), Self-efficacy (SE), Grade Motivation (GM), all five motivation scales positively related together. These results indicated that students have increased their positive motivations towards teaching English with Science in Content and Language Integrated Learning (CLIL) approach and Mobile-assisted Inquiry pedagogy.

Table 1

Description statistics, means and standard deviations for Teaching English with Science: A Result of Content and Language Integrated Learning Approach and Mobile-assisted Inquiry Pedagogy on students' science motivations

Subscale	Pre-test Mean (SD)	Post-test Mean (SD)	F	Sig.	η^2
Intrinsic Motivation (IM)	16.15 (4.21)	20.75 (3.08)	14.588	.002*	.510
Career Motivation (CM)	15.65 (4.11)	20.30 (3.25)	12.305	.003*	.468
Self-determination (SD)	15.35 (3.98)	19.10 (3.48)	10.494	.006*	.428
Self-efficacy (SE)	15.15 (2.94)	18.75 (2.83)	20.128	.001*	.590
Grade Motivation (GM)	16.50 (5.78)	20.55 (3.98)	13.512	.002*	.491

*p < .05

The finding from this result indicated that students have increased their positive learning motivations toward teaching English with Science in Content and Language Integrated Learning (CLIL) approach and Mobile-assisted Inquiry pedagogy. For example, students learned by doing activities through interactive video from Lifesaver application. Students watched and interacted with the video. It took students into the real chocking situation that students made the crucial decisions and learned the essential skills needed to save a life within time limits. Students are motivated to learn when they could use mobile devices in learning. Students have increased their positive learning motivations when they encountered the challenging situations with an enjoyable and comfortable learning environment via mobile devices. It implied that teaching English with Scientific Inquiry in Content and Language Integrated Learning (CLIL) approach toward mobile technologies had an influence on students' learning motivations.

4.2 Effect of Teaching English with Science: A Result of Content and Language Integrated Learning Approach and Mobile-assisted Inquiry Pedagogy on students' perceptions

The results for the repeated measures MANOVA pre- to post- questionnaires were conducted to determine students' perception scores on the two subscales. In Table 2, the repeated measures MANOVA indicted a significant main effect for time (Wilks' lamda = .316, $F_{(1,17)}$ = 17.333, p = .000, partial η^2 = .684). According to the repeated measures MANOVA analysis of students' perception scores on the two subscales, Experience and Impression, all two perception scales positively related together. These results indicated that students increased their positive perceptions toward teaching English with Science in Content and Language Integrated Learning (CLIL) approach via Mobile-assisted Inquiry pedagogy.

Table 2

Description statistics, means and standard deviations for Teaching English with Science: A Result of Content and Language Integrated Learning Approach and Mobile-assisted Inquiry Pedagogy on student's perceptions

Subscale	Pre-test Mean (SD)	Post-test Mean (SD)	F	Sig.	η^2
Experience	29.05 (10.08)	43.50 (6.61)	28.534	.000*	.627
Impression	24.00 (8.35)	33.40 (5.29)	24.29	.000*	.589

*p < .05

The finding from this result indicated that students have increased their positive perceptions toward teaching English with Science in Content and Language Integrated Learning (CLIL) approach and Mobile-assisted Inquiry pedagogy. For example, students interacted with inquiry activities via mobile devices through iStyle Science Note application. Students gathered evidences and explained how the evidences supporting their claims by giving logical reasoning answers. The ways of learning have encouraged the way of students perceiving the information. It implied that teaching English with

Scientific context toward Content and Language Integrated Learning approach and Mobile-assisted Inquiry pedagogy had an effect on students' perceptions.

The analysis from Wilks' lamda test revealed students' learning motivations toward Teaching English with Science in a result of Content and Language Integrated Learning approach and Mobile-Assisted Inquiry pedagogy had post-test scores greater than pre-test scores (Wilks' lamda = .287, $F_{(1,14)}$ = 4.977, p = .015, partial $\eta2$ = .713, p < .05). This evidence indicated that it was significant difference between the pre-test and post-test on student's learning motivations toward teaching English with Science in a result of Content and Language Integrated Learning approach and Mobile-Assisted Inquiry pedagogy. In addition, students' perceptions toward teaching English with Science in a result of Content and Language Integrated Learning approach and Mobile-Assisted Inquiry pedagogy had post-test scores greater than pre-test scores also (Wilks' lamda = .316, $F_{(1,17)}$ = 17.333, p = .000, partial $\eta2$ = .684, p < .05). This result indicated that it was significant difference between the pre-test and post-test on student's perceptions toward the teaching English with Science in a result of Content and Language Integrated Learning approach and Mobile-Assisted Inquiry pedagogy. These mean that when teaching English with Science toward Content and Language Integrated Learning approach and Mobile-Assisted Inquiry pedagogy in respiratory system, there had been a significant impact on students' learning motivations and their perceptions. Regarding the basis of prior research, Merzlykin, Yu, Topolova, and Tron (2018) concluded that using of both AR and CLIL in cloud-based science learning environment helped to develop language and research competencies and to remain motivated in learning Science and English. Therefore CLIL could develop a positive attitude to learning by means of diverse educational activities. Similarly, Garcia and Jurado (2019) mentioned that the students had more motivation when learning history and science subjects within the CLIL (Content and Language Integrated Learning) approach if videos are used, by creating a relaxing and comfortable environment in bilingual educational settings. The use of video was capable of increasing students' interest in the subject and in aiding learning, both of which are important factors in determining motivations, not only CLIL approach could impact on students' motivations but also technology used in the classroom. Furthermore, the students' perceptions of foreign language improvement in their CLIL class was in line with another study language improvement; Lasagabaster and Doiz (2015) pointed out the students' perceptions of language improvement, all age groups acknowledge the improvement of their language proficiency in English because of the CLIL courses when compared to their regular English class. In this study, the significant differences are observed in students' learning motivations and their perceptions toward teaching English with Science in a result of Content and Language Integrated Learning approach and Mobile-Assisted Inquiry pedagogy in pre-test and post-test design. The students' motivations and perceptions were significantly higher scores in all subscales when teaching English with Science in a result of Content and Language Integrated Learning approach and Mobile-Assisted Inquiry pedagogy was followed. Content and Language Integrated Learning approach and Mobile-Assisted Inquiry pedagogy were effective students' learning motivations and their perceptions for the teaching English in Science subject indirectly channels to a target language by means of diverse and challenging educational activities to creating a relaxing and comfortable environment classroom.

5. Conclusion and Future Study

This study reported an impact of Teaching English with Science: A Result of Content and Language Integrated Learning approach and Mobile-assisted Inquiry pedagogy on public school students' learning motivations and their perceptions. The finding revealed successful of increasing all subscales of students' learning motivations and their perceptions toward teaching English with Science in Content and Language Integrated Learning (CLIL) approach and Mobile-assisted Inquiry pedagogy. It implied that teaching English with Scientific Inquiry in Content and Language Integrated Learning (CLIL) approach toward mobile technologies had an effect on students' attitude domains. According to the preliminary findings, students' cognitive domains toward teaching English with Scientific context toward Content and Language Integrated Learning approach and Mobile-assisted Inquiry pedagogy will be carry out in future research.

References

Chaipidech, P., & Srisawasdi, N. (2017). A flipped inquiry-based learning with mobility to improving students' learning performance in science: A comparative study. *Proceedings of the 25th International Conference on Computers in Education*, (pp. 587-594).

Coyle, D. (2011). *Teacher Education and CLIL.* Milan: Unpupblished seminar presented in Milan.

Coyle, D., Hood, P., & Marsh, D. (2010). *CLIL: Content and Language Integrated Learning.* Cambridge, UK: Cambridge University Press.

Dalton-Puffer, C. (2007). *Discourse in Content and Language Integrated Learning (CLIL) Classrooms.* Amsterdam: John Benjamins Publishing Company.

Dalton-Puffer, C. (2011). Content-and-Language Integrated Learning: From Practice to Principles? *Annual Review of Applied Linguistics, 30*(2), 182-204.

Garcia, C. M., & Jurado, B. G. (2019). Motivational Effects of Technological Resources in Bilingual Education Settings. *REMIE Multidisciplinary Journal of Educational Research, 9*(1), 88-116.

Glynn, S. M., Brickman, P., Armstrong, N., & Taasoobshirazi, G. (2011). Science Motivation Questionnaire II: Validation With Science Majors and Nonscience Majors. *Journal of Research in Science Teaching, 48*(10), 1159-1176.

Hwang, G.-J., & Chang, H.-F. (2011). A formative assessment-based mobile learning approach to improving the learning attitudes and achievements of students. *Computers & Education, 56*(4), 1023-1031.

Hwang, G.-J., Wu, P.-H., & Ke, H.-R. (2011). An interactive concept map approach to supporting mobile learning activities for natural science courses. *Computers & Education, 57*(4), 2272-2280.

Jäppinen, A.-K. (2005). Thinking and Content Learning of Mathematics and Science as Cognitional Development in Content and Language Integrated Learning (CLIL): Teaching Through a Foreign Language in Finland. *Language and Education, 19*(2), 148-169.

Jeng, Y.-L., Wu, T.-T., Huang, Y.-M., Tan, Q., & Yang, S. H. (2010). The Add-on Impact of Mobile Applications in Learning Strategies: A Review Study. *Educational Technology & Society, 13*(3), 3-11.

Komalawardhana, N., & Panjaburee, P. (2018). Proposal of personalised mobile game from inquiry-based learning activities perspective: relationships among genders, learning styles, perceptions, and learning interest. *International Journal of Mobile Learning and Organisation, 12*(1), 55-76.

Lai, C.-L., & Hwang, G.-J. (2015). High school teachers' perspectives on applying different mobile learning strategies to science courses: The national mobile learning program in Taiwan. *International Journal of Mobile Learning and Organisation, 9*(2), 124–145.

Lasagabaster, D., Doiz, A., & Sierra, J. M. (2015). Motivation and foreign language learning: From theory to practice. *Revista Espanola de Linguistica Aplicada, 28*(2), 641-646.

Marsh, D. (2012). *CLIL/EMILE: The European Dimension : Actions, Trends and Foresight Potential.* Strasbourg, FR: European Commission.

Mehisto , P., Marsh, D., & Frigols, M. J. (2008). *Uncovering CLIL: Content and Language Integrated Learning in Bilingual and Multilingual Education.* Oxford, UK: Macmillan Education.

Merzlykin, O. V., Yu, I., Topolova, & Tron, V. V. (2018). Developing of Key Competencies by Means of Augmented Reality at CLIL Lessons. *Proceedings of the 1st International Workshop (AREdu 2018)*, (pp. 41-52). Kryvyi Rih, Ukraine.

Meuansechai, K., Feungchan, W., & Srisawasdi, N. (2015). Answer me for learning: Development of ubiquitous learning system for conducting context-aware learning experience. *Proceeding of the 2nd International Conference on Innovations in Education (ICIE2015)* (pp. 315-322). Nakhon Pathom, Thailand: Mahidol University.

Panjaburee, P., & Srisawasdi, N. (2018). The opportunities and challenges of mobile and ubiquitous learning for future schools: A context of Thailand. *Knowledge Management and E-Learning, 10*(4), 485-506.

Peng, H., Chuang, P.-Y., Hwang, G.-J., Chu, H.-C., Wu, T.-T., & Huang, S.-X. (2009). Ubiquitous Performance-support System as Mindtool: A Case Study of Instructional Decision Making and Learning Assistant. *Educational Technology & Society, 12*(1), 107-120.

Scott , D., & Beadle, S. (2014). *Improving the effectiveness of language learning: CLIL and computer assisted.* London, UK: European Commission.

Srisawasdi, N. (2015). Motivating inquiry-based learning through a combination of physical and virtual computer-based laboratory experiments in high school science. In M. J. Urban & D. A. Falvo (Eds.) Improving K-12 STEM Education Outcomes through Technological Integration. In M. J. Falvo, *Improving K-12 STEM Education Outcomes through Technological Integration* (pp. 108-134). Hershey, PA: Information Science Reference.

Yang, W. (2014). Content and language integrated learning next in Asia: evidence of learners' achievement in CLIL education from a Taiwan tertiary degree programme. *International Journal of Bilingual Education and Bilingualism, 18*(4), 361-382.

Foregrounding the prototype design of a generic differentiated assessment tool for mixed-ability classroom

Mas Nida MD KHAMBARI*, Su Luan WONG[b] & Noris MOHD NOROWI[c]
[a]*Faculty of Educational Studies, Universiti Putra Malaysia, Malaysia*
[b]*Center for Academic Development, Universiti Putra Malaysia, Malaysia*
[c]*Faculty of Computer Sciences and Information Technology, Universiti Putra Malaysia, Malaysia*
*khamasnida@upm.edu.my

Abstract: Acknowledging that students vary in terms of their learning abilities – culture, socioeconomic status, gender, motivation, and needs per se, has increased instructors' awareness on mixed-ability classroom. Realizing the need for a personalized learning, many instructors have started to embark on differentiated learning and instruction to capitalize students' ability. However, few research studies have been carried out on differentiated assessments. Differentiated assessments allow teachers to provide opportunities to students with diverse characteristics and backgrounds to prove that they have learned, but at their own pace and ability, though (NSW Education Standards Authority, n.d., Tomlinson, 2001). However, there is no generic, systematic and dedicated tool available yet for instructors to achieve and employ the differentiated assessment. In the context of Universiti Putra Malaysia, current evaluation practices do not provide a precise insight into the true level of CO (Course Outcome) achievement for each student as a standard test/examination is given to students despite their mixed learning ability. Identifying students' learning ability, at the first place, is also a challenging task and the process can take a long time. Therefore, it is timely to create a dedicated tool for differentiated assessment that can address these issues and challenges. Against this background, this research will develop a prototype of a generic, systematic and intelligent tool that has two-fold objectives: (i) the system allows instructors to employ differentiated assessment across courses or programmes, and (ii) it provides opportunities for students to execute tasks or complete an assessment by choice based on their actual ability. This effort is in line with UPM's agenda to expand alternative assessment across courses and programmes.

Keywords: Alternative Assessment, Differentiated Assessment, Mixed Learning Ability

1. Introduction

> Ensuring rock solid clarity about where we want students to end up as a result of a sequence of learning is fundamental to educational success. Remembering that we cannot reach the mind we do not engage ought to be a daily compass for educational planning.
>
> Tomlinson, 2001, p.1

Assessment denotes to "a process of inquiry that integrates multiple sources of evidence, whether test-based or not, to support an interpretation, decision, or action" (Moss, Girard, & Haniford, 2006, p. 152). It has been assumed as an instrument that has the potential to remould the content, process and structure of education making it responsible for causing distress in current education problems (García & Pearson, 2008). Assessment is deemed important as a proof that learning happens, regardless of students' background, characteristics, and ability per se. The aforementioned quote can be translated that assessment is a powerful tool to determine whether an instructor is engaged with the students' minds and whether students are actually learning. It can be concluded that other than getting evidence that students learned, assessment can benefit the assessor (Nasri, Roslan, Sekuan, Abu Bakar, & Puteh,

2010), namely the instructor, to improve his/her pedagogical qualities and enhance his/her scholarship of teaching and learning.

Besides that, assessment most importantly allows instructors to have a better picture of their learners' abilities as it allows continuous interaction between assessment and instruction (Al-mahrooqi & Denman, 2018). One of most crucial parts of being an educator is to assess the students' performance (Metin, 2011; Letina, 2015) as the impact of assessment for many students with diverse backgrounds is onerous (Janisch, Liu, & Akrofi, 2007) because any mismeasurement of their achievement could harm them (Stiggins, 1995). An alternative assessment is a student-centered approach that focuses on the level of the application of knowledge and skills to real life, taking the individual features of the students into consideration (Çaliskan & Kasikçi, 2010). One of the approaches to alternative assessment, namely differentiated assessment, is the approach put forth in this research to address mixed-ability and diverse learning styles. Differentiation stems from beliefs about differences among learners (Tomlinson, 2001, Lawrence-Brown, 2004, Algozzine & Anderson, 2007), like background, characteristics, learning style, needs, preferences, interests, and abilities. The role of instructor, therefore, has amplified in a multitude of forms to address these diversities. As for students, differentiated assessment gives them the opportunity to choose how they want to be assessed and prove that they have actually learned (NSW Education Standards Authority, n.d., Tomlinson, 2001.) It celebrates students' diversity and acknowledges their mixed learning ability.

2. Literature Review

Conventional assessments have been exclusively monopolised the education for centuries (Bensen, 2013). Paris, Lawton, Turner & Roth (1991) suggest that conventional assessment often dissociate the students into different aspects namely ability and expectations that steer them away into disengagement in learning and thinking, and unable to connect to the real world in terms of applying the gained knowledge. Assessment is supposedly meant for monitoring the students' performance to provide the teachers and students themselves the qualitative information about their cognitive functioning so that they will be able to know better their achievement and teachers can use the information to plan instructions (García & Pearson, 2008) rather than simply comparing their quantitative information such as score or rank (Presseisen, Smey-Richman, & Beyer, 1992) with each other. Race, Brown, and Smith (2005) also believe that assessment in learning should be equitable where students with diverse ability will not be discriminated with only one type of standardised assessment so that the scores from the result will genuinely guide them to make amendment from their mistakes as well as help them to realise how well they are developing as learners.

Janisch et al. (2007) suggest that alternative assessment holds the potential to revoke the students' old behaviour expected from the conservative assessment and rectify the autonomous, self-will as well as their decision to choose. Alternative assessment offers flexible and meaningful learning experiences because students are allowed to experiment their own ideas in order to self-evaluate their own learning styles (Gozuyesil & Tanriseven, 2017). Moreover, teachers are able to construct a motivating learning environment that suits most learning styles as well as create an atmosphere where students' self-assessment of their own learning process (Greenstein, 2010). Therefore, it is crucial to build strong foundation of knowledge about alternative assessment methods and the fundamental theory among the educators (Janisch et al., 2007).

Differentiation is defined as "a philosophy that enables teachers to plan strategically in order to reach the needs of the diverse learners in classrooms today to achieve targeted standards" (Gregory & Chapman, 2007, p.2). Differentiation is a responsive reaction by a teacher to the needs of a learner based on their readiness, interests and learning profile as the concept of differentiation is attending to all the learners' needs rather than simply teach these students with typical pattern albeit they are all fundamentally alike (Tomlinson & Allan, 2000). Differentiated assessment is a continuing assessment throughout the course in order to collect the authentic data of students' achievement for the teachers to plan better strategies in instruction. Normally, differentiated assessment is formative in nature (Koshy, 2013). Teachers who are equipped with classroom practises namely differentiated assessment and instruction will be able to learn more about their students' abilities and then capitalise those strengths as a catalyst to learning (Stefanakis, 2011). Differentiated assessments celebrate students' diverse talents and learning styles by offering mechanisms that give options for them to choose from to suit their

diversity in order to develop their skills (Varsavsky & Rayner, 2013). They also add that flexibility in learning, skills growth and types of measurement items undertaken by students are among the advantages offered by differentiated instruction and assessment. This is because all students have the ability to learn at their own pace and rate as intelligence is not a fixed trait (Presseisen et al., 1992). Furthermore, differentiated assessment also helps the students to cultivate divergent and creative thinking (Brown, Bull, & Pendlebury, 2005).

3. Research in Context

Through this research, a web-based system of an intelligent differentiated assessment system, tentatively named as iPacer, will be developed. This system is customizable at the instructor's end, which means almost any instructor can adopt this system and use it for their own customized and personalized differentiated assessment with their students. Not only this web-based system is faster than the traditional method, it also provides differentiation and produces digitalized outputs that are important for data-driven decision. Examples of output include marks, percentages, analysis of each questions (correct/wrong/out of time), number of clues used, time took to answer questions, and the like. The prototype will be tried and tested on a variety of courses whose instructors are willing to partake on the pilot test voluntarily in UPM. Participants would be undergraduate students enrolled in the selected courses and their respective instructors. Data will be collected both quantitatively and qualitatively in the forms of questionnaire, surveys, interviews, and observations in terms of users' feedback on the system's intelligence module and its graphical design, experience, and the approach for differentiated assessment for alternative assessment. The design of the system will be revisited recursively using the R2D2 design strategy (reflective, recursive, design, develop) until a concrete and robust design has been achieved.

At Universiti Putra Malaysia (UPM), instructors have started to embrace alternative assessment method as one of the means to implement innovative pedagogies in instruction. Alternative assessment can be embedded in pedagogies, be it formatively or summatively. In the spirit of embracing differentiated alternative assessment and optimizing students' heterogeneity and mixed-ability, this research aims at designing a systematic web-based tool tentatively named as iPacer. This tool provides tiered levels of assessments that are appropriate for varied types of students, such that they can demonstrate that they *have learned*, regardless of, and according to, their ability. Impeccably, the development and employment of iPacer will increase awareness of alternative assessment among instructors in UPM, thus, augments UPM's effort to promote alternative assessment implementation. iPacer enables UPM to expand alternative assessment throughout courses and programme across the campus, even if the instructor has little knowledge on this assessment method.

iPacer borrows the elements of differentiated instruction, which provides choice and opportunities for students to get appropriate education in general education classrooms (Lawrence-Brown, 2004) and learn according to their abilities. As compared to traditional assessment or tests, differentiated assessment can benefit students ranging from gifted to those with significant disabilities by providing tiered or multi-level assessment system that will adapt to students' answers and responses. Throughout the assessment, additional supports will be employed such that learners will be given hints like brief clues, strategies, and examples as a support. As alternative assessment does not aim to test what the learners remember, but rather to reveal the comprehension and accomplishment of students (Caliskan & Kasikci, 2010), these features are deemed useful to be embedded in the system. However, these hints are optional, where by learners may or may not choose to use it. If the learners chose to use the hint, a slight deduction of marks will be imposed. An analytics on the number of learners use hint at each question will also be reflected in the analytics, which can be used as a pre-cursor for the instructors to identify topics/concepts that are challenging to the learners.

iPacer provides the flexibility to ease the pressure on middle to low ability learners to genuinely learn and engage in depth with their learning instead of memorizing the information (Llewellyn, 2003), as well as benefit advanced leaners with the opportunities to engage in a more challenging and higher order thinking skills tasks. This will, in return, provide a much accurate insight of students' skills and abilities (Dikli, 2003) and reflects instructors' pedagogical strategies. iPacer will implicitly further support the implementation of smart campus by providing analytics of teaching and learning, and therefore helps instructors nourish students as individual learners.

4. Research Objectives

The main objective of this research is to develop a web-based system of a generic systematic tool for differentiated assessment that can benefit instructors who want to embrace differentiated and alternative assessment, although he/she has little knowledge or 'know-how' on this assessment method. Consequently, this tool can maximize students' potential by giving them the opportunity to take an assessment that suits their ability level. This prototype will be built based on the framework of an ADDIE model and supported by the R2D2 model as a strategy to concretize the design and development of the kit.

5. Research Methodology

This research will be carried out in five phases using the ADDIE Framework. Currently, the research has reached the third phase and is continuously being developed.

5.1 First Phase: Analyze. The first phase involves the needs analysis for the development of iPacer. At this stage, researchers had gathered information on the requirements for the development of iPacer and its modules and user manuals. This had involved several discussions among the researchers and interviewing instructors and learners on the key-characteristics that they deemed as important for the development of iPacer.

5.2 Second Phase: Design. The second phase advanced the data and information gathered from the first phase, whereby the design of iPacer and its modules and user manuals were sketched out. This include the adaptive feature and hints, graphical user interface, buttons and icons, audio visuals, clarity of instruction for users (instructors and learners), analytics, and the like.

5.3 Third Phase: Develop. The third phase focused on the development of iPacer prototype and its modules and user manuals. At this stage, the design of the system were revisited recursively using the R2D2 design strategy (reflective, recursive, design, develop) until a concrete and robust design has been achieved and developed.

5.4 Fourth Phase: Implementation. Pilot test will be conducted at the fourth phase. During the implementation, instructors and their respective students will be able to test-run iPacer and its modules and user manuals. This will be conducted on several courses whose instructor willingly participate in the pilot test, regardless of their knowledge about alternative assessment.

5.5 Fifth Phase: Evaluation. The final phase involves evaluation whereby the researchers will collect feedback from the participants (instructors and learners) in terms of their experience with iPacer, namely the graphical user interface, system, modules and manuals, and the like, in terms of their relative advantage, compatibility, complexity and triability (Rogers, 2003).

6. Anticipated Outcome

The researchers anticipate to have an initial web-based apps of a systematic, intelligent and dedicated tool for alternative assessment tentatively named as iPacer that offers differentiated assessment even for instructors who have little knowledge in this methods but want to embrace it. Additionally, iPacer is a solution that offers analytics that provide an insight into learners' ability level and questions' level of difficulty that can be translated as the concepts that learners' struggle to understand. The development of such prototype corresponds with one of UPM's strategic plan in Putra®Global 200, which aims to achieve international level teaching quality and internationalization. This also echoes UPM's vision to become a university of international repute that produces several progressive innovations.

7. Conclusion

It is hoped that the development of iPacer gives a much greater personalized experience to learners (from gifted to significant disabilities) as they are able to prove that they *have learned*. Learners will be able to proceed with the course of their study in such a way that (i) gifted learners are not delayed in their progress lest the instructor has to cater to the needs of intermediate and low ability learners, and (ii) intermediate and low ability learners are not left behind lest the instructor has to fulfil the needs of gifted learners. The feedback obtained from students will also be beneficial for the future improvements of iPacer and student users. In the perspective of differentiated assessment itself, its affective features that inspire learners to achieve their personal best and take initiative in learning enables students' empowerment. The ability to acknowledge and address learners' mixed ability and made it known to the learners, builds a positive learning environment that leads to learners' satisfaction in learning. Furthermore, the spirit of differentiated assessment that allows for do-overs helps learners to improve and grow over the course of their study. This strategy is the ultimate in designed differentiation.

This research is an evidence that Universiti Putra Malaysia supports the aspirations of the Malaysian Education Ministry to become world's leading education system that actively pursue technologies and innovations that fulfil 21st Century learners' needs as well as enables greater personalization of learning experience. The iPacer offers alternative assessment experience in the form of differentiated assessment both for instructors and learners. This system supports the initiative for smart campus by providing analytics that sheds an insight into the typology of learners that exists in UPM. This research will also shed an insight into the scholarship of teaching and learning, especially in helping instructors to identify learners' learning abilities and ways to nourish individual learners.

Acknowledgements

Note

The system is currently being filed for copyright, therefore, images of the system cannot be published at this time until the copyright has been granted.

References

Algozzine, B, & Anderson, K.M. (2007). Tips for Teaching: Differentiating Instruction to Include All Students. Preventing School Failure: Alternative Education for Children and Youth, 51(3), 49- 54.

Al-mahrooqi, R. & Denman, C. (2018) Alternative Assessmsent. In J. I. Liontas (Ed.). TESOL encyclopedia of English language teaching, Edition: 1st, Publisher: John Wiley & Sons, pp.4851-4856.

Bensen, N. (2013). The Chinese Examination Interregnum: Civil Service Testing in China Before and After 'The Century of Humiliation' (Unpublished bachelor dissertation). New College of Florida, Sarasota, United States of America.

Çaliskan, H. & Kasikçi, Y. (2010). The application of traditional and alternative assessment and evaluation tools by teachers in social studies. *Procedia Social and Behaviorial Sciences, 2*(2010), pp. 4152–4156.

Dikli, S. (2003). Assessment at a distance: Traditional vs. alternative assessments. *The Turkish Online Journal of Educational Technology*, *2*(3), pp. 13–19.

García, G. E., & Pearson, P. D. (2008). Chapter 8: Assessment and Diversity. Review of Research in Education, 20(1), 337–391. https://doi.org/10.3102/0091732x020001337

Gozuyesil, E., & Tanriseven, I. (2017). A Meta-Analysis of the Effectiveness of Alternative Assessment Techniques. Eurasian Journal of Educational Research, 70, 37–56. Retrieved from http://ezproxy.lib.uconn.edu/login?url=https://search.ebscohost.com/login.aspx?dire ct=true&db=eric&AN=EJ1150242&site=ehost-live

Greenstein, L. (2010). What teachers really need to know about formative assessment. Alexandria, Virginia USA: ASCD

Gregory, G. H. & Chapman, C. (2007). Differentiated Instructional Strategies. Thousand Oaks, CA: Corwin

Gregory, G. H. & Chapman, C. (2013). One Size Doesn't Fit All. Thousand Oaks, CA: Corwin

Janisch, C., Liu, X., & Akrofi, A. (2007). Implementing alternative assessment: Opportunities and obstacles. Educational Forum, 71(3), 221–230. https://doi.org/10.1080/00131720709335007

Koshy, S. (2013). Differentiated assessment activities : customising to support learning. University of Wollongong Research Online. University of Wollongong in Dubai.

Lawrence-Brown, D. (2004). Differentiated instruction: Inclusive strategies for standard-based learning that benefit the whole class. *American Secondary education 32*(3), pp.34-62

Letina, A. (2015). Application of Traditional and Alternative Assessment in Science and Social Studies Teaching. Croatian Journal of Education -, 17(0), 137–152. https://doi.org/10.15516/cje.v17i0.1496

Llewellyn, D. (2002). Inquiry within: implementing inquiry-based science standards. California: Corwinn Press.

Metin, M. (2011). The examinations of teachers' attitude towards performance assessment with respect to the different variables. Energy Education Science and Technology Part B: Social and Educational Studies, 3(3), 269-284.

Moss, P., Girard, B., & Haniford, L. (2006). Validity in educational assessment. Review of Research in Education, 30, 109-162. http://dx.doi.org/10.3102/0091732X030001109

Nasri, N., Roslan, S. H., Sekuan, M. I, Abu Bakar, K. & Puteh, S. N. (2010). Teachers' Perception on Alternative Assessment. *Procedia Social and Behaviorial Sciences. 7*(C), pp. 37-42.

NSW Education Standards Authority (n.d.) Differentiated Assessment. Retrieved from https://syllabus.nesa.nsw.edu.au/support-materials/differentiated-assessment/

Paris, S. G., Lawton, T. A., Turner, J. C., & Roth, J. L. (1991). Developmental Perspective Achievement. Educational Researcher, 20(5), 12–20.

Presseisen, B. Z., Smey-Richman, B. & Beyer, F. S. (1992). Cognitive Development Through Radical Change : Restructuring Classroom Environments For Students At Risk. In M. Ben-Hur (Ed.). On Feuerstein's Instrumental Enrichment: A Collection. Palatine, IL: IRI Skylight.

Race, P., Brown, S., & Smith, B. (2005). 500 Tips on Assessment. 500 Tips on Assessment (Second). Oxfordshire: RoutledgeFalmer. https://doi.org/10.4324/9780203307359

Stiggins, R. (1995). Assessment Literacy for the 21st century. Phi Delta Kappan, 77(3), 238–245.

Tomlinson, C. A. (2001). Differentiated Instruction in Mixed-Ability Classroom 2nd Ed. ASCD Publication: Alexandra, Virginia.

Varsavsky, C., & Rayner, G. (2013). Strategies that challenge: Exploring the use of differentiated assessment to challenge high-achieving students in large enrolment undergraduate cohorts. Assessment and Evaluation in Higher Education, 38(7), 789–802. https://doi.org/10.1080/02602938.2012.714739

WORKSHOP 9 - Teaching Logical Thinking and Programming Language at Different Levels of Instruction

Fictional publicness：A possible way out of practice in game

Hung-Yang SHEN a*& Jing-Li HONG b**
a *Lecture, Chang Jung Christian University, Taiwan*
b *Assistant Professor, Chang Jung Christian University, Taiwan*
*morefun.tn@gmail.com ;**jlhong@mail.cjcu.edu.tw

Abstract: It can be observed that in recent years, through scientific communication and philosophical practices, various approaches to communicating with the public have emerged. Although these approaches have emphasized bilateral interaction, such as citizen consensus and deliberative democracy, various interactive media that introduce scientific knowledge, and numerous workshops or philosophical cafes that involve open discussion, these forms basically assume active good citizens and emphasize the formation of the public domain. These practices formulate objectiveness through a space of public discussion as well as assume discussion participants to be subjects capable of rational discussion. However, in many public discussions, the definition of social relationships is commonly observed to influence the style of discussion formulated. Whether the form of public discussion also limits the selection of discussion topics is debatable. French scholar Laurent reviewed the citizen conferences on nanotechnology. This question regarding nanotechnology is not only relevant to this topic. It reveals a fundamental question: how do citizens become aware of the relationship between publicness and their rights and obligations? Based on this question, a few concepts in philosophical practices can be referred to, using dialogue-based transformation and Foucault's idea of viewing events as opportunities to inspire public awareness in order to conceive a mechanism that guides the public to engage in public affairs. Specifically, this study intends to explore a possible model that triggers actions through creative thinking. Here, we use gamification to discuss this possible mechanism. Regarding the implications of gamification as a theory of philosophical practices, we must consider whether games can serve as a field of practice for publicness. Thus, we explore whether it is possible to create game events for people to think about public issues, as well as to guide the public to further engage in discussions in the public domain, formulate decisions and actions to be implemented in the real world, and train themselves to be citizens capable of rational discussions.

Keywords: storytelling, philosophical practice, virtual publicness, board games

1. Introduction

Through scientific communication and philosophical practices, various approaches to communicating with the public have emerged in recent years. Although these approaches have emphasized bilateral interaction, such as citizen consensus and deliberative democracy (Lin & Chen, 2003), various interactive media that introduce scientific knowledge, and numerous workshops or philosophical cafes that involve open discussion, these forms basically assume active good citizens and emphasize the formation of the public domain. These practices formulate objectiveness through a space of public discussion as well as assume discussion participants to be subjects capable of rational discussion (Lin, 2005). However, in many public discussions, the definition of social relationships is commonly observed to influence the style of discussion formulated (Lin, 2012). Whether the form of public discussion also limits the selection of discussion topics is debatable. French scholar Laurent reviewed the citizen conferences (la conférence de citoyen) on nanotechnology. Before its promotion of nanotechnology in 2013, France had organized two citizen conferences, one in 2006 and the other in 2009 (Laurent, 2010). Laurent compared these citizen conferences with those held in the United States and performed an analysis. He claimed that such a form of public discussion has three problems: (1) it is difficult to organize such large-scale public discussions; (2) such a form of discussion facilitates the formulation of objective and neutral good citizens but has difficulty reflecting citizens' concrete and real opinions in conference reports; and (3) such conferences are typically funded or organized by

governmental agencies, and thus their standpoints and viewpoints can hardly be severed from governmental agenda (2010). By identifying the problems underlying citizen conferences, Laurent suggested a new type of public mobilization; that is, viewing everyone as a concern of nanotechnology projects (Laurent, 2010). He indicated that nanotechnology is an emerging technology that requires cross-departmental and interdisciplinary collaboration (Inspection générale de l'administration de l'éducation nationale et de la recherche, 2004; Brossais & Panissal, 2013). Because of nanotechnology's characteristics, it cannot be comprehensively included in any traditional fields, which not only influences internal scientific knowledge but also external social aspects. Therefore, from the aspects of public communication and teaching, scholars begin asking the following question: does nanotechnology require a different measure of response (Laurent, 2010; Brossais & Panissal, 2013; Bensaude-Vincent, 2012)?

This question regarding nanotechnology is not only relevant to this topic. It reveals a fundamental question: how do citizens become aware of the relationship between publicness and their rights and obligations? Based on this question, a few concepts in philosophical practices can be referred to, using dialogue-based transformation and Foucault's idea of viewing events as opportunities to inspire public awareness in order to conceive a mechanism that guides the public to engage in public affairs. Specifically, this study intends to create a mechanism that triggers actions through creative thinking. Here, we use gamification to discuss this possible mechanism.

Regarding the implications of gamification as a theory of philosophical practices, we must consider whether games can serve as a field of practice for publicness instead of merely being a teaching aid. Thus, we explore whether it is possible to create game events for people to think about public issues, as well as to guide the public to further engage in discussions in the public domain, formulate decisions and actions to be implemented in the real world, and train themselves to be citizens capable of rational discussions.

2. The process of engagement: storytelling in games

Regarding storytelling in games, the author proposes approaching from the development of digital games. After half a century of development, narrative games have distinguished themselves from conventional goal-driven games to become one of the indicators of contemporary games. Writer Tom Bissell tailored the script for *Gears of War: Judgement*, a game produced by Microsoft Studios. Although players rated this version of the game as inferior to its three previous installments, their feedback primarily focused on an unfavorable interface design that imposes interruptions on a smooth narrative rhythm. Hence, players were still highly interested in the story of the game and were looking forward to a more comprehensive narrative experience (Lee, 2014)

Lee noted that compared with other conventional media, games feature a relatively powerful narrative capacity. Lee used books and movies as objects of comparison to illustrate the advantage of games [1]. According to Lee, when readers read books or newspapers, they only absorb single-dimensional story images. Movies, however, add a second dimension: sensory experiences. In other words, books can be viewed as storytellers, and readers engaging in reading listen to a story that has already happened from a third-person perspective; furthermore, all images of the story can only be imagined by the readers using their imagination. With the assistance of visual and audio effects, movie audiences can adopt a second-person viewpoint to experience the story vividly along with movie characters.

In addition to possessing the characteristics of the two previous types of media, games introduce a third dimension, interactivity, which constitutes its primary advantage. If movies allow participants to view a story from a second-person perspective, games enable participants to directly interact with the story from a first-person perspective. The participants are no longer passive viewers of the story but active participants of the game world who can affect its operation through their behaviors[2].

---

[1] Retrieved from https://hitboxteam.com/designing-game-narrative

[2] The inner process of people interacting with media may be complicated, however Lee here points out what is important for motivations is to decide what is going to happen next, not just to follow the story.

Storytelling in games refers not only to story narratives but also to various story elements, such as operations, dialogues, images, and music, which together enable participants to deeply engage with the games, experience emotional fluctuations, and learn about the framework of the game worlds. Hence, it is not enough to insert a story into a game; story elements must be arranged in appropriate places to allow participants to feel they are part of the game, and are therefore willing to invest time to complete their stories. Only this fulfills the intention of storytelling in games. Bissell (2014) shared a similar point of view in an interview:

A game is basically about the connections among the players, the game world, and the central game mechanic. It is about creating a space where players can get involved in the mechanic, and the way the world responds to the players' engagement should be fun and intriguing, even producing a sense of agency. Based on this, story writing in a game is about creating an ambience and a sense of basic goals. The players can roughly detect the so-called author's intention, but the right of the creator must ultimately be conferred to the players. It applies to all games. I believe good game writing means not getting in the players' way. (Bissell, 2014)

In sum, what is favorable storytelling in games? By comparing gamification and storytelling in games, the author suggests defining it as *a type of storytelling that renders game participants willing to interpret and respond to authors' hidden messages; furthermore, participants would change their understanding after they interact with the messages, and change their behaviors.*[3] In the following subsections, the author takes digital games and board games as examples to elucidate how games and players interact with each other through storytelling.

2.1 Case analysis on storytelling in games: An example of digital game

a. Detention[4]

Detention is an adventure thriller game produced by a Taiwanese Team, Red Candle Games, in 2017. Based on the martial law period in Taiwan (1949–1987), this game centers on female protagonist Rui-Xin Fang and her investigation into why her classmate hung himself. She roamed the campus, which forced her to face hidden secrets in her mind. Adopting the context of white terror (the suppression of political dissidents during Taiwan's martial law period) and presenting Taiwanese folklore, ghost stories, and social topics, this game is filled with consideration for local issues. In addition to viewing reconstructed Taiwanese landscapes in the 1960s, participants are exposed to Taiwanese deities such as the Seventh Lord and the Eighth Lord, Taiwanese customs such as "the rice prepared for the recently deceased and placed by the feet of the deceased," and Taiwanese ballads such as *Wang Chunfeng*. In this game, players control Fang to fight against various demons and monsters as the story unfolds to reveal the truth. However, behind these scenes of insanity lies the protagonist's prison of the mind as well as the sadness of the time.

The producer of *Detention*, Yao Shun-Ting, expressed that this game was first inspired by George Orwell's *1984*, and was intended to be a dystopian work based on a Taiwanese context. In addition to representing the ambience of omnipotent suspicion and fear during the white terror period, Yao included campus bullying, family problems, and romantic relationships in the game, topics that have existed throughout history. As the plot unfolds, these topics are presented to players sequentially in the form of riddles, forcing them to reflect upon whether they have unintentionally inflicted harm on others or been subjected to such harm themselves, all while simultaneously solving the riddles. As the game's English name suggests, detention not only refers to being detained at the school but also to being detained in past wounds.

Detention received great attention domestically and abroad after its official launch. In addition to being played on the channels of some Western streamers, a novel and a movie of the game will be released, creating numerous opportunities to discuss the history of that time, which used to be a forbidden topic. Therefore, with appropriate storytelling techniques, a game can exert influence on the real world and receive profound feedback.

2.2 Case analysis on storytelling in games: Examples of board games

[3] The texts are italicized by the author.
[4] Retrieved from https://redcandlegames.com/detention

a. Trains[5]

Game designer Brenda Brathwaite mentioned in her speech that "the mechanic is the message."[6] In other words, through the rules and interactive process of the game, players can experience the cultural reflections the designer imbedded in the game. She designed six games as a series to explore the dark history of human culture. Here, the author discusses her most famous game, *Trains*.

In this game, each player finds a typewriter placed in front them, on which game rules are written. For each round, the players must throw a die to decide the number of people who embark on a train. They then must stuff yellow dolls whose size is larger than the train car's entrance into the car, and ensure that the train is heading toward its destination. In this game, the designer incorporated means for the players to disrupt their competitors' plans, such as causing derailment of other players' trains or taking out their yellow dolls. All players who actually played the game cheered when they hindered their competitors' progress. Amid this pleasant competition, when the trains arrived at the terminal station and the name of the station was revealed, the players' mood quickly turned to embarrassment or even anger because the train stop read Auschwitz. At that moment, the players immediately grasped the reality behind this game.

Brathwaite wished to use this game to have players relive the history of the German army blindly participating in the massacre of the Jews under the instruction of Hitler. Brathwaite was diligent about accessory design. For example, she presented a replica of a Nazi typewriter, the table covered with shattered glass, and the yellow dolls that each represented tens of thousands of Jews. The players simply followed the instructions on the typewriter, happily and unknowingly sending Jews to concentration camps such as Auschwitz. The game hinted that the accomplices of that massacre might have also treated reality as a game according to a similar mentality. Therefore, European players who were familiar with this cruel episode in history were naturally ashamed of the truth, and even left the game in anger.

The author considered that although such a design has its own story, the approach of turning the story in a game is not entirely satisfactory. In this game, players experience emotional fluctuations and participate in the unfolding of the event. However, they cannot understand the cause of that event, nor can they conceive methods to change fate. The author is aware of the major challenge that games, or more specifically educational games, face in simultaneously presenting details and the overall context. In addition to presenting the consequences, such games should inform participants of the causes, which can then serve as a basis for changing the status quo.

b. De Vulgari Eloquentia[7]

The aforementioned examples have demonstrated two key points of game design: (a) the participants' control of the game, and (b) the participants' motivation to improve game performance. In *Trains*, the first problem is the luck involved in throwing dice; participants cannot make strategic plans, leaving them with no sense of control, simply becoming agents of the dice. Second, the ending has been written, and its purpose is to create an emotional gap at the moment the station's name is revealed; however, the game does not include possibilities for its participants to revert this sad ending.

De Vulgari Eloquentia, a game designed by the Italian designer Mario Papini and named after Dante's thesis, describes the process of dialect unification in Italy in late Middle Ages. Players assume the role of businessmen in the game. Various regions in Italy spoke different dialects at that time. For the purpose of trading with other businessmen in different regions, businessmen spoke a common language designated as the businessmen's language. Therefore, players must travel between regions of Italy marked with different colors (representing different dialects) to produce a colorless collection of proverbs by the end of the game. The game ends when the Pope dies, after which Italy no longer has language barriers between regions.

---

[5] Retrieved from http://brenda.games/

[6] Retrieved from https: www.ted.com/talks/brenda_brathwaite_gaming_for_understanding

[7] Retrieved from https://www.giochix.it/scheda.php?item=2610&lingua=1

After participating in this game, the author considers that *De Vulgari Eloquentia* avoids the disadvantages of *Trains* by its design:

(a) No dice throwing is involved. Each player can act five times, and players must select the moves they wish to make and the priorities of these moves. Accordingly, the game does not include uncontrollable tools; the progress of the game is only affected by individual choices and other players' decisions. Such a design method prevents players from attributing the gaming result to luck. From beginning to end, each step is based on the players' choices; hence, the actions the players take determine the responsibilities they must shoulder.

(b) Apart from reduced randomness, European games differ from American ones in the manner of interaction among players. In *Monopoly* and *Trains*, players can all snatch resources from their competitors or cause direct harm to their competitors' status quo. However, the European game emphasizes interaction with the world. *De Vulgari Eloquentia* does not incorporate any means of attacking; instead, the game allows players to do their best, competing to create their own scoring engine in the shortest time. That is, interaction replaces conflicts.

(c) Following on from the previous point, because no score- or resource-snatching mechanisms are provided in *De Vulgari Eloquentia*, each player sees their scores increase over rounds as well as differences in increased scores of other players, which are the results of different choices. Therefore, players can understand the possibilities as well as increases or decreases in efficacy generated by dissimilar decisions. Because of positive interaction and cultural beauty, players will be willing to participate in the game again and can expect to perform more satisfactorily.

Based on these points, the author claims that a good game not only creates a sense of achievement in its players but also triggers them to actively discuss the game elements and attempt to improve their performance by playing again. Imagine what could happen if we incorporated global issues that require immediate resolution into the game world and have players explore and develop resolutions.

3. From board games to changing the world

The author hence offers a developing model of game-narrative interactions. The scope of games is constantly being redefined. From simple mechanic-driven games to fictional spaces based on a specific historical context, and further to designs based on real history in the contemporary period, games have evolved to allow players to experience intangible reality. From the perspective of media development, the dynamic relationship among games, players, and the world is illustrated in Fig. 1 as follows:
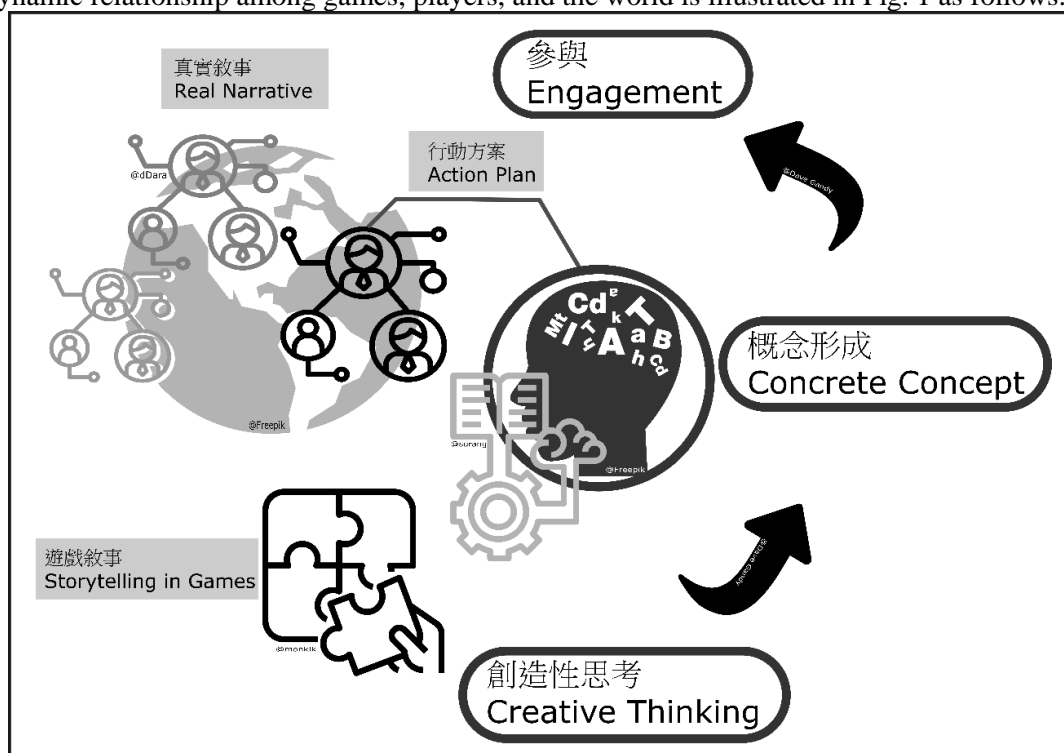

Fig. 1: (*This figure was arranged and drawn by author)

When the media of reception develops from book to game, players are allowed to actively participate in the game world and experience real-time feedback about their choices. When elements of the real world are presented in a game, players can experience the influence of their behaviors on the world as the game unfolds, and the game will inexplicitly inform players of the actual events that took place and the causes behind them. However, the ending of a game is not always fixed. Players have a chance to prevent tragedy from occurring by making a different choice.

The greatest benefit of designers rebuilding part of the real world in games is that participants can become aware of the possibility to make the world a better place through making different choices. For example, when playing *De Vulgari Eloquentia*, players can experience how businessmen and priests became key figures in promoting dialect unification in Italy. Players in this game do not hurt one another; instead, they use all their might to interact with the world, through which they become a better self.

In addition to *De Vulgari Eloquentia*, many other European games have incorporated historical contexts. For instance, *London*[8] by Martin Wallace adopts as its context the construction of a new London after the Great Fire of London of 1666, allowing participants to understand the modernization of London over the course of 300 years. The game echoes *London Rising*, a book by Leo Hollis. The book describes five key people who modernized London and indirectly made it the benchmark of modernization. Similar to players in the game, these people did not directly change the appearance of London but promoted the evolution of London behind the scenes, and even created many other possible London cities by playing the game.

Because of the restraints of digital games, the author considers that the most optimal path for the design of games is to adopt the experience of storytelling in digital games, as well as to employ the form of board games without fixed endings.

4. Conclusion

According to the aforementioned discussion, the aims of this study are to explore a way out for games to serve as a medium between truth (knowledge) and the public, as well as formulate public awareness of public issues. Games are not only treated as a medium for becoming familiar with topics, nor a warm-up activity before entering public communication, but are expected to become an event in themselves. This is because in an event, the following can be found:

In the context of interactive relationships and multiple strategies, how does the inseparableness between knowledge and power lead to uniqueness, which is determined according to their acceptable conditions, and also leads to certain possible, open, indecisive, reversible, and dislocated fields? Which of these fields renders such uniqueness fragile and temporary, and turn such effects into events and unquestionable events? (Foucault, 1978)

By designing a mechanic for experiencing events, analyzing the interactive relationship and multiple strategies the players have experienced, game designers can introduce the discussion of public issues. Participants would observe that such complexity cannot be left completely to experts for resolution, as well as that each citizen occupies a strategic place that can affect the scope to which this event spreads. In the following subsections, we review current game mechanics in Taiwan to locate and create a new game mechanic that satisfies the expected output of this project.

Habermas distinguished between instrumental rationality and communicative rationality (Dews, 1998). He claimed that unlike instrumental rationality, which was premised upon individual benefits, communicative rationality is centered on respect and employs discussion to formulate a consensus. Ogawa (2017) indicated three necessary principles of communicative rationality: participants talk in a natural language, they are honest, and they are in equal positions. These three principles can be practiced favorably in games as follows:

a. The participants must follow the same rules for the game.
b. The participants must face the challenges in the game honestly.
c. The participants must all compete fairly in the game.

Through appropriate translation, games can be regarded as the terms indicated by Habermas (1984) "ideal speech situation." As players continue to test strategies to determine the most satisfactory

---

[8] Retrieved from https://ospreypublishing.com/london

one, they supposedly also transform the society into its most satisfactory state, thereby allowing it to step into a more favorable future.

In addition to the provision of an ideal speech situation, the author considered that the role of the game participants cannot be overlooked. The solutions Habermas proposed for social dilemmas are rooted in a collective society; hence, the achievement of this goal requires the rational capacity of individuals. From the perspective of participants' behavior, each choice that participants make changes the appearance of the game world (society). When participants learn that their choices engender unfavorable results for society, they can adjust their strategies in a timely manner and ensure the same mistakes are not repeated. If each selection is considered an improvement of ideal self-status, then the behavior of the participants in the game becomes a process of self-betterment. In European games, participants also start from nothing. Through continual interactions between individual choices and feedback from society, the participants finally formulate a perfect self and attain balance with the society.

References

Bensaude-Vincent B. (2012). Nanotechnology: a new regime for the public in science ?, Scientlae studia, 10, Special Issue, pp. 85-94.

Brossais E. & Panissal N. (2013). Nouvelles formes d'interaction science-société au collège : le cas de l'éducation citoyenne aux nanotechnologies, Les doissiers des sciences de l'éducation, 29, pp. 81-108.

Bissell, Tom. (2013). Essays on Grantland. Retrieved from http://grantland.com/contributors/tom-bissell/#.

Bruno Faitutti, (2018). Let's Draft, Boardgame Design by Bruno Faitutti Website, http://faidutti.com/blog/.

Dews, Peter. (1998). Communicative rationality, Routledge Encyclopedia of Philosophy, Taylor and Francis, https://www.rep.routledge.com/articles/thematic/communicative-rationality/v-1. doi:10.4324/9780415249126-N007-1.

Foucault, M. (1978/1990). Qu'est-ce que la critique?, Paris: Bulletin de la société française de philosophie.

Huotari, K., & Hamari, J. (2012). Defining Gamification - A Service Marketing Perspective. Proceedings of the 16th International Academic MindTrek Conference, Tampere, Finland.

Habermas, Jürgen (1984). Theory of Communicative Action, Volume One: Reason and the Rationalization of Society. Translated by Thomas A. McCarthy. Boston, Mass.: Beacon Press.

IGAENR, Le financement des nanotechnologies et des nanoscience : http://media.education.gouv.fr/file/39/0/6390.pdf, 2004.

Laurent, B. (2010). Les politiques des nanotechnologies : Pour un traitement démocratique d'une science émergente, Paris: Charles Léopold Mayer.

Leo Hollis. (2008). London Rising: The Men Who Made Modern London. FL: Walker & Company.

Terrence Lee. (2013). Designing game narrative. HITBOX Team. Retrieved from http://hitboxteam.com/designing-game-narrative

Stéphane Chauvier. (2007). Qu'est-ce qu'un jeu? Paris: Vrin.

伯爾納德‧舒茲(Bernard Suits)，胡天玫、周育萍譯，(2016)。《蚱蜢：遊戲、生命與烏托邦》(The Grasshopper: Games, Life, and Utopia)。台北：心靈工坊。

林火旺(Huo-Wang, LIN)（2005）。審議民主與公民養成。國立臺灣大學哲學論評，(29)，99-143。doi:10.6276/NTUPR.2005.03.(29).03

林國明、陳東升(Kuo-Ming, LIN & Dung-Sheng, CHEN) (2003)。公民會議與審議民主：全民健保的公民參與經驗。台灣社會學，6，61-118。

林祐聖(Yu-Sheng, LIN)（2012）。公共審議中討論風格的建構：社會關係與社會技能的影響。臺灣社會學刊，(51)，63-114。doi:10.6786/TJS.201212.0063

李立凡(Li-Fan, LEE)，(2014)。論「遊戲敘事學」：從 Tom Bissell 兩則訪談說起. U-ACG線上論壇。Retrieved from https://www.u-acg.com/archives/619.

小川仁志(Hitoshi OGAWA)，張育銘、趙誼譯，(2017)。《一口氣讀懂哲學家們：從30位哲學家生平、學說、名言，自我省察，探究自我，破解生活、職場、人際關係的迷思！》。台北：美藝學苑社。

Argument Analyzer: Visualizing and explaining logical arguments in context

John BLAKE
Center for Language Research, University of Aizu, Japan
jblake@u-aizu.ac.jp

Abstract: This paper describes the design, development and preliminary evaluation of a visualization tool, the Argument Analyzer. This interactive online tool aims to help students understand applied logic by visualizing logical features in context. Multimodal bilingual explanations can be revealed on demand using toggle buttons. The two main sets of digital artefacts, namely annotated texts and explanations were student-created. Users can view preloaded texts or submit their own texts that have been annotated according to the guidelines. Users decide which logical features to reveal and hide. On revealing logical features, users can see more information by hovering over the visualization. When users want a fuller explanation, they can click on the hyperlinks to multimodal explanations. Thus, users are able to direct their own learning, and follow their own learning path of discovery and exploration. Preliminary evaluations of accuracy, usability and efficacy are positive.

Keywords: teaching logical thinking, visualization, argumentation, digital artefacts

1. Introduction

Japanese students of applied logic in a credit-bearing university course display difficulties analyzing arguments logically and critically. In an elective course named *Logic and Language* learners develop their ability to apply logical and critical thinking. Some of the participants have already taken a foundation course in logic and/or a course on logic for programming. The course is delivered in English, but some examples are provided in Japanese as well. This course differs from the other two logic courses in that the focus is on the application of logic to natural language texts written in English.

The credits from this course count as part of the English language graduation requirement, but the course focuses on teaching logic through English rather than English through logic. This course consists of approximately twenty-four teaching hours and is delivered over an eight-week quarter. The course is divided into three blocks: identifying arguments, identifying fallacies and evaluating arguments. Most of the logical concepts and terminology are introduced in the first half of the course, creating a steep learning curve that tapers off as the focus moves to application rather than acquisition, allowing students to consolidate and extend their learning.

In most classes delivered in English within the Center for Language Research at the University of Aizu, Japanese students appear to focus on the grammar and meaning of individual English words rather than considering the real-world meaning. The question below illustrates the problem. This question was presented as part of a reading quiz to three classes of computer science majors taking compulsory English language classes.

Question:
 Why do polar bears eat penguins?
Relevant extract from longer text:
 Due to global warming, polar bears rely on penguins as their primary source of food.

Of the 92 student responses, not one pointed out that polar bears do not eat penguins, which should be obvious because they live in different hemispheres. The Japanese term for polar bear is *hokkyokukuma*, which directly translates to "arctic bear" making their habitat even more obvious. Almost all students, however, gave "global warming" as the answer. This apparent uncritical acceptance of information is worrying, particularly given the rapid growth of fake news (Lazer *et al.*

2018) and the rise in the reliance of algorithmic-curated social media news feeds (DeVito, 2017) and a growing preference for opiniated rather than objective news (Marchi, 2012).

To analyze arguments, readers need to be able to pinpoint conclusions and related evidence, and evaluate the truth value and validity. Evaluation of validity necessitates knowledge of the five forms of valid arguments and at least nine formal fallacies that invalidate arguments. In addition, readers need to be able to identify whether deductive, inductive or abductive reasoning is used to discriminate sound and cogent conclusions from unsound or uncogent conclusions. Moreover, at the bare minimum, students are expected to understand twenty-four informal fallacies that may impinge on arguments. Language difficulties exacerbate the problem of identifying and explaining arguments as students study in their second language.

An extensive search of the Internet and published literature failed to discover any interactive pedagogic online tool that visualizes logical arguments in context. There are a number of teaching-focussed websites that explain example arguments, but none of these are interactive. Cutting-edge research automatically identifying claims and evidence within texts (Rinott *et al.*, 2015), causality relations (Dasgupta, Saha, Dey and Naskar, 2018) and so forth exist, but none are deployed online or designed for pedagogic purposes.

To fill this niche and ameliorate the difficulties faced, an IT artefact (Oates, 2005) was designed and created by the author. The Argument Analyzer was developed to provide contextualised examples of arguments. The Argument Analyzer detects annotated arguments and executes scripts to control website behaviour, revealing emoticons, colour-coded labels and displaying further details on demand. Links are also provided to bilingual multimodal explanations created by previous cohorts of students.

This paper is organized as follows. The following section details the creation of the digital artefacts, namely the database of annotated argument texts and the explanatory materials available in text, image, audio and video formats. Section three describes the design and development stages of the software. Section four describes and evaluates the beta version of the Argument Analyzer while the final section identifies future work.

2. Digital artefact creation

The first set of digital artefacts comprises annotated arguments. These are plain text files containing an argument that is annotated for logical features using html-like tags. The second set of digital artefacts consists of multimodal explanations. These are stored in plain text, rich text, image, audio or video files depending on the specific content. Both sets of digital artefacts are created by students. The final artefact is the delivery system, i.e. the backend and the frontend of the web-based interface. The student-created artefacts are described in this section. The software development is described in the following section.

2.1 Annotated arguments

One cohort of students taking the elective course created a database of 400 annotated arguments as part of their coursework. The tailormade annotation tagset comprises 57 items divided into five broad categories, namely arguments, reasoning, formal fallacies, informal fallacies and causality. These tags were selected for pedagogic purposes rather than to adhere rigidly to a particular school of logical thought. Arguments includes elements (e.g. premises, conclusions), valid propositional forms and assumptions. Three types of reasoning are currently included: deductive, inductive and abductive. Formal fallacies are divided into three subcategories: invalid arguments, syllogistic fallacies and invalid references. Informal fallacies are broadly divided into red herring fallacies, *non causa pro causa*, vagueness and ambiguity, and weak analogies. The final category of causality comprises proximal, distal, root, common, rival, sufficient and necessary causes.

An indicative extract of the complete tagset is given in Table 1. Each item within a specific category is assigned an opening and closing tag. The content of the tags uses abbreviations of the item and relevant category to make it easier for students to use. Students use the text editor of their choice to insert tags. Each annotated text was manually double checked and added to a database. The database consists of letters, teaching texts, extracts from research articles and books. The majority of the texts, however, are letters to editors. This genre was chosen because of the high incidence of argumentation

and the use of fallacies to support claims. Figure 1 shows an extract of the annotation coding document, showing some of the annotation tags that can be inserted into texts containing fallacies.

Table 5
Extract of Annotation Coding Document

Category	Item	Opening tag	Comment displayed on hover
Invalid argument	Affirming the consequent	< IA-AC>	Invalid argument: affirming the consequent
	Denying the antecedent	< IA-AD>	Invalid argument: denying the antecedent
	Undistributed middle term	< IA-UM>	Invalid argument: undistributed middle term
Syllogistic fallacies	Fallacy of four terms	<SF-fourterms>	Syllogistic fallacy: fallacy of four terms
	Illicit major	<SF-major>	Syllogistic fallacy: illicit major
	Illicit minor	<SF-minor>	Syllogistic fallacy: illicit minor
	Affirming a disjunct	<SF-disjunct>	Syllogistic fallacy: affirming a disjunct

<inductive></inductive><conc>Professor X is an efficient and effective teacher.</conc> <prem> <redherr>All his students enjoy his classes </redherr>according to the feedback given on the student feedback questionnaires.</prem><prem><misstat>Every student who attended the course in full received a grade A which is testimony of his expertise in teaching.</misstat> </prem> <prem><redherr>The professor not only holds a doctorate in physics but is also a polyglot and a polymath.</redherr></prem> <prem><bandwagon>His course is always popular with students.</bandwagon></prem> <prem><misstat>Every course offered in the previous two years has seen enrolments meeting or exceeding the minimum number of students.</misstat></prem> <prem><redher>To ensure he has enough energy, he always brings a cup of coffee to the classroom.</redherr></prem> This is yet more evidence of his dedication to his students. <prem><bandwagon>Finally, the Facebook page of Professor X has received thousands of "Likes", a clear indication of votes of confidence in his teaching.</bandwagon></prem>

Figure 1. Screenshot of submission interface of the Argument analyzer

2.2 Multimodal explanations

Interviews with focus groups of students revealed the demand for an online tool showing logical features in example texts accompanied by explanations. Preferences were expressed for video and audio rather than textual explanations, which is in line with Hafner, Chik and Jones (2015). Teacher-led creation of videos was an option; but following Chewar (2016), student-created materials were selected. The decision to enable students to create digital materials for future cohorts stems from the Latin proverb *Docendo discimus*, i.e. the best way to learn is to teach. Typically, this is realized synchronously in class, but given the current ease of creating digital artefacts using smart phones, teaching can now be conducted asynchronously online.

Ohashi *et al.* (2018) provide a detailed comparison of methods for educational video production, and noted that when used linearly throughout a course, there was initial enthusiasm, which waned as the course progressed. This tool, however, does not present videos in a specific order, but users select the video that is of relevance as and when they need it. Hansch *et al.* (2015) detailed a typology of eighteen types of videos including talking head, conversation, screencast, webcam capture and green screen. The videos created so far are presentation slides with voice-over.

Students created audio and video explanations in English and Japanese for sixty technical terms as part of their coursework. Over two hundred explanations were contributed, from which the best quality versions were selected for inclusion.

3. Software development

A requirements analysis audit was conducted to determine the operational specifications for this project. The audit comprised focus group interviews and observations. Focus group interviews were held with ten students taking the *Language and Logic* elective course. Students on the same course were observed analyzing both paper-based and electronic texts. In both cases students made extensive use of Google Translate, Weblio (a popular online Japanese-English dictionary) and Google images. Students frequently highlighted the paper-based texts using different colours for conclusions and premises. Students also wrote annotations in the margins of paper-based texts to indicate the types of reasoning (inductive or deductive), presence of assumptions. Fallacy types (formal or informal), fallacy classes (e.g. causal fallacies) or names of fallacies (e.g. *post hoc ergo propter hoc*) were labelled. In short, students hoped to see and immediately understand rather than struggle to decode spoken or written text. This explains the use of Google images when students were looking up unknown terms. A list of the required functionalities and the necessary operations for visualizing logic were created. Potential difficulties and obstacles were anticipated, and ways to overcome or remove them were determined. A software requirement specification (SRS) was drawn up. This included detailed information of the technical terms and concepts that students struggled with, including pairs of terms that students had problems discriminating between. Such pairs included: inductive/abductive, illicit major/minor, and affirming the consequent/antecedent.

Based on the SRS the specific architecture to achieve the required functionalities was considered. Google cloud server was selected to store and deliver the database of annotated texts, JavaScript used to highlight the logical features and links to the digital explanations were embedded. A graphical user interface was created to display the annotated texts. Users can select to input their own annotated text or view pre-loaded texts housed in the cloud database. Figure 2 shows the interface that users use to submit their own texts.

Argument visualizer

Interactively explore the arguments within texts..

| Arguments | Reasoning | Formal fallacies | Informal fallacies | Causality |

Identifies types of reasoning

Paste text here and click button.
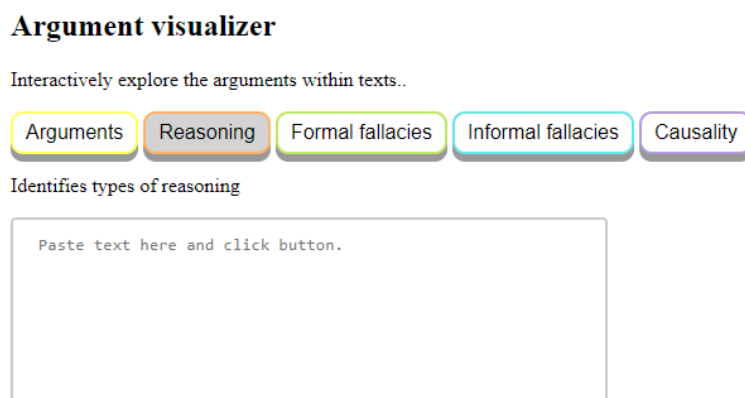
Figure 2: Screenshot of input interface for users to submit annotated texts

An agile approach was adopted in which usability tests were conducted *ad hoc* to gain early feedback on the user interface and user experience. The subjects in the usability tests were all Japanese speakers, who varied greatly in their knowledge of English and of logic. The feedback received informed the final design of this tool.

Five toggle buttons are used to hide and reveal logical features using rule-based parsing, giving learners full control of their learning, encouraging learner direction and discovery-based learning. The functionality of each button is explained on hover, and users click to reveal whichever logical aspects they want visualized. On click, a regular expression searches the annotations and raw text, and on matching, the relevant emoticon and label are displayed inline as shown in Figure 3. When users hover their cursor over the emoticon, explanations are displayed. Each subcategory of logical terms is assigned a different colour and emoticon. Hyperlinks to audio and video explanations in both Japanese and English are provided.

Figure 3: Screenshot of extract of output of the Argument analyzer

The Argument Analyzer is used extensively throughout the *Logic and language* course. In the first half of the course students primarily use the tool to view pre-loaded texts while in the latter half, students also use the submission system for annotated texts to complete their coursework and final assignment.

4. Preliminary evaluation

This tool transforms a plain black-and-white text into an interactive multi-coloured text with embedded multimedia explanations. Computer science majors taking an elective course, *Logic and Language,* were able to interact with annotated texts, clicking on toggle buttons to hide and show particular logic features and use the on-hover function to reveal further details. Users are, therefore, able to scaffold their own learning by deciding which features to reveal and which explanations to read, listen to or watch. Teachers can use this tool for discovery-based, inductive or deductive learning activities.

The accuracy of the Argument Analyzer is contingent on the accuracy of both the regular expressions and the annotations in the texts. All the regular expressions are simple, each matching only one specific annotation tag. There were no occurrences of false positive or false negative results and so the accuracy rate for the regular expressions is 100%. The accuracy of the annotated texts is more difficult to determine. The meaning of any text is negotiated between the writer and the reader, who may not share the same background knowledge nor make the same assumptions. The context (i.e. shared cultural environment) and cotext (i.e. words occurring before and after annotations) may also affect the meaning. The ambiguity that is pervasive in all natural languages adds a further dimension of complexity. The pedagogic purpose of the annotations also needs to be taken into account. The aim is to enable students to practice the application of the logical concepts taught. Most initial annotations were completed by students. which were double-checked and amended where necessary by the author.

The efficacy of the Argument Analyzer has not yet been empirically tested, but the results of focus group usability tests undertaken during the software development phase were positive. In addition, on the standard student feedback questionnaires administered by the institution at the end of course, the usefulness of the visualizer was mentioned by a number of students.

This is the first beta release of the Argument Analyzer and no doubt there are numerous areas in which further improvements can be made in terms of software design, accuracy of annotated texts, quality and quantity of explanatory materials and the associated learning efficacy. Given that no comparable tool exists, the Argument Analyzer is leading the way towards providing interactive online learning materials that harness language visualization and multimodality to help students learn logic.

Future cohorts of students now have access to a large bank of practice materials that they can use anywhere, anytime.

5. Future work

More textual and multimedia explanations will be added by the next cohort of users. In terms of effect on learning, a small-scale empirical or experimental study could be used to evaluate its efficacy. Where feasible, rule-based parsing of raw rather than annotated text will be used to reduce reliance on manual annotations.

References

Chewar, C., and Matthews S. J. (2016). Lights, Camera Action! Video Deliverables for Programming Projects. *Journal of Computing Sciences in Colleges, 31*(3), 8–17.

Dasgupta, T., Saha, R., Dey, L., & Naskar, A. (2018, July). Automatic Extraction of Causal Relations from Text using Linguistically Informed Deep Neural Networks. In *Proceedings of the 19th Annual SIGdial Meeting on Discourse and Dialogue (pp. 306–316).* Association for Computational Linguistics.

DeVito, M. A. (2017). From editors to algorithms: A values-based approach to understanding story selection in the Facebook news feed. *Digital Journalism*, *5*(6), 753–773.

Hafner, C. A., Chik, A., and Jones, R. H. (2015). Digital literacies and language learning. *Language Learning and Technology, 19*(3), 1–7.

Hansch, A., Hillers, L., McCnachie, K., Newman, C., Schmidt, P., and Schidhauer, T. 2015. *Top MOOC Research Project: The Role of Video in Online Learning: Findings From the Field and Critical Reflections*. https://www.hiig.de/wp-content/uploads/2015/02/TopMOOC_Final-Paper.pdf

Lazer, D. M., Baum, M. A., Benkler, Y., Berinsky, A. J., Greenhill, K. M., Menczer, F., ... & Schudson, M. (2018). The science of fake news. *Science*, *359*(6380), 1094–1096.

Marchi, R. (2012). With Facebook, blogs, and fake news, teens reject journalistic "objectivity". *Journal of Communication Inquiry*, *36*(3), 246–262.

Oates, B. J. (2005). Design and Creation. Researching Information Systems and Computing. Sage Publications.

Ohashi, Y., Katsumata, M., Nakamura, K., Hashiura, H., Matsuura, T., Ishihara, J., ... & Tsujimura, Y. (2019). Comparison of Educational Video Production Methods for Students Studying Computer Programming. In *Proceedings of the 2019 7th International Conference on Information and Education Technology (pp. 105–110).* ACM.

Rinott, R., Dankin, L., Perez, C. A., Khapra, M. M., Aharoni, E., & Slonim, N. (2015, September). Show me your evidence-an automatic method for context dependent evidence detection. In *Proceedings of the 2015 Conference on Empirical Methods in Natural Language Processing (pp. 440–450).* Association for Computational Linguistics.

Another Perspective of the Sleeping Beauty Problem: What Lessons Can We Learn from the Sleeping Beauty Problem?

Shih-Hsun CHEN

Faculty of Philosophy and Arts at the University of West Bohemia, Czech Republic
* bb9124037@hotmail.com

Abstract: The Sleeping Beauty problem is still an important issue in decision theory. Since Elga raised this problem in 2000, there are two opinions as to what the solution is, with some thinking the answer is 1/2 and others thinking the answer is 1/3. Even though both sides seem to have reasonable reasons to support their answer, there is still no convincing conclusion. In addition to attempting to solve this debate, this paper provides another perspective on the Sleeping Beauty problem: no matter whether the final answer is 1/2 or 1/3, it will not challenge our intuition to a fair coin.

Keywords: decision theory, the Sleeping Beauty problem, paradox

1. Introduction

The Sleeping Beauty problem is as follows: researchers tell Sleeping Beauty about the following experimental procedure: Sleeping Beauty will be put to sleep on Sunday. After she falls asleep, the researchers will toss a fair coin. If the coin toss lands heads up, Sleeping Beauty will be woken up on Monday, and then will answer the question "What is your credence now for the proposition that the coin landed heads up?" After she answers, Sleeping Beauty is put back to sleep with an amnesia-inducing drug which means she has no memory of being woken. If the coin toss is tails, Sleeping Beauty is woken up on Monday and Tuesday and is asked, "What is your credence now for the proposition that the coin landed heads?

EIga (2000) first proposed the Sleeping Beauty problem which has generated great debate amongst the decision theory community. The candidate answers can be divided into two options: 1/2 and 1/3. Here we call supporters of 1/2 Halfers ((Lewis (2001), White (2006), Hawley (2013)), and supporters of 1/3 Thirders ((EIga (2000), Arntzenius (2003), Horgan (2004, 2007), Weintraub (2004), Bovens (2010)). Even though the proponents of the same answer may base their thinking on different reasons and even cause some inconsistent situations, this does not pose any problem in this paper.

This paper is divided into four sections. The first section is the introduction. The second section roughly explains the difference between Halfers and Thirders and uses Bertrand's box paradox as a comparison. The third section argues that when a Thirder claims that the answer to the Sleeping Beauty problem is 1/3, this may be due to their misunderstanding of the results of the experiment. The fourth section attempts to analyse the Sleeping Beauty problem from a more comprehensive perspective, indicating that no matter what the final answer is to the Sleeping Beauty problem, we must be careful whether such an answer challenges our intuition about a fair coin. The fifth section is the conclusion.

2. Halfers and Thirders

In this section, I briefly explain the differences between Halfers and Thirders. The reason why Halfers believe the answer is 1/2 is that Sleeping Beauty knows the details of the test on Sunday and when she wakes up, she does not gain any extra information. Therefore, when Sleeping Beauty is woken up during the experiment, this does not change the probability of the coin toss.

The reason why Thirders believe the answer is 1/3 is because there are three situations in which Sleeping Beauty could have been woken up: C1(Heads, Wake on Monday), C2(Tails, Wake on Monday) and C3(Tails, Wake on Tuesday). The probability of these three events is the same, and the three events constitute the whole situation. Hence, the probability of these three events occurring is 1/3. In this case, the head event only occupies one of three situations. Therefore, under the premise that Sleeping Beauty has been woken up, the probability of the coin toss landing heads up is 1/3.

The Halfers argue that Sleeping Beauty has received no new information upon waking, so there is no difference in the information Sleeping Beauty has before the experiment and the information she has during the experiment. As the fourth section in this paper raises similar arguments, I discuss this later.

I compare the Thirders' argument to Bertrand's box paradox. Joseph Bertrand first posed Bertrand's box paradox in his 1889 book "Calcul des probabilités". Bertrand's box paradox is as follows: there are three boxes. The first box contains a gold coin and a silver coin. The second box contains two silver coins. The third box contains two gold coins. After randomly selecting a box and taking out a coin, what is the probability that the coin will belong to the first box given that this coin is gold?

Bertrand's box paradox can be regarded as a classic exercise in teaching probability. I use a structural analogy between Bertrand's box paradox and the Sleeping Beauty problem to highlight the difference. Given a gold coin has being drawn (Sleeping Beauty has been woken up), the chance that the gold coin belongs to the first box is 1/3 (the probability that the coin toss landed heads up is 1/3). Because there are only three possibilities for getting a gold coin (there are three possibilities for Sleeping Beauty to be woken up), namely G1 in the first box (C1), G2 in the third box (C2), and G3 in the third box (C3), G1, G2, and G3 are three possible events given one gold coin has been taken out (C1, C2, and C3 are three possible events given Sleeping Beauty has been woken up). Hence, the probability of the gold coin belonging to the first box is 1/3 (so the probability of the coin toss landing heads up is 1/3). Figure 1 shows the probability branch diagram of Bertrand's box paradox.
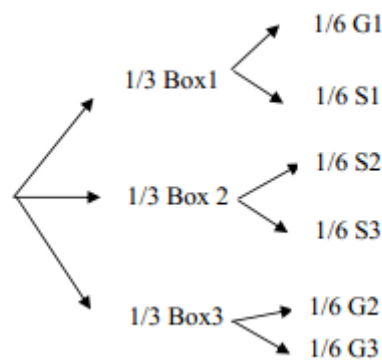
Figure 1.

However, we should be careful, even though the above analogy looks reasonable. The difference lies in the fact that G1, G2, and G3 are mutually exclusive, that is, $P(G1 \cap G2) = 0 = P(G1 \cap G3) = P(G2 \cap G3)$. After all, we know that only one coin will be taken out during the entire experiment, so the probability of drawing out two (or more) coins is zero.

However, C1 and C2 are not mutually exclusive. When one of C1 or C2 occurs, the other must happen. In other words, regardless of the individual probability of these three events, $\Pr(C2 \cap C3)$ is not equal to zero. This is a reasonable. When the coin toss lands tails up, Sleeping Beauty will be woken up on Monday and Tuesday. Based on this, even if $\Pr(C1) = \Pr(C2) = \Pr(C3)$, we can question whether $\Pr(C1) + \Pr(C2) + \Pr(C3) = 1$.

From White's paper (2006), we can see some of the differences between Halfers and Thirders. White proposed a generalized Sleeping Beauty problem. In the generalized Sleeping Beauty problem, White introduced c, $c < 0 \leq 1$. In this version, c refers to the probability that Sleeping Beauty will be actually woken up during the experiment. When c = 1, it is the original Sleeping Beauty problem. In the generalized Sleeping Beauty problem, in addition to C1 (Heads, Wake on Monday), C2 (Tails, Wake on Monday) and C3 (Tails, Wake on Tuesday), we also have C1*(Heads, Not Wake on Monday), C2*(Tails, Not Wake on Monday) and C3*(Tails, Not Wake on Tuesday). Through the calculation of

conditional probability (details can be seen in White 2006), we can know that the probability of the coin landing heads up is 1/ (3-c). Here, we can see the difference between the probability branch diagrams of both sides from Figure 2 and Figure 3. Figure 2 represents the perspective of Thirders and Figure 3 represents the perspective of Halfers.

1/3 (Heads, Wake up on Monday)

1/3 (Tails, Wake up on Monday)

1/3 (Tails, Wake up on Monday)

Figure 2

1/2 (Heads, Wake up on Monday)

1/2 (Tails, Wake up on Monday) and
(Tails, Wake up on Monday)
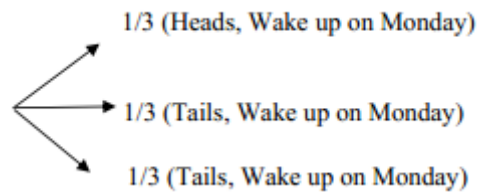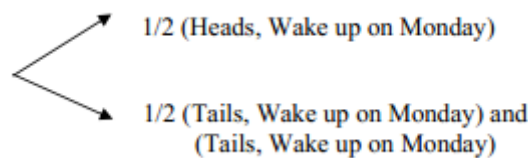
Figure 3

In this regard, if the Thirders attempt to support their answer using a similar proof, they may need to give other reasons to justify it.

3. Experimental point of view

For the Sleeping Beauty problem, Thirders (who believe the answer is 1/3) sometimes attempt to justify their point of view by changing some of the conditions of the experiment. For example, if the coin toss lands tails up, Sleeping Beauty will be woken up in all the following thousand days. This is an attempt to capture the intuition that "1/2 is unreasonable" by amplifying the number of days that Sleeping Beauty is awakened. However, these authors do not give a thorough explanation for this kind of experiment. I argue that it is because of the misunderstanding of the experimental details such that Thirders misused the experimental results. This is why the Monty Hall problem is a classic example of probability teaching, but the Sleeping Beauty problem is still unsolved in the field of decision theory.

Thirders explain that there are only three situations in which Sleeping Beauty will be woken up: (Heads, Monday) (Tails, Monday) (Tails, Tuesday). Of the three possibilities, because each probability of occurrence is equal, the likelihood of the coin toss being heads up is 1/3. Regardless of whether the Thirders hold some philosophical position to defend their belief that the answer is 1/3, I argue from an experimental aspect that 1/3 is not correct.

Suppose there are a hundred Sleeping Beauties to participate in this experiment, and when any Sleeping Beauty is woken up, we ask her "what do you think is the probability that the coin toss landed heads?" In typical statistical calculations, about 50 people say the coin toss is heads, and the remaining 50 people say tails. In this way, we can get 150 pieces of data roughly: 50 pieces (Heads, Monday), 50 pieces (Tails, Monday), and 50 pieces (Tails, Tuesday). Thirders claim that the heads situation is one-third of the total. Therefore, under the premise that Sleeping Beauty has been woken up, the probability of the coin toss being heads up is 1/3.

All this sounds reasonable, but it is an incorrect claim. It can be claimed that if someone randomly picks one of the 150 samples, the chance of it being heads is indeed 1/3. However, if we ask the awakened subjects what is the probability of the coin toss being heads, the answer is 1/2. We have to be careful of the difference between the two claims. There are 150 samples in this experiment, but this experiment only has 100 subjects. In other words, not every subject will provide the same number of samples: each Sleeping Beauty who thinks the coin toss is heads only offers one piece of data, but each Sleeping Beauty who thinks the coin toss is tails provides two pieces of data. Thirders misread the experiment results.

I contend that the Thirders' argument can be refuted from an experimental point of view, but as there are many other arguments in favour of the Thirders' viewpoint, this thesis cannot provide a more

detailed explanation. Even so, we can draw an analogy between the Monty Hall problem and the Sleeping Beauty problem. If Thirders' arguments about the experiment are correct, then similar to the Monty Hall problem, when the statistics tell us how to choose in this game, it is rational to follow this advice. However, as previously mentioned, it is because of the details of the experiment that Thirders omit, so that the actual meaning of the experiment, that is, the statistical results, cannot play a real effect.

Of course, there may be some other experimental designs. But if Thirders want to convince everyone that 1/3 is the correct answer in the practical sense, they need to show that the experiment I discussed in this section has reasoning errors, or else suggest another experiment that really captures the meaning of the Sleeping Beauty problem.

4. Another Perspective for The Sleeping Beauty Problem

This section looks at the Sleeping Beauty problem from another perspective. First, we discuss the classic problem of probability: the Monty Hall problem.

The Monty Hall problem is as follows: a participant is given the choice of selecting one of three doors. Behind one door is a car; behind the others, goats. When the participant chooses a door, the host who knows what is behind every door opens one door with a goat behind it. Then, the host asks the participant if they want to change to the other closed door. Or in other words, will changing to another closed door increase their chances of winning the car?

The proof of the Monty Hall problem is very similar to that of Bertrand's box paradox. First, there are three possible things that can be selected, C (car), G1 (Goat 1), G2 (Goat). At the beginning of the game, $Pr(C) = Pr(G1) = Pr(G2) = 1/3$. After the host opens one of the doors with the goat behind it, if the participant chooses to change their choice of door, there are three possibilities. The first possibility is that the participant had firstly selected C at the beginning, but after switching to a different door, the participant gets G1 or G2. The second possibility is that the participant had firstly selected G1 but got C after the switch. The third possibility is that the participant had first selected G2 and got C after the switch. Based on the assumption that these three possibilities are equal, the chance of choosing the car is 2/3. Figure 4 shows a probability tree diagram of the Monty Hall problem.

What can we learn from the Monty Hall problem? At the end of Elga's paper (Elga, 2000), Elga states: "at least one new question arises about how a rational agent ought to update her beliefs over time." It is essential that when information changes, the original probability configuration may also change accordingly. We do not doubt this, so at the beginning of the game, the chance of selecting a car is 1/3. We also do not doubt that knowing that there are two closed doors and only one car is behind them, the probability of winning a car is 1/2. However, we should think about it: after the first choice we make, and then the host opens another door in a non-random manner, does the behavior of the host affect the original probability distribution? If the host's behavior and the participant's behavior are independent, the behavior of the host will not affect the chances of this participant getting a car. However, this is not an independent case. Therefore, from the example of the Monty Hall problem, we know that when new information is generated, we should check whether the new information affects the original probability distribution of beliefs. Moreover, we can test whether the new information is independent of the probability distribution of old beliefs.

Taking the example of the Monty Hall problem to compare with the Sleeping Beauty problem, we can think in the following way. The coin toss not only determines whether the Sleeping Beauty will be woken up on Tuesday, it also determines the number of days that Sleeping Beauty will not be woken up. When we asked: "When Sleeping Beauty wakes up for the first time, what is the probability of the coin toss being tails?" or we can also ask: "When Sleeping Beauty falls asleep on the third day, what is the probability of the coin toss being tails?" Of course, when Sleeping Beauty falls asleep, she cannot answer this question, but we can solve this problem in another way, such as asking Sleeping Beauty this hypothetical question before the experiment. If we agree that "when Sleeping Beauty falls asleep on the third day, what is the probability of the coin toss being tails?" is a legitimate question, then we can easily conceive similar questions, such as changing the third day to the n-th day.
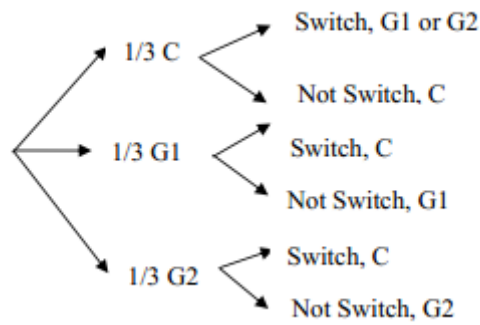
Figure 4.

In addition, we can see that the ratio of "being sleeping" and "been woken up" in the probability space is very huge. Therefore, the Sleeping Beauty problem is a problem of conditional probability and the proportion of "been woken up" in the entire probability space is extremely small. Therefore, no matter whether the final answer to the Sleeping Beauty problem is 1/2 or 1/3, this should not challenge our intuition about a fair coin. When we are thinking about the problem of Sleeping Beauty, it is easy to overestimate the significance of Halfers' and Thirders' arguments which will challenge our daily intuition about a fair coin.

From the above analysis, in the situation where Sleeping Beauty is awakened relative to the situation of falling asleep, the proportion in the probability space is relatively very small, so the Sleeping Beauty problem, regardless of the answer, is essentially irrelevant to the probability of the coin toss being heads.

5. Conclusion

This paper does not solve the problem of Sleeping Beauty and does not offer proof or counterevidence in relation to Halfers' and Thirders' arguments. In section 3, I challenge Thirders using an experimental point of view and argue that Thirders misunderstand the results of the experiment. The challenge is mainly to indicate that if the results in the actual sense of the experiment are clear, then the problem may not cause such a big controversy. Taking the Monty Hall problem as an example, even though some people may not understand the mathematical demonstration immediately, in a practical sense, we should give the participants the chance to "switch the door".

Section 4 explores the lessons we can learn from the Sleeping Beauty problem from a broader perspective. I argue that no matter whether the final answer is 1/2 or 1/3, it cannot challenge our intuition about a fair coin. The Sleeping Beauty problem is a problem of conditional probability. As for whether the Sleeping Beauty problem can challenge our other intuitions, and whether the answer is 1/2 or 1/3, or even other answers, this requires more research.

References

Arntzenius, F. (2003). Some problems for conditionalization and reflection. *Journal of Philosophy* 100: 356–70.
Bovens, l. (2010) Judy Benjamin is a Sleeping Beauty. *Analysis*, 70(l):23-26.
Elga, A. (2000). Self-locating belief and the Sleeping Beauty problem. *Analysis* 60: 143–147.
Hawley, P. (2013). Inertia, Optimism and Beauty. *Nous* 47(1), 85-103.
Horgan, T. (2004) Sleeping Beauty awakened: new odds at the dawn of the new day. *Analysis* 64: 10–21.
Horgan, T. (2007) Synchronic Bayesian updating and the generalized sleeping beauty problem. *Analysis*, 67(293):50- 59.
Lewis, D. (2001). Sleeping Beauty: reply to Elga. *Analysis* 61: 171–76.
Weintraub, R. (2004). Sleeping Beauty: a simple solution. *Analysis* 64: 8–10.
White, R. (2006) The generalized sleeping beauty problem: a challenge for thirders. *Analysis*, 66(290): 114- 119.

Conceptual Metaphor in Teaching Logic

Tzu-Keng FU[a] &Anca Christine PASCU[a*]
[a]College of General Studies, Yuan Ze University, Taiwan (R.O.C.)
[b]University of West Britanny, Brest, France
[a]futzukeng@saturn.yzu.edu.tw
[b]ancapascu@icloud.com

Abstract: In this paper, we discuss the concept of *conceptual metaphor* and its role in the teaching of logic. Starting from our experience in the teaching of logic to students in human sciences at University of West Britanny and students who take general education courses at various universities in Taiwan and from our research in the field of logic, we defend the point of view according to which the teaching and learning of logic adopts metaphoric devices to adapted students' previous knowledge.

1. Introduction

The notion of conceptual metaphor was first introduced by George Lakoff and Mark Johnson in their works, Conceptual Metaphor in Everyday Language (Lakoff and Johnson, 1980) and Metaphor We Live By (Lakoff and Johnson, 1980). This notion has been studied in related to some philosophical notions such as the the nature of meaning, truth, rationality, logic and knowledge. By its later developments, it is further analyzed by postulating the concept of conceptual blending by Gilles Fauconnier and Mark Turner in (Fauconnier and Turner, 2003). A systematic study from the conceptual metaphor to conceptual blending as a new framework of integrating two conceptual spaces has been studied in theoretical computer science by Kutz et al. (Kutz et al., 2010). Starting from the classical optimality principles of blending (Fauconnier and Turner, 2003), Goguen and Harrell explore more conditions for applying these principles in (Goguen and Harrell, 2004). This framework "as a basic mental operation will lead to new meaning, global insight, and conceptual compressions useful for memory and manipulation of otherwise diffuse ranges of meaning" (Fauconnier and Turner, 2003, p. 57). Classical examples for the notion of conceptual blending are new emergent conceptual spaces of boathouses and houseboats. As a process of analyzing two conceptual spaces, the transfer operations, which lead from concepts in source space to new concepts in target space, has been modeled in the framework of the Logic of Determination of Objects (LDO) in (Pascu et al., 2014) in order to build a computational system for its analysis. All of these works are cognitive analysis of conceptual translation, which includes either to interpret old concepts by new ones or to build a new concept by appealing to the combinations of old ones.

In this paper we present conceptual metaphor for teaching logic. From the viewpoint of knowledge acquisition, we investigate the role of conceptual metaphor by understanding logic both as a language and a system of reasoning. Logic as a scientific discipline impacts other scientific education will be highlighted in this paper. Finally, the role of conceptual metaphor in logic education is noted. This paper is organized as follows: The introduction reviews some notions introduced in the literature around conceptual metaphor and conceptual blending. In section 2, we roughly explain the model of conceptual metaphor in Institution Theory. In section 3, based on the LDO model, we analyze some logical notions in natural deduction that has been taught to the students in humanities. In section 4, the conceptual metaphor in inferences of a deductive system is discussed. Finally, a conclusion about the importance of teaching logic will be given.

2. Conceptual Metaphor in Institution Theory

Institution theory is a very general algebraic description by using category theory. In (Diaconescu, *IEP*), a very good and brief characterization of Institution Theory is given.

An *institution* is a *mathematical structure* built initially to model mathematically logical systems. The concept of institution is built from the concepts of algebraic theory of categories. An institution consists of four kinds of entities: *signatures*, *sentences, models*, and the *satisfaction* between models and sentences. All these are considered fully abstractly and axiomatically. This means the focus is on their external properties, how they relate to the other entities, rather than what they actually are or may be.

Institution Theory

Formally, according to (Goguen and Burstall, 1984), an institution is a quadruple (Sign, sen, Mod, rel) where:

- Sign is a set of *signatures* with a set N of sorts partially ordered by a sub-sort relation.
- sen, sen : Sign $\rightarrow$ Set is a functor building for each signature Σ, the set of its sentences, sen (Σ) and for each morphism $\sigma : \Sigma \rightarrow \Sigma'$, the *sentence translation map*, sen (σ) : sen (Σ) $\rightarrow$ sen (Σ').
- Mod is a functor, Mod : Sign^{op} $\rightarrow$ Cat that builds for each signature Σ, the category of models, Mod (Σ) and for each signature morphism $\sigma : \Sigma \rightarrow \Sigma'$, the *reduct functor* Mod(σ) : Mod (Σ') $\rightarrow$ Mod (Σ).
- A *satisfaction relation* $\models\Sigma \subseteq |$Mod ($\Sigma$)$| \times$ sen (Σ) for each $\Sigma \in$ Sign, such that, for each morphism σ, $\sigma : \Sigma \rightarrow \Sigma'$ in Sign, the following satisfaction condition holds: M' $\models\Sigma'$ $\sigma(\varphi)$ if and only if Mod(σ)(M') $\models\Sigma$ φ.

The satisfaction condition expresses that truth is invariant under change of notation (and also under enlargement or quotienting of context).

For two logical systems $L_1 = (\Sigma_1 , \models_1)$ and $L_2 = (\Sigma_2 , \models_2)$ having the set Σ_1 and Σ_2 (of propositional symbols) as signatures, and a function $\rho: \Sigma_1 \rightarrow \Sigma_2$ between such sets as a signature morphism, the functor Mod is a *model translation*.

Model translation, which is interaction between semiotic systems in general, can be seen as the underlying *logical* behavior of *conceptual metaphor* (Pascu et al., 2014), where source domain and target domain are taken as two semiotic systems. As Diaconescu states in (Diaconescu, *IEP*), "the key step was the definition of the concept of institution in (Goguen and Burstall, 1984) intended to capture formally the structural essence of logical systems beyond specific details. Since semantics plays the primary role in formal specification, institutions lean towards the semantics side of logic, known as model theory."

3. Conceptual Metaphor in Logic of Determination of Objects (LDO)

Institution Theory is a very general framework. It can be applied to build ontologies. However, if we model the conceptual metaphor process, then taking the framework of logic of Determination of Objects (LDO) will be suitable and not be too laborious. The LDO was proposed by Jean-Pierre Desclés et al. LDO is a logical system, which take into account a definition of "concept" and "object" by generalizing Frege's (Frege, 1971) notions by providing a formal distinction between "concept" and "object". Moreover, LDO was used to account, in particular, for the distinction between typical and atypical instances of a concept in (Desclés et al., 2011). The primitives of this logic are the concepts and the objects. Inspired from Frege's definitions (Frege 1971), it extends and formalized them in the framework of applicative systems of Curry (Curry and Fey, 1958). The concepts are operators in the sense of Frege (Frege, 1971) and the objects are operands. The whole language of the LDO is an applicative system in Curry's sense (Curry and Fey, 1958). The differences between LDO and the classical logic are: (1) objects in LDO are of two kinds: fully (totally, completely) determinate objects and more or less determinate objects; (2) objects in LDO are typical and atypical; (3) the duality between extension and intension of a concept is not kept.

In (Pascu et al. 2014), based on LDO, we analyze the construction operated by "conceptual metaphor". It is a *complex transfer-operator* pairing from the *source concept—object* space to *the target concept- object* space. This operator is applied to concepts, more or less determinate objects or determinations. It is not only a simple transfer; it can change the category of the operand (i.e. a concept from essence from the source space can become the determination of a more or less determinate object in the target space). In (Pascu et al. 2014), among other examples, the analysis of the example of "boat people" is presented. In this current paper we are interesting only in the structural part of the LDO, that is, the definitions of concepts and objects.

In the mathematical model of LDO (Desclés and Pascu 2019), a concept is a quadruple $< f$, Ess f, Int f $>$, where f is a property, Int f a set of properties defining f and Ess f a subset of Int f, a set of properties necessarily defining f. The concepts of Int f are organized in a network as represented in Figure 1. This network ends with the concept f to which is associated τf the typical object totally indeterminate associated to f. Following this, we can obtain the *objects more or less determinate* represented in the part O of the Figure 1 by *determination* operations. In Figure 1, $\mathcal{F}$ represents the sub-network of concepts and O the subset of objects. In what follows, we present the mathematical model associated to LDO following (Desclés and Pascu 2019), in Figure 1. To apply this model to conceptual metaphor, we take as semiotic spaces a space $(\mathcal{F}_1, O_1)$ as source space and $(\mathcal{F}_2, O_2)$ as target space. Between them must define a *translation operator* as in Figure 2. The model of metaphor in LDO consists in considering the two spaces, source space and target space as a LDO spaces of concepts f1 and f2 respectively. The translation of a feature g0 of f1 as feature g'0 of f2 can be done in the following way
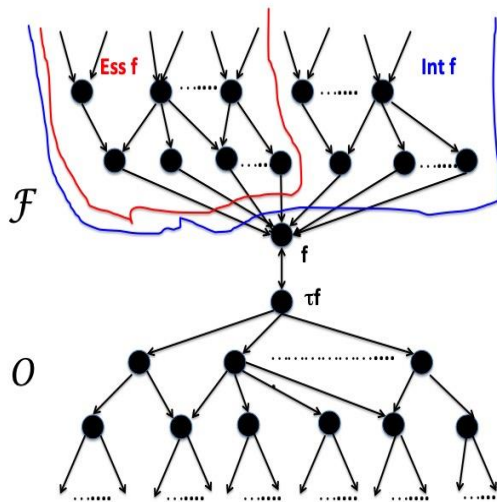
Figure 1. The lattice structure of concept and object in LDO   Figure 2. Conceptual metaphor in LDO
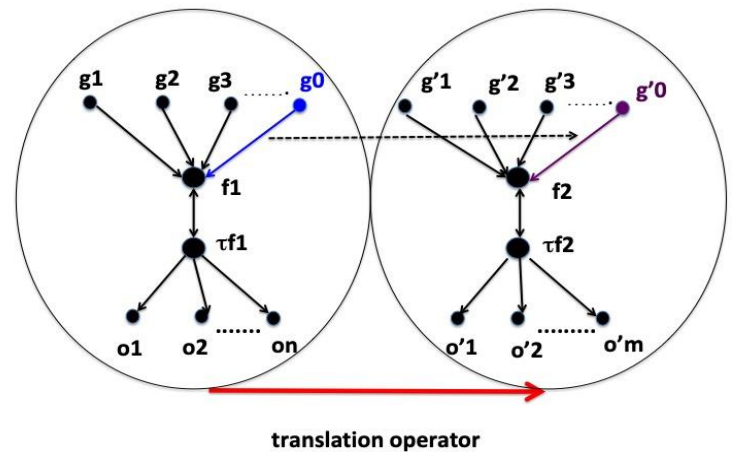
- Either g0 belongs to essence Ess f1 of f1;
- Or
- g0 belongs to essence Int f1 de f1 and not to Ess f1 of f1.

Some other possible cases concerning the objects are presented in (Pascu et al. 2014).

4. **Conceptual metaphor in teaching logic**

If we speak about classical logic presented in two forms: *natural deduction* and the *theory of models* we can distinguish the great feature differentiating one from the other. The natural deduction expresses each logic connective by the pair of introduction rule and elimination rule. The theory of models postulates the language, its model and the correspondence between them. Taking our natural reasoning as a logical system, natural deduction can be taken as a conceptual metaphor of our natural reasoning, where natural deduction system can be presented by a class of valid argument forms, e.g. (Tidman and Kahane, 1998). Moreover, the theory of model can be taken as a conceptual metaphor of natural deduction. That is to figure out the meaningful part of natural deduction, called interpretation that is usually used in model theory. The scope of this analysis is the empirical digging of our natural reasoning. By the following example we give an analysis of the two rules, the *rule of deduction (modus ponens)* and the *rule of abduction*. Let us recall the deduction rule (modus ponens) and abduction rule. For deduction rule:

$$\frac{p, \; p \to q}{q} \qquad (1)$$

Interpretation: for two propositions p and q, if p is true and p → q, then q is true.
For abduction rule:

$$\frac{q,\ p \to q}{p} \qquad (2)$$

Interpretation: for two propositions p and q, if q is true and p → q, then p is *plausible*.

Consider two logical systems L1 and L2 with their corresponding sets of propositions P1 and P2, respectively. $P1 = \{P1_1, \ldots P1_{n1}\}$ and $P2 = \{P2_1, \ldots P2_{n2}\}$, have structures in the form of categorizations. Suppose that the logic L1 is equipped with the rule of deduction (modus ponens as only rule) and L2 is equipped with both deduction rule (modus ponens) and abduction rule. In L1 we can have only the truth values {t(truth), f(false)}, but in L2 we must have several truth values or a mean to express the notion of "plausible".

We can rewrite the deduction rule in both L1 and L2 by:

$\forall q, \forall p, q, p \in P1$, if p is true and p → q, then q is true

$$(3)$$

But for the abduction rule in L2, we have:

$\forall q, \exists pi \in P2$, if q is true and pi → q, then pi is plausible $\qquad (4)$

Here we can give a LDO model of conceptual metaphor for the *rule of abduction*:
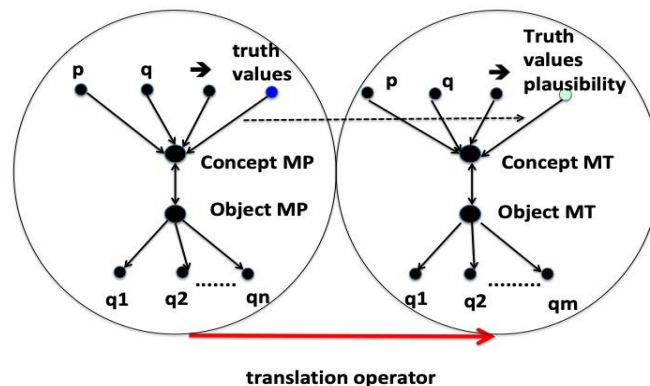
Figure 3. LDO model of conceptual metaphor for the rule of abduction

5. Discussion and Conclusion

We show that the conceptual metaphor is a *logical notion* w.r.t. LDO. What lesson can we learn from this?

From this short study about the notion of conceptual metaphor, we are aware that one of the basic feature of our reasoning in knowledge acquisition is the analogy of features. A kind of analogy operates that can be constructed by a new *logical* system. We can call this type of analogy "conceptual metaphorization". It is a very complex process that can be modeled by a number of mathematical or non-mathematical models.

A child learns a new concept in three forms:
- From a concept already known by a transfer of structural properties;
- From an object already known by transferring functional properties;
- From a known context built with concepts and already known objects by removing and adding properties already known.

We call this cognitive process a *conceptual metaphorization process*. Obviously, the first years of education from preparatory school to junior high school the logic is introduced by the game and a concept is born from the game by a *conceptual metaphorization*. Suppose that logic can be taught at all levels of education, then learning logic can be taken as a conceptual metaphorization process, which

means that conceptual metaphorization process can be a framework of learning logic, including learning natural reasoning by natural deduction and learning natural deduction by the concept of interpretation in the theory of model.

In the process of acquisition of a new concept or in the process of understanding a new system of reasoning, learners need to adapt their previous concepts. As stated in (Desclés et al. 2010), *"Logic is the art of reasoning, the discipline of deduction, rigorous demonstrations, the mechanization of proofs ...But logic is also the place of interpretations, of the meaning of utterances, of possible models or worlds. Thus, logic is built in the opposition between syntax and semantics:*
• The syntax is the world of symbols, grammatical operations empty of any content,
• Semantics is the place of interpretations, possible models or worlds, the place of realizations, the place where a meaning is given.
In mathematical logic, we must distinguish between an 'axiomatic' conception of logic, which was that of Frege, Russell, and Hilbert, and a more 'pragmatic' conception in terms of proofs, which we find in systems deduction of Gentzen".

(Our translation) .[1]

For learners, learning this subject is multi-perspective. To understand this learning process is interesting for educators to take suitable metaphoric devices to teach this subject. Nevertheless, to know symbolization as a highly structured device is usually important for learners to understand this subject, where conceptual metaphorization process can be the underlying process from a perspective of cognitive linguistics.

References

Lakoff G. and Johnson M. 1980. « Conceptual Metaphor in Everyday Language », *The Journal of Philosophy*, 77: 453 – 486.

Lakoff G. and Johnson M. 1980. *Metaphor We Live By*, Chicago, University of Chicago Press.

Fauconnier G. and Turner M. 2003. The Way We Think: Conceptual Blending and the Mind's Hidden Complexities. Basic Books.

Fauconnier G. and Turner M. 2003. Conceptual Blending, Form and Meaning. https://tecfa.unige.ch/tecfa/maltt/cofor-1/textes/Fauconnier-Turner03.pdf, pages 57 - 86.

Pascu A., Fu Tzu-Keng, Desclés J.-P. 2014. « Toward a Computational Theory of Conceptual Metaphor », Proceedings of the Twenty-Seven International Florida Artificial Intelligence Research Society Conference, aaai Press,p. 455-460.

Goguen, J. A. 1999. « An Introduction to Algebraic Semiotics, with Applications to User Interface Design ». In *Computation for Metaphors, Analogy and Agents*, LNCS 1562: 242–291. Springer.

Goguen J. and Harrell D. F. 2009. « Style: A Computational and Conceptual Blending-Based Approach», In Shlomo Argamon, Kevin Burns, Shlomo Dubnov, editors, *The Structure of Style: Algorithmic Approaches to Understanding Manner and Meaning*, Springer, 2009.

Goguen J. and Harrell D. F. 2004. « Style as a Choice of Blending Principles ». https://pdfs.semanticscholar.org/6c9d/4c14549451e3b892f3af6e73e29d1580da69.pdf

Kutz O., Mossakowski T., and Dominik L. 2010. « Carnap, Goguen, and the Hyperontologies », *Logica Universalis*, Special Issue on "Is Logic Universal?", 4(2): 255-333.

Goguen J. A. and Burstall R. M. 1992. « Institutions: Abstract Model Theory for Specification and Programming », Journal of the Association for Computing Machinery 39: 95–146.

---

[1] The original texts:
«La logique est l'art de bien raisonner, la discipline de la déduction, des démonstrations rigoureuses, de la mécanisation des preuves...
Mais la logique est aussi le lieu des interprétations, de la signification des énoncés, celui des modèles ou mondes possibles.
Ainsi, la logique se construit dans l'opposition entre syntaxe et sémantique :
- *- la syntaxe est le monde des symboles, des opérations grammaticales vides de tout contenu,*
- *- la sémantique est le lieu des interprétations, des modèles ou mondes possibles, le lieu des réalisations, le lieu où une signification est donnée.*
En logique mathématique, on doit distinguer entre une conception "axiomatique" de la logique, qui fût celle de Frege, Russel et Hilbert, et une conception plus "pragmatique" en terme d'actes de preuves, que l'on retrouve dans les systèmes de déduction naturelle de Gentzen.

Goguen J. A. and Burstall R. M. Introducing institutions. In Edward Clarke and Dexter Kozen, editors, *Proceedings, Logics of Programming Workshop,* volume 164 of *Lecture Notes in Computer Science,* pages 221–256. Springer, 1984.

Introducing Institutions, LNCS 164: 221-256.

Goguen, J. A. 1999. « An Introduction to Algebraic Semiotics, with Applications to User Interface Design ». In *Computation for Metaphors, Analogy and Agents*, LNCS 1562: 242–291. Springer.

Diaconescu, R. Institution Theory, Internet Encyclopedia of Philosophy, https://www.iep.utm.edu/insti-th/

Desclés J.-P., Pascu A. 2011. « Logic of Determination of Objects (LDO): How to Articulate "Extension" with "Intension" and "Objects" with "Concepts" », in *Logica Universalis*, Volume 5, Issue 1 (2011), Springer:75.

Van Dalen D. 1980. *Logic and Structure*, Springer.

Frege G. 1971. *Ecrits logiques et philosophiques*. Editions de Seuil, Paris.

Curry H.B. and Fey R. 1958. *Combinatory Logic*, vol. 1. North Holland, Amsterdam.

Desclés J.-P. 2014. «Différentes négations : langues naturelles et logiques ». https://www.unilim.fr/actes-semiotiques/5112.

Desclés J.-P and Anca Christine Pascu. 2019. «Logic of Typical and Atypical Instances of a Concept – A Mathematical Model ». Axioms, septembre 2019. https://www.mdpi.com/2075-1680/8/3/104/htm

Tidman, P. and Kahane, H. (1998). Logic and Philosophy: A Modern Introduction (8th ed.). Wadsworth Publisher: Cengage Learning.

Desclés, J.-P., Djioua, B., Le Priol, F.: Logique et langage: déduction naturelle. Hermann, Paris (2010)

WORKSHOP 10 - The 6th ICCE Workshop on Learning Analytics (LA) - Scaling up Evidence-based Institutional La Practices

Impacts of a knowledge sharing-based e-book system on students' language learning performance and behaviors

Mei-Rong Alice CHEN[a*]**, Hiroaki OGATA**[a]**, Gwo-Jen HWANG**[b]**, Gökhan AKÇAPINAR**[a]**,
Brendan FLANAGAN[a]**, Yi-hsuan LIN**[c]** & Hsiao-Ling HSU**[d]
[a]*Academic Center for Computing and Media Studies, Kyoto University, Japan*
[b]*Graduate Institute of Digital Learning and Education, National Taiwan University of Science and Technology, Taiwan*
[c]*Department and Graduate Institute of English Language & Literature, Chinese Culture University, Taiwan*
[d]*Institute of Applied English, National Taiwan Ocean University, Taiwan*

* ntustalice@gmail.com

Abstract: E-books are becoming a popular medium for delivering learning materials in the globe. The gap between e-books and pedagogical practices has been highlighted since teachers do not generally integrate the e-book tool into their instruction in a way that facilitates student learning. In particular, new pedagogies in language teaching and learning tend to encourage students to acquire knowledge and use the language in real-life situations. Knowledge sharing with collaborative tasks in the class can be useful. Studies on knowledge sharing, specifically in language education, are limited. To this end, this study proposes a knowledge sharing-based e-book system to enhance students' learning performance in an EFL course. This study adopts a quasi-experimental design. Seventy-one freshmen were recruited from two classes of a freshman English course at a university in northern Taiwan. The implication from this study finding might help teachers to identify suitable technology based on the learning needs of students, and help consider the ability of teachers to adopt appropriate technology and to fit specific learning activities.

Keywords: Knowledge sharing, Constructive learning, e-books, learning behavior analysis

1. Introduction

English as a foreign language (EFL) learning tends to involve vocabulary memorization, grammar explanations, and practice as typical teaching and learning activities. Accordingly, EFL students are instructed in such a way that they have inadequate opportunities to acquire knowledge in their classes (Bakar, 2009; Chai, Wong, & King, 2016) even though current pedagogies in language teaching and learning tend to encourage students to acquire and use the language in real-life situations. In other words, EFL learners need to develop their knowledge and to use the target language as a way of communicating with others (Thornbury, 2016). This issue raises the importance of the social constructivist view of learning (Amineh & Asl, 2015). Constructivism is broadly treated as a way to promote learners' competence and to illustrate that competence can improve and change to higher-level thinking. That is, educators should situate learners in a learning environment that will allow them to acquire the knowledge and to practice it in-group activities (Bakar, Latiff, & Hamat, 2013).

Furthermore, technologies such as e-books have gradually affected language teaching and learning. Technology-enhanced education stresses students' intervention in meaning-making. Some technological systems are widely recognized as facilitating social interactions for collaborative learning (Kreijns, Kirschner, & Vermeulen, 2013). A technological system with collaborative learning is exclusively suitable for language learning as the primary purpose of language learning. When interacting with peers, students can learn from others as well as practice their language skills; therefore, they are more likely to acquire the content knowledge. However, there is a limited understanding of knowledge sharing in language learning.

This study proposes a knowledge sharing-based e-book learning approach to help students learn new knowledge. This study intended to identify two central values: (1) increasing learners' language learning performance, (2) supporting learners' learning by analyzing their learning behaviors from the logs. Therefore, two research questions were raised:

- RQ1. Is there a significant difference in learning performances with the knowledge sharing-based e-book learning compared to the conventional e-book learning approach?
- RQ2. Is there a significant difference in learning behaviors with the knowledge sharing-based e-book learning compared to the conventional e-book learning approach?

2. Literature Review

2.1 Using constructive learning for knowledge sharing

Knowledge should be learned actively, so the primary duty of an instructor is to facilitate and foster meaningful learning through constructivist pedagogy, and to provide the essential tasks and to guide learners as they attempt to integrate new knowledge into what they have previously learned. Constructivists claim that learners should practice higher-order thinking skills they will need to use in their life. Learners cannot deal with difficulties unless authentic learning situations are made available to them (Bada & Olusegun, 2015).

Constructive learning emphasizes cultivating students' knowledge and skills by sharing and collaboration. When learners communicate and work with their peers, they are more likely to develop new ideas and improve their learning. Interaction between peers is a way to foster students' higher-order thinking competencies (Hwang et al., 2018). Kiili et al. (2012) explored an activity on constructive learning for meaning and knowledge. When learners can make explicit the new experience in their interpretations, it shows that they have acquired it. In this study, we aimed to foster students' abilities in "differentiating" knowledge, which has been categorized by Anderson et al. (2001) as an "analyze" competence including the cognitive processes of "focusing," "selecting," "discriminating" and "distinguishing." In this study, these cognitive skills were adopted in the developed approach as a knowledge-sharing activity to enhance students' learning.

2.2 E-books for EFL learning

E-books not only present learning content in text, images and other media, but also provide various functions to facilitate learning, such as highlighting and looking-up of words (Godwin-Jones & Technology, 2011). E-books can provide more than just reading materials because they have all the trustworthy tools to support students to take notes and highlight content. Boticki, Akçapınar, and Ogata (2019) have analyzed data from e-book systems, but there have been comparatively few studies on actual e-book practices during in-class instruction. Previous studies have found that certain functions in the e-books could support learners' learning. Hwang and Lai (2017) claimed that the interactive e-book approach promoted the students' self-efficacy for learning mathematics, but also improved their learning achievement. Not only can e-books be applicable to learning math but also to language learning. Su and his colleagues (2017) found that the music function in e-books could be a possible feature to improve reading. Kiyota, Mouri, Uosaki, and Ogata (2016) claimed that their e-book system could support learners learning the connection between formal learning at school and informal learning after school. However, instructors do not generally incorporate e-books into their teaching in their classes to facilitate student learning. In this study, cognitive processes were conceptualized as involving a knowledge sharing-based e-book learning approach to support teachers' use of e-books in a class setting to build a variety of cognitive skills and to enhance language learning.

3. Research Methodology

3.1 The E-book System and Analysis Tool

An e-book system, BookRoll, was developed by Ogata et al. (2015). BookRoll offers valuable features such as annotations and page zoom. Besides, teachers can include questions in BookRoll as quizzes and exercises throughout the chapter and also at the end of the chapter to ensure that students retain the information that they are learning. As shown in Figure 1, the student's interface shows a "Memo" function to indicate sections where students can make their own annotations at the page level. Annotations in the system support learning performance and help collaborative learning (Nokelainen, Miettinen, Kurhila, Floréen, & Tirri, 2005). Five types of annotation (Chen & Chen, 2014) were adopted in the e-book, namely reasoning, discrimination, linking, summary, and explanation. Students are required to make reasoning, discrimination, question, clarification, and summary annotations in BookRoll. All course materials were uploaded to BookRoll in PDF format, and can be accessed through a standard web browser. In addition, it can support different devices such as smartphones, computers, laptops, and tablets.
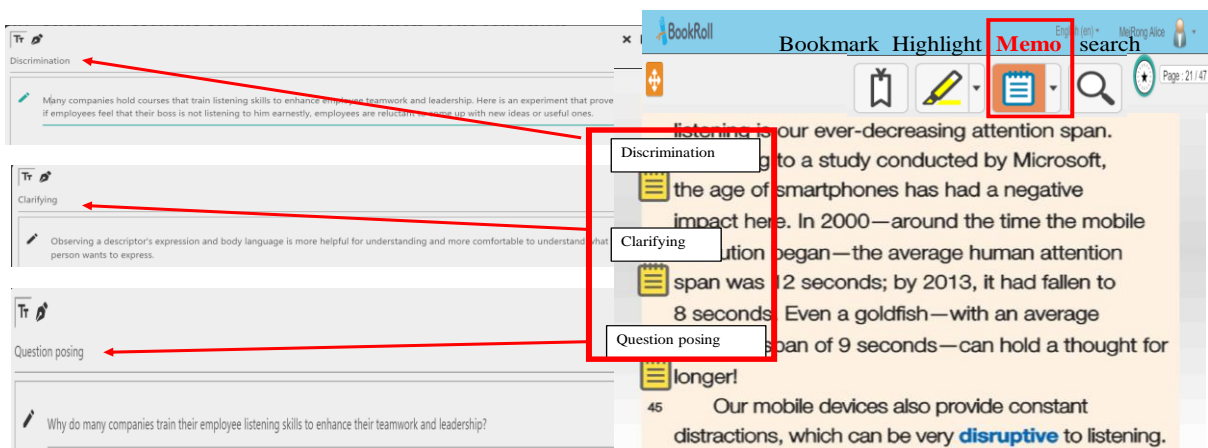
Figure 1. BookRoll system student interface.

The students' learning behavior from BookRoll is logged in a local database, Analysis Tool. After students used the memo in BookRoll, the Analysis Tool, as shown in Figure 2, generates the data of learners, content, engagement, learning traces, reading analysis, memo analysis, memo list, reading completion, and time. This information can help teachers and researchers to examine students' work and monitor their engagement (Akçapınar et al., 2019).
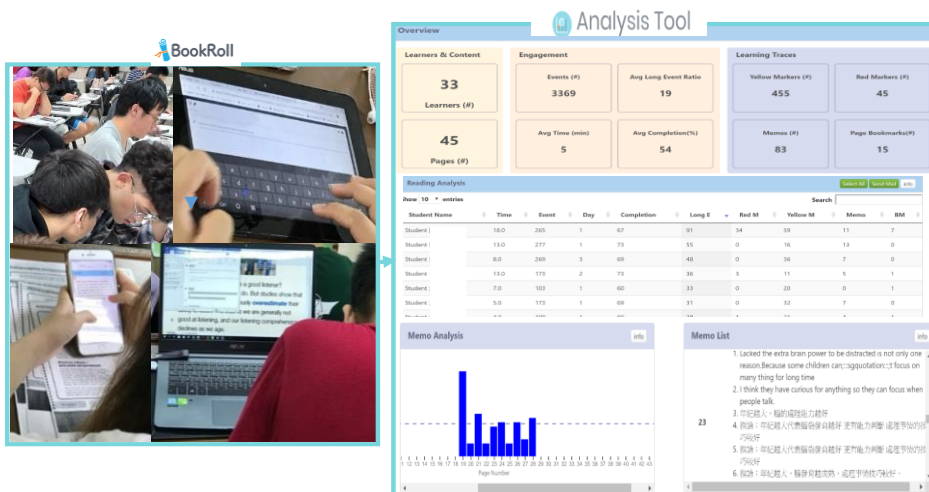
Figure 2. Students' engagement and Analysis Tool interface.

3.2 Participants

The experiment was carried out in a freshman English course at a university in the northern part of Taiwan. This course aimed to develop students' English skills, including speaking and reading skills. Two classes were recruited and randomly assigned as the experimental group and the control group. There were 38 (28 male, 10 female) students in the experimental group, while 32 (26 male, 6 female) students were in the control group. The students were 18-19 years old and had much experience reading from computer devices, such as mobile phones or tablets. Their English proficiency was at the low-intermediate level, comparable to the Common European Framework of Reference (CEFR) B1 level (Council of Europe 2001).

4. Experimental design

4.1 Experimental procedure

All participants first completed the pre-study survey, which was conducted one week prior to the beginning of the experiment. The instructor gave an introduction to the cognition skills (i.e., reasoning, discrimination, summary, question, and explanation) and some examples to both groups.

The BookRoll was introduced and showed how the students could access and make annotations through BookRoll. In order to understand students' group collaboration, the control group was required to make one of the five annotations by themselves without discussing with their peers; the experimental group was required to make five annotations on a group basis. Their annotations and performance were observed from the BookRoll system.

There are two chapters of 47 and 48 pages respectively published in BookRoll. During the 4 weeks of learning, the participants in the experimental group and the control group learned the course materials, shared and posted their memos on the course lectures and reading content as the in-class tasks.

4.2 Measuring instruments

In this study, the students' learning performances and participation of learning behaviors in BookRoll were assessed. Their pre- and post-learning performances were evaluated through five criteria, as follows:

- *Pronunciation: whether students convey their meaning accurately.*
- *Vocabulary: whether students use a large amount of vocabulary.*
- *Accuracy: whether students use the language grammar correctly.*
- *Fluency: whether students speak the language at an appropriate speed.*
- *Interaction: whether students interact with members of the group appropriately.*

The total score of both the pre- and post-learning performances was 100. Two experienced instructors rated the students' performances based on a rubric consisting of five dimensions, that is, pronunciation, vocabulary, accuracy, and interaction. The two instructors' ratings were found to have a rater reliability with Cohen's kappa= 0.505. As the kappa value exceeds 0.5, it is considered as indicating moderate interrater reliability (Cohen, 1960).

The time spent during class activities and the memos posted in the assigned tasks were collected for analysis of participation behaviors in the in-class knowledge-sharing tasks.

5. Results

To respond to RQ1, analysis of covariance (ANCOVA) was used to exclude the difference between the experimental group and the control group by using the pre-performance scores as the covariate variables and the post-performance scores as dependent variables. For the ANCOVA, this study tested the assumption of homogeneity of variance. Levene's test for determining homogeneity of variance was applied (F $=1.42$, $p= 0.24 > 0.05$), which indicated that ANCOVA was applicable. The ANCOVA result of post-learning performance showed that significance was reached (F $= 5.56$, $p = 0.02 < 0.05$);

moreover, the mean score of the experimental group (M=79.78, SD= 0.80) was higher than that of the control group (M=77.08, SD= 0.81), as can be seen in Figure 3.
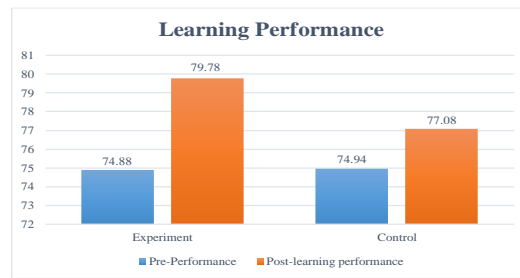
Figure 3. The results of pre- and post-learning performance.

Furthermore, the participants' learning logs, such as total time, total event, and memo length, were analyzed using the independent-samples *t*-test. As shown in Figure 4, there was a significant difference in the total time ($t = 5.74$, p <.001) for the experimental group (M= 58.89, SD=28.95) and the control group (M=25.41, SD =7.60). There was also a significant difference in the total event ($t = 4.69$, p <.001) for the experimental group (M= 185.19, SD =92.15) and the control group (M=92.15, SD =58.27). In addition, there was a significant difference in the memo length ($t = 4.40$, p <.001) for the experimental group (M= 615.36, SD =315.60) and the control group (M=293.79, SD =223.18).
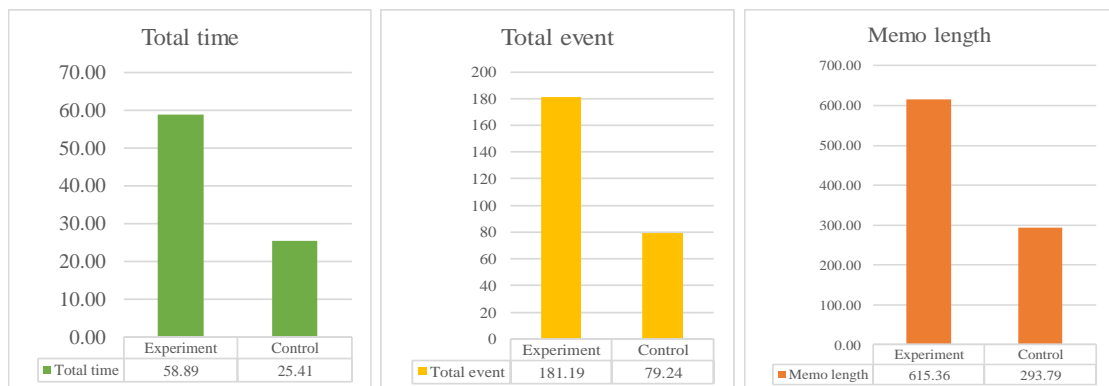
Figure 4. The results of learning behaviors.

6. Conclusions

Within the context of language learning in higher education, this study aimed to examine the effectiveness of a knowledge sharing-based e-book learning approach on students' learning performance and on facilitating class tasks involving cognitive skills. The results showed that using the knowledge sharing-based e-book system learning approach can help the participants' learning performance and enhance their learning behaviors. In the future, it would be worth exploring more research issues concerning the effects of e-books adopted in a real class setting with practical strategies for different aspects and subjects.

Acknowledgments

References

Akçapınar, G., Hasnine, M. N., Majumdar, R., Flanagan, B., & Ogata, H. J. S. L. E. (2019). Developing an early-warning system for spotting at-risk students by using eBook interaction logs. *Smart Learning Environments, 6*(1), https://doi.org/10.1186/s40561-019-0083-4.

Amineh, R. J., & Asl, H. D. (2015). Review of constructivism and social constructivism. *Journal of Social Sciences, Literature and Languages. 1*(1), 9-16.

Anderson, T., Rourke, L., Garrison, D. R., & Archer, W. 2001. Assessing teaching presence in a computer conferencing context. *Journal of Asynchronous Learning Networks, 5*(2), 1–17.

Aparicio, M., Bacao, F., & Oliveira, T. (2016). An e-learning theoretical framework. *Journal of Educational Technology & Society, 19*(1), 292-307.

Bada, S. O., & Olusegun, S. (2015). Constructivism learning theory: A paradigm for teaching and learning. *Journal of Research & Method in Education, 5*(6), 66-70.

Bakar, N. A., Latiff, H., & Hamat, A. J. (2013). Enhancing ESL learners speaking skills through the asynchronous online discussion forum. *Asian Social Science, 9*(9), 224.

Bakar, N. A., & Ismail, K. (2009). Using blogs to encourage ESL students. *Journal of Teaching and Learning in Higher Education. 1*(1), 45-57.

Boticki, I., Akçapınar, G., & Ogata, H. (2019). E-book user modelling through learning analytics: the case of learner engagement and reading styles. *Interactive Learning Environments, 27*(5-6), 754-765.

Chai, C. S., Wong, L. H., & King, R. B. (2016). Surveying and Modeling Students' Motivation and Learning Strategies for Mobile-Assisted Seamless Chinese Language Learning. *Educational Technology & Society, 19*(3), 170–180.

Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educational and psychological measurement, 20*(1), 37-46.

Council of Europe. (2001). Common European Framework of Reference for Languages: Learning, Teaching, Assessment. Cambridge University Press.

Godwin-Jones, R. (2011). Mobile apps for language learning. *Language Learning & Technology, 15*(2), 2-11.

Hwang, G.-J., Lai, C.-L., Liang, J.-C., Chu, H.-C., & Tsai, C.-C. (2018). A long-term experiment to investigate the relationships between high school students' perceptions of mobile learning and peer interaction and higher-order thinking tendencies. *Educational Technology Research and Development, 66*(1), 75-93.

Hwang, G. J., Sung, H. Y., Hung, C. M., Yang, L. H., & Huang, I. (2013). A knowledge engineering approach to developing educational computer games for improving students' differentiating knowledge. *British Journal of Educational Technology, 44*(2), 183-196.

Keengwe, J., & Onchwari, G. (2013). Fostering meaningful student learning through constructivist pedagogy and technology integration. *International Journal of Information and Communication Technology Education*, *7*(4), 1-10

Kiili, C., Laurinen, L., Marttunen, M., & Leu, D. J. (2012). Working on understanding during collaborative online reading. *Journal of Literacy Research, 44*(4), 448–483.

Kiyota, M., Mouri, K., Uosaki, N., & Ogata, H. (2016). AETEL: Supporting seamless learning and learning log recording with e-book system. *Proceedings of the 24th International Conference on Computers in Education.*

Kreijns, K., Kirschner, P. A., & Vermeulen, M. (2013). Social aspects of CSCL environments: A Research framework. *Educational Psychologist, 48*(4), 229-242.

Mor, Y., Ferguson, R., & Wasson, B. (2015). Learning design, teacher inquiry into student learning and learning analytics: A call for action. *British Journal of Educational Technology, 46*(2), 221-229.

Nakanishi, C., Ando, K., Nakanishi, H., & Suzuki, R. (2017). Analyzing Post-Reading Questions from the Viewpoints of Cognitive Skills. *Proceedings of the International Conference on EEE*.

Nokelainen, P., Miettinen, M., Kurhila, J., Floréen, P., & Tirri, H. (2005). A shared document-based annotation tool to support learner-centered collaborative learning. *British Journal of Educational Technology, 36*(5), 757-770.

Ogata, H., Yin, C., Oi, M., Okubo, F., Shimada, A., Kojima, K., & Yamada, M. (2015). E-Book-based learning analytics in university education. Proceedings of the 23rd International Conference on Computers in Education. China: Asia-Pacific Society for Computers in Education.

Powell, K. C., & Kalina, C. J. (2009). Cognitive and Social Constructivism: Developing Tools for an Effective Classroom. *Education, 130*(2), 241.

Rau, P.-L. P., Chen, S.-H., & Chin, Y.-T. (2004). Developing web annotation tools for learners and instructors. *Interacting with Computers, 16*(2), 163-181.

Thornbury, S. (2016). Communicative language teaching in theory and practice. *The Routledge handbook of English language teaching* (pp. 242-255): Routledge.

Analysis of Student Behaviors in Programming Exercises in Controlled and Natural Environments

Thomas James TIAM-LEE[*] **& Kaoru SUMI**
Future University Hakodate, Japan
*g3117002@fun.ac.jp

Abstract: We performed an analysis of the behaviors of novice students while solving programming exercises from data collected in two environments: a controlled laboratory setup and an online system that could be used freely in the wild. We modeled student behavior from raw action sequences using hidden Markov models to capture the sequential information of the problem solving process. We found similar sequential structures between the two environments, with students generally starting from being idle, followed by writing of the code, followed by testing and submission, which may then transition back to an idle state if not successful. While the models were similar, we found evidences of less persistence in solving the problems on students using the online system compared to those in the controlled setup.

Keywords: Student modelling, learning analytics, programming

1. Introduction

Tutoring is considered to be one of the most effective ways to learn (Bloom, 1984). Because of this, there has been significant research interest in intelligent tutoring systems (ITS) that can replicate aspects of human tutoring. A core part of these systems is being able to keep track of a student model, so that the system is able to respond in a personalized way to the needs of the student. However, many ITS are developed and evaluated on data from controlled laboratory experiments, and it is often difficult to determine if findings are reproducible in natural learning environments.

A recent study on ITS design has found that findings from a controlled laboratory experiments contradicted with those of a same experiment performed in a more natural setting (Kumar, 2019). This is of particular interest to researchers because it is important for findings to be reproducible in order to have a real impact in solving societal problems (Drummond, 2009). Thus, there is value in understanding the differences between controlled and natural settings in various domains.

In this study, we focused on the specific learning domain of programming. In our previous studies, we developed a simple intelligent programming tutor that offers guides and adjusts problems based on the presence of confusion on the student (Tiam-Lee & Sumi, 2018) and made classifier models to predict various student emotions in programming from face features and logs (Tiam-Lee & Sumi, 2019). In these studies, datasets were collected from and evaluated on controlled laboratory setups. Our motivation for this paper is to take a step towards understanding the similarities or differences in how students interact with such systems in controlled and natural programming environments. To achieve this, we modeled student solving behaviors from raw action sequences using hidden Markov models using data from a controlled laboratory setup and a natural online system that could be used freely by students. We present a comparison of the models of the student learning behaviors between the groups, and discuss its implications in future research.

2. Data Collection Methodology

In this section, we describe the two programming environments from which we collected our data for analysis. The first environment followed a controlled laboratory setup, while the second environment was an online system that was used by students freely.

2.1 Environment 1: Controlled Laboratory Setup

For the controlled laboratory setup, we used data collected from an observational setup. We recruited 73 students who were all enrolled in a university introductory programming class at the time. Each student was asked to participate in a simulated programming session in which they must solve several coding exercises while a video recording of their face and their activity logs were saved for analysis.

Before the session, each student underwent a briefing phase in which details of the data collection process was explained. The student was also informed that a video camera would be recording their face and all of their activity logs would be saved throughout the duration of the coding session. Thus, in this environment, each student was aware that his or her actions would be observed and analyzed. Each student was asked to sign an informed consent form, indicating that he or she agreed to participate in the session voluntarily.

After the briefing, the student started the programming phase. In this phase, he or she must solve coding exercises. There are a total of nine exercises that increased in difficulty. The exercises covered introductory programming concepts such as variables, expressions, if-else statements, loops, and arrays. All students used the same set of exercise. In each exercise, the student must write the body of a function that performs a specified task. For example, one of the exercises required the function to return the area of a square, given the measurement of one of its sides as an argument.

A custom local application was developed to serve as an interface for the students to write their programs. This application provided an interface for the students to view the exercise specifications, write the code, test the code by providing user arguments, and submit the code for checking. Submitted codes can automatically evaluated by running it on a set of pre-defined test cases. In addition to these, the application also records a video of the student's face and saves all activity logs, which included information on document changes, compilations, and submissions. A screen shot of the application is shown in Figure 1. Each student used the system for 45 minutes or until all exercises were solved correctly. Exercises must be solved sequentially with no option to skip.

2.2 Environment 2: Online System in the Wild

To represent data coming from an uncontrolled setup, we used data collected from an online system for programming practice that we have deployed for freshmen students as a supplementary tool for their introductory programming class. The data was collected over a month in the latter part of the semester, from June 2018 to July 2018. The online system was introduced to all students enrolled in the introductory programming class of Future University Hakodate in that month as an online tool for them to hone their programming skills. None of the students were enforced to use the system, so all usage was on a voluntary basis. 96 unique users used the system in total by the end of the period.

Each student was given a unique account that they could use to log into the online system. The online system worked very similarly to the programming session application used in the controlled observational setup discussed in the previous section. In this system, students could solve exercises in which they have to write the body of a function that performs a specified task. The system provides an interface to view the exercise specifications, write code, test code by providing user arguments, and submit code for checking. Submissions are automatically checked as well.

Students could select from various categories of exercises in this system, but all of them follow the same format of writing the body of a function to satisfy specifications. When a user successfully solves a problem, he is taken back to the selection menu and a new one could be selected. Unlike the controlled setup, the student could at any time give up on a problem and select a different one if he wished to. As can be seen in a screen shot of the online system showing the interface for performing the programming exercise in Figure 2, the online system shares an almost identical interface with the

application used in the controlled setup. Unlike the controlled setup, the users' video recordings were not saved and they were not conscious their system actions were being logged.
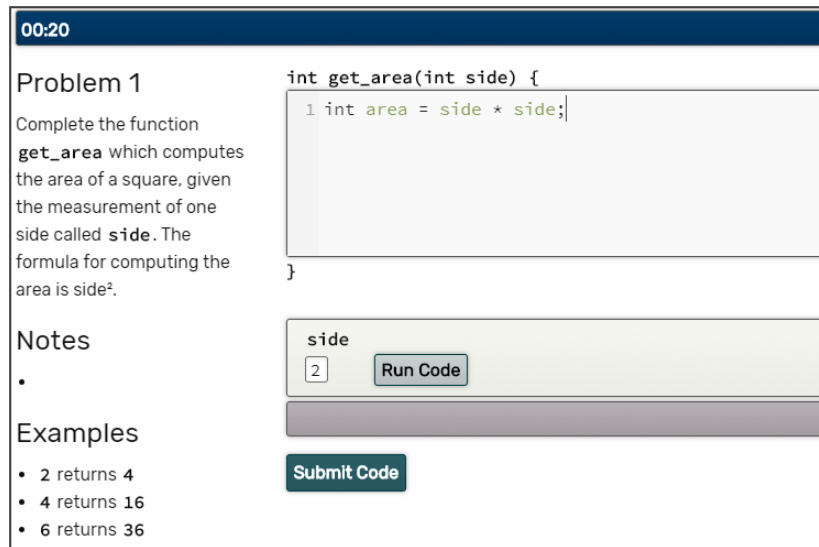
Figure 1. Screen shot of custom application for controlled laboratory environment setup.
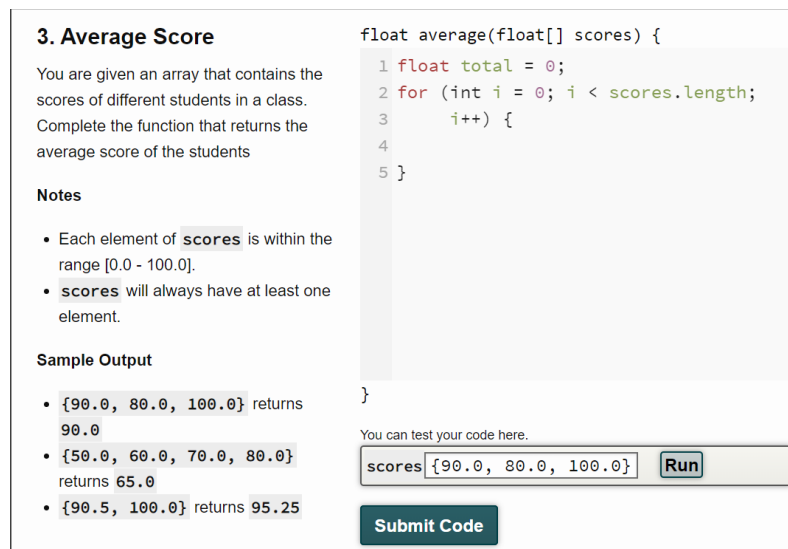
Figure 2. Screen shot of online application in the natural environment setup.

3. Modelling Student Behavior

In this section, we discuss how we modeled the student behaviors in solving programming exercises. We chose a hidden Markov model (HMM) in order to capture the time-sequential nature of coding tasks, which involve actions such as modifying the code, thinking, and compiling to test the program.

3.1 Hidden Markov Model

A hidden Markov model is a statistical Markov model that can be used to describe observable events and hidden events. Observable events are a set of directly observable occurrences in the data, while the hidden events are hidden factors that are considered to be casual factors for the probabilistic model. An HMM is composed of a set of states $Q = \{q_1, q_2, \ldots, q_N\}$, with each state having an emission probability for each observation $O = \{o_1, o_2, \ldots, o_T\}$. In this case, the observations are the individual actions in the Markov chain, while the states are the hidden factors that cause such actions.

As the HMM is based on a Markov chain, it follows the Markov assumption that the probability of a particular state q_i depends only on the previous state. Furthermore, the probability of an observation depends only on the current state and not in any other states or observations in the sequence:

$$P(q_i \mid q_1, ..., q_{i-1}) = P(q_i \mid q_{i-1})$$

$$P(o_i \mid q_1, ..., q_i, ..., q_L, o_1, ..., o_i, ..., o_L) = P(o_i \mid q_i)$$

The HMM also contains a transition probability matrix containing the probabilities of transitioning from one state to another, and an initial probability distribution for which state the model starts in. The transition probabilities and emission probabilities can be estimated from a set of training data where each instance in the set is a sequence of observations from O using an algorithm called the Baum-Welch algorithm. Given an HMM, it is also possible to compute the likelihood that a given observation sequence is generated by the model using the forward algorithm. A good summary of hidden Markov models can be found in Appendix A of Martin & Jurafsky (2009).

3.2 Sequence Extraction from Activity Logs

We represented student coding behaviors as a sequence of actions that are performed in the process of solving a coding exercise. We extracted these actions from the activity logs collected from the programming environments. All events were marked with a timestamp. Figure 3 shows an example of an action sequence extracted from the activity logs.
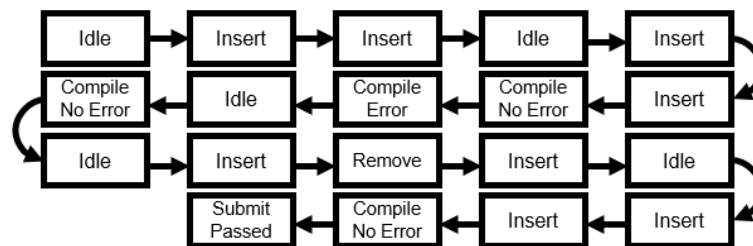
Figure 3. Example action sequence from student log data.

Compilations represent points in the session where the student tested the code by providing some arguments. A compilation may result into a successful compilation (i.e., no syntax errors) or an unsuccessful compilation (i.e., with syntax errors). A successful compilation did not necessarily mean that the code was correct, as it was possible to have a syntactically correct code that did not accomplish the target task. Submissions, on the other hand, represent points in the session where the student attempted to submit the code for checking. This may result into either a "submission passed" (i.e., the code is correct and passed all test case) or a "submission failed" (i.e., code failed at least one test case).

Typing information is captured with the "insert" and "remove" actions. We considered a typing sequence as a series of document changes with intervals of at most 3 seconds in between. Typing action was classified as "insert" or "remove" based on how many characters were inserted and deleted within the typing sequence. If there were more characters inserted, we considered the action as the student adding more to the code. If there were more characters deleted, we considered the action as the student removing parts of the code. Ties are resolved in favor of the "insert" classification. Although this metric has limitations as it does not capture the semantic information of the code, it is a good enough heuristic for the general type of action being performed in this analysis.

Finally, an "idle" action is added when the student did not perform any actions in the system for at least 10 seconds. These actions represented long pauses in the action sequence, which may represent the student thinking, reading the problem, or even being unfocused. Only a single "idle" action is added to the sequence regardless of the length of inactivity.

3.3 Model Training

We trained an HMM with a fully-connected structure for each of the two datasets (laboratory-controlled and natural environments) using the Baum-Welch algorithm. Our HMM model is defined by the set of states $Q = \{q_1, q_2, ..., q_N\}$ and the set of observations $O = \{$idle, insert, remove, compile error, compile no error, submit failed, submit passed$\}$. The average number of observations in each sequence is 39.09 in the laboratory environment and 11.83 in the online environment.

We selected the number of hidden states N based on a ten-fold cross validation that maximizes the likelihood computed using the forward algorithm. We first divided the set of observation sequences into ten groups. In each fold, one group served as the validation set while the others served as the training set. We trained an HMM using the training set from randomly initialized values. To account for the randomness, each training process was repeated 5 times, each time having different random values, and the model that maximizes the probability of the training set to be generated by the model was selected. Once the model was trained, we computed the likelihood of the validation set being generated by the model, and got the average across all the folds. We computed this for N = 2, 3, ..., 10 hidden states and selected the best number of states based that information. Figure 4 shows the mean log-likelihood score across folds across different values of N.

We selected N = 5 as the number of hidden states for both the laboratory and online datasets since the improvement in the log-likelihood significantly decreases beyond N = 5. We generally prefer to have less states for easier visualization and understanding of the model. From this, we estimated the model parameters from the training data using N = 5 using the Baum-Welch algorithm.
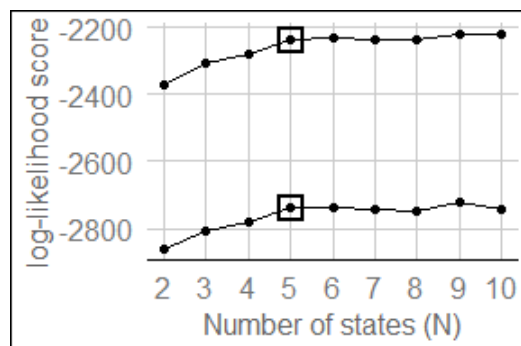
Figure 4. Log-likelihood score for different values of N.

4. Results

In this section, we discuss the resulting HMMs trained from our datasets. Figures 5 and 6 show graphical representations of the HMMs trained from the action sequences extracted from the controlled laboratory environment setup and the online system natural environment setup, respectively. Each node in the graph represents a single state in the model. The directed edges represent the transition probabilities from one state to another. While an HMM normally has a non-zero probability to transition from every pair of states, only transitions with substantial probabilities over 15% are shown for clarity. In each state, the emission probabilities for each of the coding actions are shown when the model is in that particular state. All values are rounded off to 2 decimal places. We manually placed a loose label to describe each state based on the emission probabilities, shown on the lower-left corner of each node. This helps in getting a contextual understanding of the model as well as for easier discussion in this paper.

4.1 HMM for Controlled Laboratory Setup

The states in the HMM for the controlled laboratory setup appeared to represent different parts of the coding process. In the "mostly idle" state, the most probable action is being idle (72%). This state represents moments of inactivity in terms of interaction with the system. In the "building code" state, the most probable action is inserting characters into the code (80%), and likely represents moments where the student building modules of the code. On the other hand, the "modifying code" state contains

a mixture of character insertions (65%) and removals (18%), with a small chance of idle (8%) actions. This state likely represents modifying parts of the code. The "testing" state has a mixture of compilations and typing actions. It could represent moments of testing the code, or finding and fixing bugs revealed by running tests on the code. Finally, the "testing and submitting" state has relatively high emissions for compilations and submission actions, which could represent moments of verifying the correctness of the code and submitting it.

The initial probability distribution for this HMM puts the probability of starting in the "mostly idle" state at 96%. This was expected, as the students mostly take the time to read the problem specifications first before writing any code. From the "mostly idle" state, students likely transition to the "building code" state. Students may move between the "building code" and "modifying code" states back and forth. Both "building code" and "modifying code" states are relatively persistent states, having a fairly large probability of spanning through several actions (i.e., transitioning to itself). From these states, the student may transition to the "testing" state and eventually the "testing and submitting" state, which represent actions wherein the students are evaluating the correctness of the code that they have built. There are also strong transitions from these states back to the idle state, likely because students take the time to process the result of a compilation or submission (e.g., thinking about why results were unexpected).
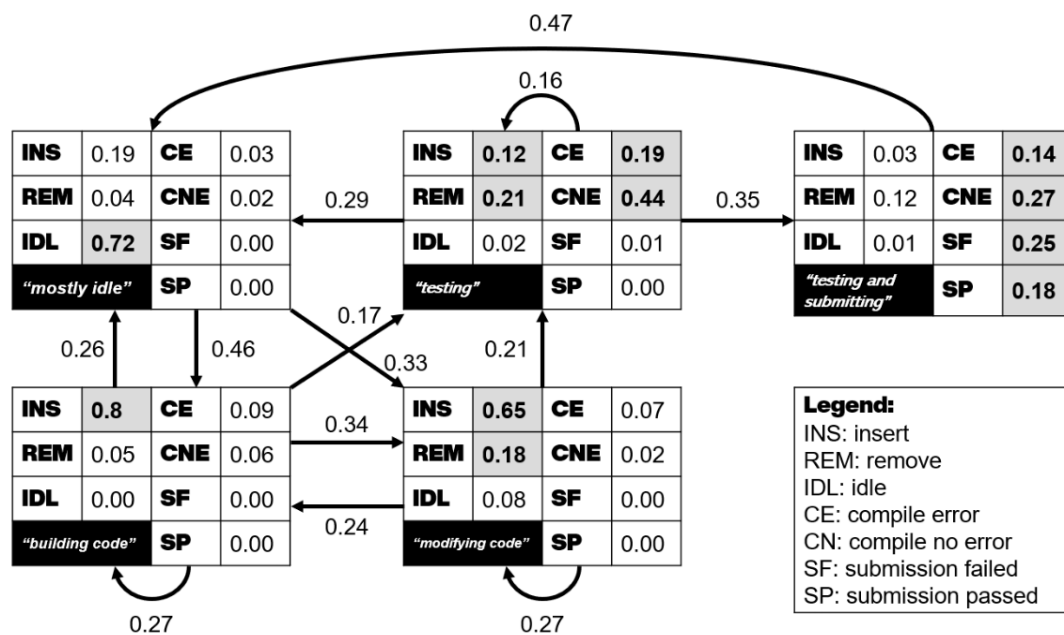
Figure 5. Hidden Markov model for online system natural environment setup showing emission probabilities and transition probabilities at least 15%. All values are rounded off to two decimal places.

4.2 HMM for Online System in the Wild

Interestingly, the HMM trained from the action sequences extracted from the online system dataset yielded similar states to the HMM trained from the laboratory setup, despite being both trained from random initial model parameters. One state appears to be a "mostly idle" state, with a high emission probability for the idle action (85%). There are two similar states, which we both labelled as "building code" states, in which high emission probabilities for character insertion could be observed (88% and 81%). There appears to be not as much removal actions in this model compared to the previous one, which suggests that modifications of the code did not occur as strongly as it did in the laboratory setup. Similar to the previous model, however, there was also a state that likely represented "testing" of the code, with emissions of compilations and typing actions, as well as a state the likely represented "testing and submission" of the code, with emissions for compilation and submission actions.

Similar to the laboratory setup, the initial probability distribution of this model has a high probability (71%) of starting on the "mostly idle" state. However, there was a fairly high chance (23%)

of starting on the "building code (2)" state as well. This suggests that unlike the laboratory setup, students don't take as much time reading the problem before starting to execute some typing actions.

While the states' emission probabilities suggest similar hidden events for both of the environments, one noticeable difference is on the transition probabilities of the model. While both "building code" states are similarly persistent to their counterparts in the laboratory setup model, there is a noticeable lack of strong transitions from these states to the "testing" state. This reveals that in the online system, there was weaker evidence found that students moved towards the testing and submission phase.
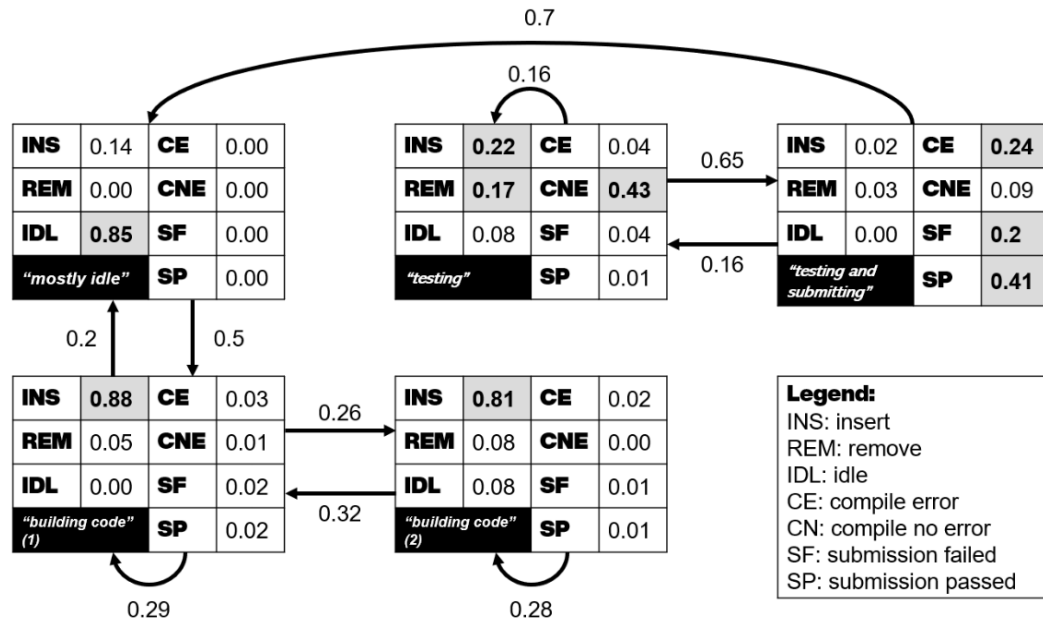
Figure 6. Hidden Markov model for online system natural environment setup showing emission probabilities and transition probabilities at least 15%. All values are rounded off to two decimal places.

4.3 Usage Statistics

The online system was used in substantially more sessions than the laboratory setup (note that the number of participants in the latter is fixed). In the laboratory setup, we recruited a total of 73 students which yielded a total of 468 sessions. In this case, a session refers to a single problem attempted by a student. On the other hand, the online system was used by 96 unique users with a total of 2,259 sessions.

Although the HMMs capture sequential information of the coding sessions, it does not provide information on the length of the sequences. In order to further investigate the differences between the controlled laboratory and online system setups, we analyzed the number of actions in each sequence for each of the two environments. Figure 7 shows a side by side boxplot comparing the sequence lengths. For the controlled laboratory setup, the mean is 39.09 actions and the median is 19 actions, while for the online system the mean is 11.83 actions and the median is 7 actions.
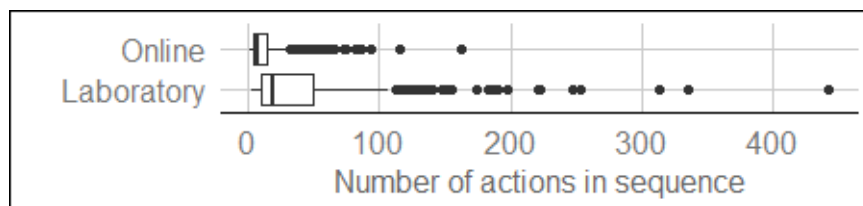
Figure 7. Number of actions in the sequences collected from the two environments.

Despite being used in more sessions, the number of actions performed in a single session was noticeably less in general in the online system compared to the controlled laboratory setup. This is also

likely related to why there was a weaker transition to the testing states in the HMM for the online system, as students tend to give up and quit earlier resulting into generally shorter sessions.

Another interesting data to look at is the distribution of the number of sessions for each unique student that used the online system. This is shown in Figure 8. Majority of the users only used the system for one time or only a few times. On the other hand, there are fewer students used the system constantly and did a lot of sessions. This reveals differences on students' motivations to use a system in settings where they are not enforced to do so.
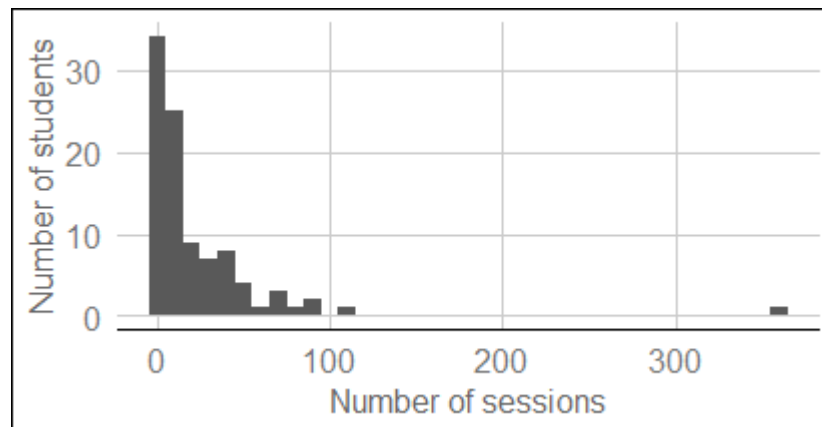
Figure 8. Distribution showing the number of sessions done by each unique user in the system.

5. Discussion

In this section, we discuss the main findings in this study and its implications in education-related research.

We have used HMMs to model freshmen students' coding behaviors while solving introductory programming exercises. These models can be used to gain an understanding of the general trajectories of actions undertaken by students when solving exercises. In the HMM models, the problem solving process were broken into logical states such as building the code, testing the code, and being idle. From the models produced, we could understand that a problem solving session usually starts with an idle state, followed by a moment of building the code, followed by a moment of testing or debugging, which may either result in a correct submission or move back to the idle state.

Such models can also have applications in artificial intelligence in education. For example, a series of actions could be mapped to sequence of states using an algorithm like the viterbi algorithm. The viterbi algorithm takes in an observation sequence as input and estimates the most probable sequence of hidden states that generated that sequence. Using this algorithm, contextual information could be estimated from raw action sequences, allowing for a better a student model. This contextual information could then be used to improve how intelligent programming tutors provide personalized feedback while the student is solving programming exercises. Currently, we only focused on action sequences and solving behaviors, but there is a possibility of using other modalities such as facial information to model emotions while doing programming exercises, thus allowing for the development of affective programming tutors that can respond emotionally to students without special and often invasive equipment.

In this study, we have also performed a comparison of students' coding behaviors between a controlled laboratory setup and an online system that could be used freely. Although there were many similarities between the two models, there were some transitions that were weaker in the online setup. In particular, students appeared to be less persistent in solving the problems and thus did not make as much effort to modify, test, and submit their code. This finding has implications on research being done in the field.

Researchers should always consider that students' behavior in controlled laboratory setups may not always be exactly the same when studies are reproduced in an uncontrolled natural environment. In this particular study, there are certain conditions that are present in the laboratory setup which were not present in the online system environment. The students were conscious that their actions were being

recorded in the laboratory setup. Furthermore, students who participated in the laboratory setup voluntarily committed to participate for a set duration of time, as opposed to those who used the online system who could use the system freely as they wished. Students were also allowed to complete the exercises in the order they wished in the online system, while exercises had to be solved sequentially in the controlled laboratory setup. These differences are often overlooked when drawing conclusions from studies that are performed in controlled environments. Thus, when student models are trained heavily on data from controlled laboratory setups, researchers must consider those models are acceptably representative of students in natural environments as well.

6. Conclusion and Future Work

In this paper, we presented an analysis of student behaviors in programming exercises using HMMs, and compared models trained from data in a controlled laboratory setup with that trained from data in a natural environment. Our findings show that while the models are similar, there are evidences of less persistence in solving the problems in the online setting. Such differences highlight the need for researchers to consider the reproducibility of findings from controlled setups to more natural environments. Currently, we have only used simple units of actions in this study to analyze the behavior of students in programming activities in this study. More in-depth features such as types of errors and the classification of different phases and events during the programming sessions could be done as next steps for those who are interested in a more detailed analysis of the session data.

Acknowledgements

References

Bloom, B. S. (1984). The 2 sigma problem: The search for methods of group instruction as effective as one-to-one tutoring. Educational researcher, 13(6), 4-16.

Drummond, C. (2009). Replicability is not reproducibility: nor is it good science.

Kumar, A. N. (2019, June). Providing the Option to Skip Feedback–A Reproducibility Study. In International Conference on Intelligent Tutoring Systems (pp. 180-185). Springer, Cham.

Martin, J. H., & Jurafsky, D. (2009). Appendix A. Speech and language processing: An introduction to natural language processing, computational linguistics, and speech recognition. Upper Saddle River: Pearson/Prentice Hall. Retrieved from https://web.stanford.edu/~jurafsky/slp3/A.pdf

Tiam-Lee, T. J., & Sumi, K. (2018, June). Adaptive feedback based on student emotion in a system for programming practice. In International Conference on Intelligent Tutoring Systems (pp. 243-255). Springer, Cham.

Tiam-Lee, T. J., & Sumi, K. (2019, June). Analysis and Prediction of Student Emotions While Doing Programming Exercises. In International Conference on Intelligent Tutoring Systems (pp. 24-33). Springer, Cham.

Measuring Analysis Skill in Data-informed Self-directed Activities

Yuanyuan YANG[a*], Rwitajit MAJUMDAR[b], Huiyong Li[a], Gökhan AKÇAPINAR[b], Brendan FLANAGAN[b] & Hiroaki OGATA[b]
[a]*Graduate School of Informatics, Kyoto University, Japan*
[b]*Academic Center for Computing and Media Studies, Kyoto University, Japan*
*44.yangoo@gmail.com

Abstract: Current technology enables tracking of various learning and physical activities. User can use the data to analyze issues in the execution of those activities. Current work focuses on this analysis phase of data-informed self-directed activity cycle and proposes a measurement framework of the skill while learners work in a data-rich context. It is a paradigm shift to support and measure analysis skill from previous approaches which mostly rely on questionnaire-based measurements. In our approach, we emphasize the monitoring of learner's analytical process and the automatic evaluation of the analysis results through system. Based on that, an automated measurement is carried out in the system to depict learner's analysis skill and changes of skill. Additionally, we elaborate the framework in the context of the GOAL system which provides affordances of analysis based on physical and reading activity data.

Keywords: Data analysis, Quantified-self, Self-directed learning, Self-direction skills, Automated skill measurement, GOAL

1. Introduction and Background

Various frameworks for the 21st century learning consider self-direction skill (SDS) is a necessary skill for learners (P21 framework, 2015; enGauge 21st century skills 2003; SCANS report 1991). According to Knowles (1975), Self-Directed Learning (SDL) is described as "a process in which individuals take the initiative, with or without the help from others, in diagnosing their learning needs, formulating goals, identifying human and material resources, choosing and implementing appropriate learning strategies, and evaluating learning outcomes". Researchers also propose different models to understand the process of SDL, such as Candy's model (1991) comprises personal autonomy, self-management, learner-control, and autodidaxy. Garrison's model (1997) contains self-management, self-monitoring, and motivation. Loyens, Magda, and Rikers (2008) point out that SDL generally entails goal setting and task analysis, implementation of the constructed plan and self-evaluation of the learning process.

We notice that both learning and physical activities play an important role in students' life and being self-directed is important in those contexts. For example, developing a habit of running one hour every day and a habit of reading one hour every day, both of them require individuals to choose appropriate strategies, to monitor process, to evaluate outcomes and so on. In our research, we pay our attention to learner's daily life and focus on self-directed activities in learning and physical activity contexts.

Moreover, with the current e-learning tools and wearable devices, tracking and logging learning behaviors and physical activities has become more affordable. It provides us a chance to search for data-driven way to support execution and acquisition of learner's SDS. We proposed a process model called DAPER (Data Collection – Data Analyze – Setting Goal and Plan – Execution and Monitoring - Reflect) for execution of data-informed self-directed activity and acquisition of the sub skills (Majumdar et.al., 2018). The five phases in the model relates to the five subskills of being self-directed. We developed GOAL (Goal Oriented Active Learner) system based on DAPER model, as a technology support for promoting learner's SDS.

This paper focuses on the Data Analysis phase of the DAPER model showing in figure 1. Analysis phase requires learners to get aware of their own situation, trend and current skill level by checking and comparing the collected data of an activity context. It is a crucial precondition of setting

meaningful goals and feasible plans. In past researches, scholars have proposed some useful strategies to help improve students' SDS. For example, Diclemente and Proschaska (1998) designed guideline for it, which contains various items to help people recognize their possible problematic behavior. However, such strategies don't take the affordances of the current e-learning tools and often can't be directly adopted for implementing in an e-learning system. In our work, we provide strategies within digital environment, which asks the learner to analyze their own activity data synthesized in the GOAL system. Figure 1 highlights data analysis phase in DAPER model and learner's analysis task in this phase.
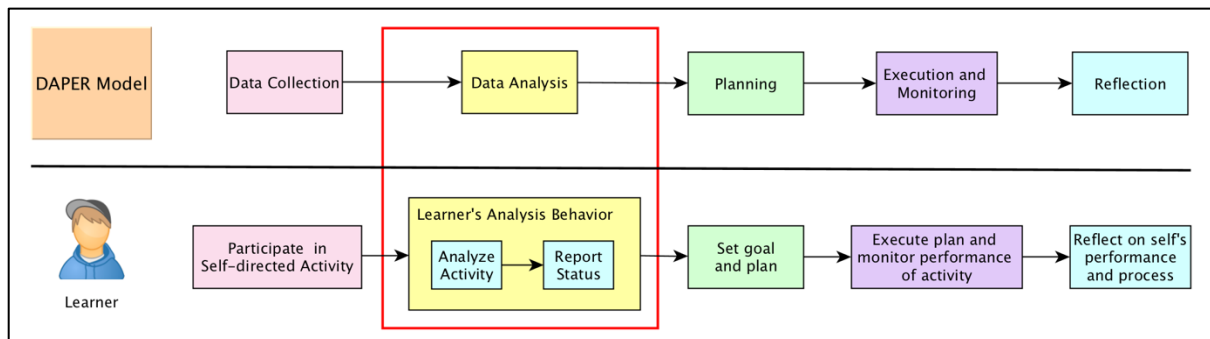
Figure 1. Data Analysis Phase and Analysis task of learner

Based on previous literature, we elaborate our notion of Data Analysis as a sub-skill of Self-directedness. Then we propose our framework to answer the following research question: *How to measure data analysis skill of learners in a data-rich system?* We implement this framework in the GOAL system and demonstrate on simulated data.

2. Literature Review

2.1 Analysis Skill and Strategies of Analysis

Analyzing own activities is crucial for being self-directed in learning. Loyens, Magda, and Rikers (2008) consider that analysis happens in the starting point of SDL. They state that analysis in the practice of SDL is to analyze the task at hand and to determine the task (e.g., what is the task about?) and personal features (e.g., what knowledge can I apply? Do I find the task interesting?). In Thornton's research (2010), he mentioned analyzing needs and analyzing current skill in planning phase which is one phase in four phases of a self-directed learning cycle. Noguchi, J., and McCarthy, T. (2010) states that analytical skill is the ability to examine what happened in their learning process in detail and discern the cause and effect relationship among various elements involved in the process.

In order to achieve this objective, most common strategies are either suggesting learner following questions or hints to think and self-report. For example, Diclemente and Proschaska (1998) designed guideline that contains various items for helping learner to analyze. Curry, Wagner and Grothaus (1990) suggest learners think about their personal reason in analysis. M.E. Gredler and L. S. Schwartz (1997) designed questionnaire for helping learner to self-report. However, none of them is able to observe learners' analysis behavior itself but only relies on their self-report.

In DAPER model, we treat analysis as the second phase of any self-directed activity. The learner is required to analyze their activity data for understanding their own status. By using the system affordances, the learners can complete specific analysis task with their activity data and identify their own status.

2.2 Measuring Data-analysis skill as a Sub-skill of Self-directedness

To help learner to acquire skill, one needs to measure and estimate current skill level. To measure SDS, interview and questionnaire were widely used in past research. In Williamson's research (2007), SRSSDL (the self-rating scale of self-directed learning) is used as the instrument to measure the level of self-directedness in learner's learning process. It covers five constructs, which are awareness, learning

strategies, learning activities, evaluation and interpersonal skills. Stockdale and Brockett (2010) designed PRO-SDLS (Personal Responsibility Orientation to Self-Direction in Learning Scale). Noguchi, J., and McCarthy, T. (2010) asked advisors of learners to speak their thinking process out while they are evaluating and deciding final grades for the submitted module work of their students and he recorded the think-aloud sessions. A list of the criteria of grading was made on that record in this research. These survey- or questionnaire-based evaluations give score on learners' answers for rating learners' skill. Measuring analysis is covered by some items in the scales. For example, in Williamson's scale (2007), the item in 3.10 asks students to rate their ability to analyzing new ideas, information or any learning experiences. Too many items in the scale would overload the learners while rating the skill. And it significantly relies on learners' memory but not their actual analysis behavior.

In our research, we explore the possible way to automatically measure learners' analysis skill from their actual performance in analysis task as a part of the self-directed activity and performing a real-time track on their skill's changing. Automated measurement based on performance would eventually be a more seamless experience for learners comparing with past researches.

3. Framework for Skill Measurement of Data Analysis Skill

Based on the previous works and contextualizing it for a data-rich environment, we set the objectives of analysis skill of learners. In the analysis phase of DAPER model, the individual needs to check their collected data in a specific context, then analyze issues in their activities which can lead to planning phase to set appropriate plans to overcome those problems or pursue challenges. In this section, we describe our framework for analysis skill measurement.

3.1 Framework and Data Flow

Figure 2 shows the overview of the components of our framework for analysis skill measurement. Before analysis phase, learner should participate in self-directed activities in learning or physical context.

The framework contains 4 components. The first component provides analysis function that allows learners to analyze their activity with the help of system. The second component is to gather data while learner is using analysis functions in the system. Two kinds of data are gathered, learner's interaction log and their analysis report. The third component is the system analysis. In automatic analysis, activity data compares with criterion to report status of learner's activity. Based on that, the system analysis component classifies whether an individual has problems. The last component rates skill from learner's interactions, learner's report, system report, and the scale of analysis skill.
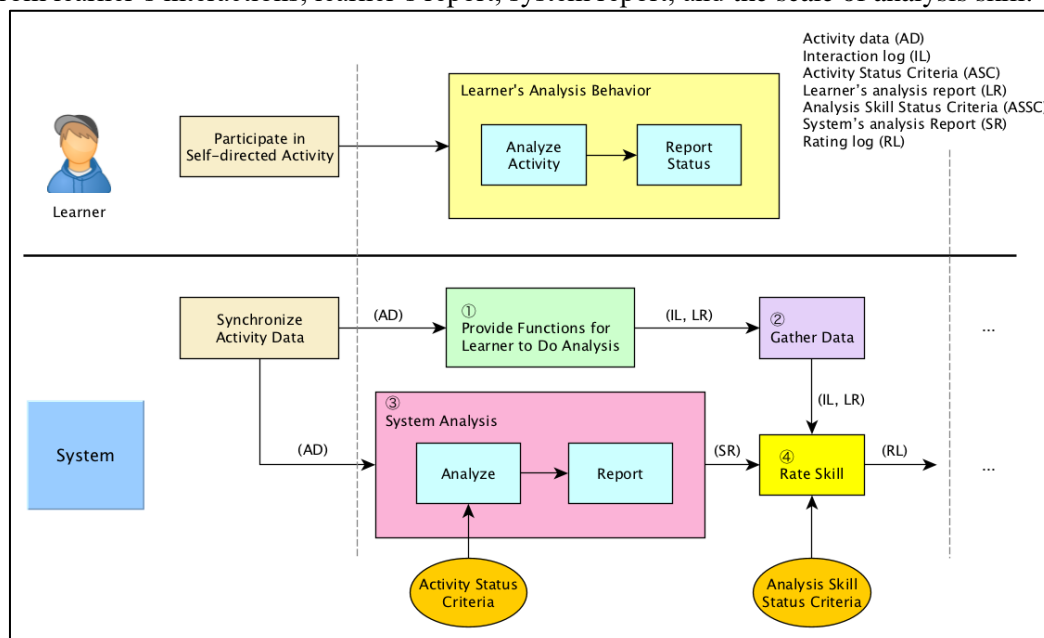
Figure 2. Framework for Analysis Skill Measurement and Relation to Learner's Behavior

343

3.2 Data Model and Criteria

Our method advocates automatic data gathering and calculating for skill measurement by the system. This section describes what kind of data the system will gather and use for calculation.

Table 1 describes the five kinds of data and the two types of criteria in our measurement. Activity Data (AD) is collected automatically from other data-logging platforms, such as, physical activity data from iOS Healthkit or Androids Google Fit, learning data from digital learning system. While the learners use the system to analyze their Activity Data, Interaction Log (IL) and the Learner's analysis Report (LR) are recorded. System's analysis Report (SR) are generated automatically by comparing Activity Data based on the Activity Status Criteria (ASC). Considering the interaction log, the learner's report and the system's report and comparing to the Analysis Skill Status Criteria (ASSC), the Rating Log (RL) is generated by the system.

Table 1 *Data Model and Criteria*

	Description	Sample	Relation to Analysis
Activity data (AD)	A specific activity, which might be a physical activity or a learning activity.	One walked 4000 steps in 2019/5/15.	Object of analysis
Interaction log (IL)	Interactions while learner do analysis in the system.	One checked his activity data for last 7 day in 2019/5/12 on the system.	Process of doing analysis by using system's features
Activity Status Criteria (ASC)	Criteria for analyzing learners' activity	Tudoe-Locke C.'s (2008) zone-based hierarchy on daily steps	Help to get result from analyzing activity data
Learner's analysis report (LR)	Contents that learner reports their analysis result.	One found himself lacking physical exercise.	Result of analysis as noted by learners
Analysis Skill Status Criteria (ASSC)	Criteria for rating learners' analysis skill	Criteria of SDS proposed by Majumdar. et.al. (2019)	Help to rate learners' analysis skill
System's analysis Report (SR)	Result of automatically analyzing activity data by the system	System distinguished one lacking physical exercise	Result of analysis as computed by system
Rating log (RL)	Related data and result on rating analysis skill	Comparing results from the learner and system, rate the learner's skill based on the scale of analysis skill	Related to get analysis skill level

3.3 Implementation of framework in GOAL System

In the GOAL system, we implement this framework to automate the measurement of analysis skill. This section details how we implement each component in GOAL system.

3.4 Component 1: Functions for Analysis

Based on DAPER model, we developed GOAL (Goal Oriented Active Learner) system, which contributes to technology solutions of promoting learner's SDS (Self-Direction Skill). Learner's analysis behavior becomes observable and traceable through the GOAL system. It supports data logging of physical learning activities.

We provide visualized graphs for learners which allows them to check their own activity status. We consider from Williamson's (2007) and Noguchi, J., and McCarthy, T. 's (2010) research. In Williamson's (2007) research, strategy is considered as an important element of analysis. In order to understand self's status, we suggest learner comparing their own data with other related data as one of strategies in analysis phase. Hence, various options are designed in the graph, such as showing recommend value, or maximum, minimum, average value of all users' activity data, as shown in figure 3a. Noguchi, J., and McCarthy, T. (2010) mentioned that the key word "details" reflects learner's analysis skills. Details means how deep learner understand data. Checking detail data helps learner know the exact gap which relates to setting an effective plan. The graph showing in figure 3b provides function for exhibiting detail data of every related value.

Additionally, analysis report function shown in figure 3c, requires learners to report the result of their analysis and note the issue they have found. And learner can see system analysis result to compare their own analysis.
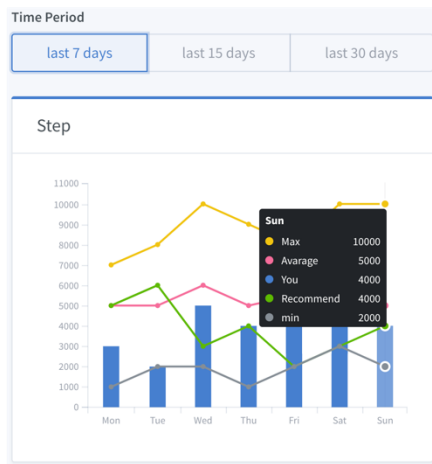
Fig 3a. *Visualized Data to analyze*
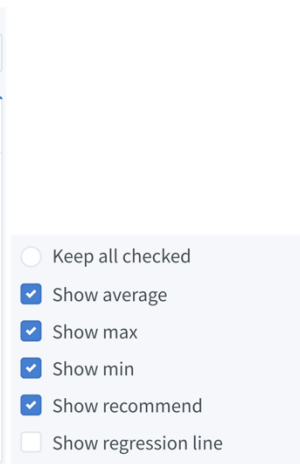
Fig 3b. *Details on Demand for Analysis*

Fig 3c. Record report and verify with system

Figure 3. the Analysis Page in GOAL System

3.5 Component 2: Data Gathering in Analysis phase

Two kinds of data are captured in the data gathering component. The first one is interaction logs when user using system's features, such as choosing an activity to analyze, clicking "show result" button to check system's analysis result. The second one is the content of report from using feature in Fig 3c.

3.6 Component 3: Analysis of Activity by System

To measure learner's analysis skill, our approach is to compare the student's analysis report with the system's analysis report regarding an activity. One can potentially implement various methods in this component by using statistical techniques or different machine learning approaches. To demonstrate we use a linear regression method for system analysis. Linear regression is a method used for explaining the relationships among variables. In our context, we hope to find out daily changes in physical activities and learning activities. We use following linear regression formula to express the relationship between activity and day.

$$Y_i = \alpha + \beta X_i + \varepsilon_i$$

Where i : the number of the data; α: the constant coefficient. β: the slope of the line, which reflect the tendency of the variation. X: the number of days. Y: the value of an activity in one day. ε: random disturbances and cannot be directly observed.

System does analysis on collected activity data in recent time period and calculate the coefficients of expression from it. Based on that we predict the value of activity in one day later than that time period. Next, we compare it with the criteria of the activity. Depending to different type of activity, we use different criteria. The criteria of the activity can come from other researches, for example Tudor-Locke, C.'s (2008) zone-based hierarchy for computing status of daily steps activities.

3.7 Component 4: Rating Analysis Skill

We aim to measure their analysis skill automatically by using technologies. The GOAL system captures data and calculates their skill level from that data. This section gives our data structure of rating log and approach for rating data analysis skill from the rating log.

Rating log keeps the unified record of the related computed values in component 2 for rating analysis skill and result of skill level. The related computed values contains count of interaction logs, learner's analysis result and system' analysis result. These data will be used for classifying the learner's analysis skill. Table 2 gives all of attributes of the log.

Table 2 *Attributes of Analysis Rating log*

Attributes	Description
id	Unique identifier of report
uuid	Whose activity belongs to
activity_type	Report for which activity
count_interaction	The count of interaction logs while the learner is analyzing
check_sys_result	Whether system analysis result has been shown before learner report the result
self_result	Result from learner doing the report 0: bad, 1: poor, 2: fair, 3: good, 4: excellent
system_result	Result from system analyzing learner's activity data 0: bad, 1: poor, 2: fair, 3: good, 4: excellent
skill_level	The result of rating analysis skill
date	When learner did report

On the other hand, we introduce criteria of analysis skill shown in the first two columns of table 3 (Majumdar. et.al. 2019), which contains five levels to describe different analysis skill. In addition, we give more specific logic expression on it shown in the third column of table 3.

Table 3 *Scoring Rubric for Analysis Skill*

Score	Analysis behavior	Logic expression
4	Check data - Successfully identify status WITHOUT system support	$N_1 > 0$ && $N_2 > 0$ && $(R_1 == R_2)$ && S
3	Check data - Successfully identify status WITH system support	$N_1 > 0$ && $N_2 > 0$ && $(R_1 == R_2)$ && $!S$
2	Check data - PARTIALLY identify status	$N_1 > 0$ && $N_2 > 0$ && $(R_1 != R_2)$
1	Check data - DID NOT identify status	$N_1 > 0$ && $(N_2 == 0)$
0	DID NOT Check data	$N_1 == 0$

Where N_1: Count of interaction logs; N_2: Count of learner's analysis reports; R_1: Result of learner's analysis report; R_2: Result of system report; S: Boolean data, whether system analysis result has been shown before learner report his result.

4. Demonstration with Pilot Data

In this section we present an illustration of our framework in a data-informed self-directed activity by picking one kind of activity to explain how the framework works and what the result would be.

4.1 Sample of Activity Data and System Analysis

The GOAL system collected physical and learning activity data of 15 learners. We select a set of daily steps data from a male master student which is most complete. It had 183 records of the daily steps from April 1, 2018 to September 30, 2018. The daily steps data ranges from 1490 to 55903. Mean of sample

is 12265.85, and the sample standard deviation is 8467.808. The data set in each month and the regression line is shown in figure 4.

On the other hand, we introduce the criteria of adults' daily steps proposed by Tudor-Locke, C. (2008), which classified adults into 5 status: 1) < 5000 steps/day (sedentary); 2) 5000–7499 steps/day (low active); 3) 7500–9999 steps/day (somewhat active); 4) ≥10,000–12,499 steps/day (active); and 5) ≥12,500 steps/day (highly active). At the end of each month, system executed a linear regression on the data for that month and got the regression coefficients shown in table 4. According to these coefficients, the system predicted the value of the next day of the data set. Then comparing it with the criteria of adults' daily steps, system computed the status of his physical activity in each month.
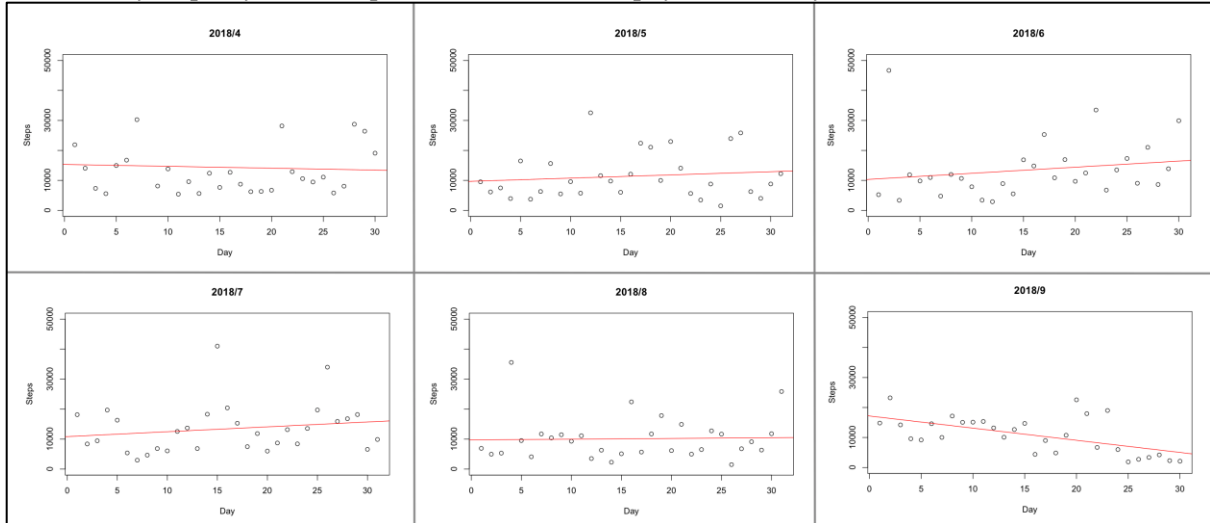
Figure 4. Daily Steps over 6 Months along with Regression Line

Table 4 *Coefficients and Result Analyzed by System*

month	α	β	predicted value	system_result
2018/04	15327.01	-62.93	13376.18	5
2018/05	9670.4	107.7	13116.8	5
2018/06	10327.7	203.8	16645.5	5
2018/07	10816.7	163	16032.7	5
2018/08	9723.11	24.59	10509.99	4
2018/09	17172.9	-405.7	4596.2	1

4.2 Simulated Interaction Logs and Rating Report

At the time of writing this paper the interaction logging module was under development. Hence, we simulated analysis interaction data for the same student and the same activity shown in table 5. By comparing with system analysis result and the criteria of analysis skill level, system got this student's skill level in each month (see table 5).

Table 5 *Rating Report*

id	date	count_ interaction	check_system_ result	self_result	system_result	skill_level
1	2018/4/30	0	0	0	5	0
2	2018/5/31	15	0	0	5	1
3	2018/6/30	15	0	3	5	2
4	2018/7/31	14	0	3	5	2
5	2018/8/31	10	1	4	4	3
6	2018/9/30	12	1	1	1	3

From the results we can see, this student didn't have awareness of analyzing his own status at first. Then, his analysis skill keeps improving over the next five months.

5. Conclusion

In this article, we focus on Analysis phase in SDS which examines learners' propensity and actual situation which leads to successfully pursue challenges. As strategy of doing analyze, we suggest learner to get aware of their own situation, trend and current skill level by checking and comparing the collected activity data. We proposed a framework for analysis skill measurement in data-informed self-directed activities, which considers the object, process, and outcome of the analysis. Then we implemented this framework in the GOAL system. With the pilot activity data that we collected, we demonstrate a proof of concept of the framework to measure and track the changes in skill level in the context of physical activity.

We contribute by proposing a new method to automatically measure analysis skill in data-rich context. The automated measurement aims to benefits the learners to understand their skill better. With this approach and understanding of the current level of students' skill would enable the system to give a further adaptive support for the learners in the future.

In this paper, we use regression to support component 3, system analysis. In this future, it is worthwhile to explore and compare other statistical methods and machine learning approaches, to build the system analysis component. In our demonstration with pilot data, we let the system measure the analysis skills monthly. However, choosing the appropriate time granularity for different activity context and developing flexible algorithm is also one of our future work.

Lastly, this research considers both learning and physical contexts. It potentially gives us more insights for supporting SDS in multiple contexts.

References

Candy, P. C. (1991). Self-Direction for Lifelong Learning. A Comprehensive Guide to Theory and Practice. Jossey-Bass, 350 Sansome Street, San Francisco, CA 94104-1310.

Curry, S., Wagner, E. H., & Grothaus, L. C. (1990). Intrinsic and extrinsic motivation for smoking cessation. *Journal of Consulting and Clinical Psychology, 58(3)*, 310-316.

DiClemente, C. C., & Prochaska, J. O. (1998). Toward a comprehensive, transtheoretical model of change: Stages of change and addictive behaviors. *In W. R. Miller & N. Heather (Eds.), Applied clinical psychology. Treating addictive behaviors (pp. 3-24).* New York, NY, US: Plenum Press.

Framework for 21st century learning http://www.p21.org/our-work/p21-framework.

Garrison, D. R. (1997). Self-directed learning: Toward a comprehensive model. *Adult education quarterly, 48(1)*, 18-33.

Knowles, M. S. (1975). Self-directed learning: A guide for learners and teachers. New York: Association Press.

Loyens, S. M. M., Magda, J., & Rikers, M. J. P. (2008). Self-directed learning in problem-based learning and its relationships with self-regulated learning. *Educational Psychology Review*.

M.E. Gredler, & L. S. Schwartz (1997). Factorial Structure of the Self-Efficacy for Self-Regulated Learning Scale. *Psychological Reports*, 1997,81, pp 51-57.

Majumdar R., Yang Y.Y., Li H., Akçapınar G., Flanagan B., & Ogata H. (2018) GOAL: A System to Support Learner's Acquisition of Self Direction Skills. *26th ICCE,* Manila, Philippines, Nov 2018.

Majumdar R., Li H., Yang Y.Y., Akçapınar G., Flanagan B. and Ogata H. (2019). Towards Adaptive Support for Acquisition of Self-direction Skills in GOAL system, 19th IEEE ICALT, Maceió, Brazil July 2019.

NCREL and Learning Point associates (2003) http://www.cwasd.k12.wi.us/highschl/newsfile1062_1.pdf

Noguchi, J., & McCarthy, T. (2010). Reflective Self-study: Fostering Learner Autonomy. In A. M. Stoke (Ed.), JALT2009 Conference Proceedings. Tokyo, Japan: JALT.

Stockdale, S. L., & Brockett, R. G. (2011). Development of the PRO-SDLS: A measure of self-direction in learning based on the personal responsibility orientation model. *Adult Education Quarterly, 61(2)*, 161-180.

Thornton K. (2010), Supporting Self-Directed Learning: A Framework for Teachers. *Language Education in Asia, 1(1),* 158-170.

Tudor-Locke, C., Hatano, Y., Pangrazi, R. P., & Kang, M. (2008). Revisiting "how many steps are enough?" Medicine and Science in Sports and Exercise, 40(7 SUPPL.1).

What work requires of schools. A SCANS report for America 2000 (1991), https://wdr.doleta.gov/scans/whatwork/whatwork.pdf

Williamson, S. N. (2007). Development of a self-rating scale of self-directed learning. Nurse researcher, 14(2).

Predicting the level of linguistic knowledge from appropriately chosen learning data: A pilot study of English prepositional acquisition for Japanese EFL learners

Yuichi ONO[a*]

[a]*Faculty of Humanities and Social Sciences, University of Tsukuba, Japan*
*ono.yuichi.ga@u.tsukuba.ac.jp

Abstract: In institutions like foreign language education center, it is highly possible, given a proper online learning environment, or Computer-Assisted Language Learning (CALL) environment, that daily learning log data will be stored automatically at an institutional level. However, predicting learners' level of overall linguistic knowledge, or performance proficiency level, is a real challenge, due to the difficulty to set up an appropriate predicting model under multiple complex factors affecting linguistic knowledge or learner's performance. Especially, it is very difficult to predict proficiency level from regular tasks in the classroom or online learning at home under the context of flipped-classroom model. In this paper, I attempt to demonstrate that the prepositional knowledge can lead to the prediction of overall linguistic knowledge including actors affecting linguistic knowledge or learner's performance. Especially, it is very diff grammatical knowledge, reading comprehension, structures, and so on. This study conducted a survey of testing Japanese EFL learner's knowledge of English prepositions by asking 80 questions on *in, on, over, above, under,* and *below*. The analysis involves correlation analysis and implementation of Random Forest Algorithm to detect the key conceptual constructs to divide proficient-less proficient learners. The result is that a strong correlation between overall linguistic knowledge and prepositional knowledge that we collect during the classroom, and the acquisition of "special" or "metaphorical" concepts accompanied with English prepositions seems to be the key to predict overall knowledge of prepositions. Lastly, this paper concludes that this finding is interesting because it provides promising implications for collaborative data-driven or knowledge-driven research between learning analytics and theoretical linguistics, especially, the field of second language acquisition.

Keywords: Foreign Language Center, Micro-level Learning Analytics, Decision Tree, Japanese EFL Learners

1. Introduction

The increasing amount of data generated in digital learning contexts provides opportunities to benefit from learning analytics. As is frequently stated, even in the call for paper to this workshop, new methodologies and technological tools are necessary to analyze and make sense of these data and provide personalized scaffolding and services to stakeholders including students, faculty/teachers and administrators. The curriculum or everyday syllabus must be properly incorporated on the basis of newly-devised methodology which is connected with the needs of institutions with specific purposes. In the case of foreign language education center, instructors and researchers have been familiar with the use of media or technology to improve the instructional design since the age of structural linguistics or behavioral psychology paradigm (Ono & Ishihara, 2012; Rüschoff & Ritter, 2001; Warschauer & Healey, 1998). In the recent paradigms of communicative approach and Computer-Assisted Language Learning (CALL), an increasing number of students are learning with mobile devices at any time even outside the classroom. In addition, instructors are able to collect every log data from the students under the online learning environment. It looks as if language instructors and researchers were ready for learning analytics to provide prediction, clustering, and personalization to improve the quality of the foreign language courses. However, although we have an amazing number of the techniques for

analyzing big data, the use of datamining in education, particularly in language learning, has only recently emerged (Mark, Soobin, Hansol & Bindin, 2019).

Firstly, linguistics knowledge is a purely abstract concept and is not measurable at a deep level. Conceptually, we may posit some constructs which affect proficiency for better prediction, but most of the constructs are not easily measurable due to their invisibility. Secondly, the concept of linguistic proficiency is not operationalized easily in analysis, since language acquisition is associated with linguistic competence, as well as superficial memory such as memorization of words and phrases. For example, acquisition of prepositions involves understanding its core meaning and its degree of extension to peripheral meanings (Tyler & Evans, 2003). The acquisition of these abstract ideas does not originate from human experience to hear and learn prepositions, but possibly from the more universal competence that might be installed unconsciously in the human brain as a linguistic knowledge. Whether or not a student does understand and operationalize this knowledge is highly crucial when they are/are not able to understand and use the prepositions correctly. It is generally assumed that the learners with such knowledge will do better in other linguistic performances in writing or speaking.

Under the assumption that the accurate knowledge of preposition at a deeper level is highly related with the overall linguistic knowledge like reading, vocabulary, grammar and structures, this paper makes a pilot attempt to demonstrate the validity of this assumptions by using the data collected in regular classroom online tasks that are conducted in the classroom.

2. Previous Studies

2.1 Big Data and Little Data in Learning Analytics

Ono (2018) claims that, in order to avoid the so-called "click-to-construct issue" in learning analytics, we need to pick up the "right" data, instead of "big" data, especially in the case of language learning issues, since a lot of factors are not sometimes reflected as the frequency of log data, citing the statement by Borgman (2014):

> "Big Data" offers today's scholars vast opportunities for discovery and insight, but having the right data is often better than having more data. (p. 1)

Ono (2018) further suggests that the page-flipping might be the key to predict overall reading comprehension, among other indices often suggested in the learning analytics literature.

In the current research, main focus is placed on the acquisition English prepositions of *in, on, over, above, under,* and *below*. It is needless to say that these prepositions involve several uses and meanings, making it difficult for Japanese EFL learners to learn and use. We set up multiple-choice questions of diverse uses for each preposition to explore an acquisition order model for Japanese EFL learners.

2.2 Cognitive Linguistics and Instruction in the Classroom

A lot of studies of prepositional acquisition assume that the so-called "unidirectionality hypothesis" holds for Japanese EFL learners as to the acquisition order of English prepositions. This hypothesis originates from cognitive linguistics and states that the direction of semantic extensions is from "Core" meaning, called "Prototypical meaning", "Temporal meaning" and to "Abstract meaning". The metaphorical extension in meaning from Prototypical to Abstract meanings is described as a semantic network. These image-based instructions are very popular in prepositional instructions in the classroom. The example of "Core image" of *over* is given below in Figure 1.
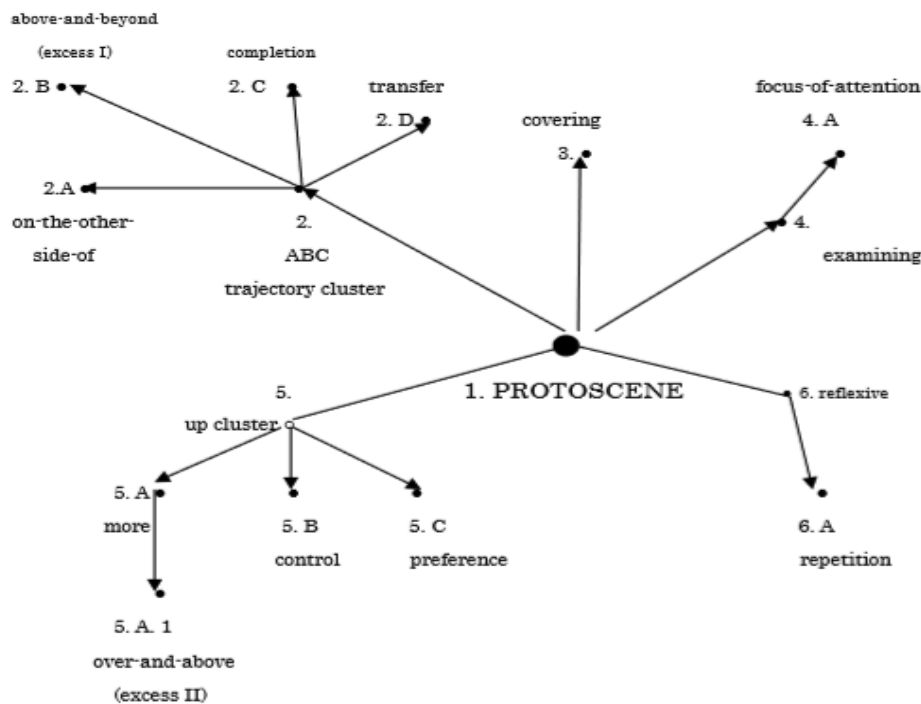
Figure 1. Semantic network of *over* (Tyler and Evans, 2003)

On the basis of the above network model, examples involving *over* such as the following are classified as in Table 1 below:

Table 1
Examples of *Over* and Their Types according to Tyler and Evans (2003)

Example	Type	Notes
He looked at himself in the mirror *over* the table.	Proto	
He was wearing a light-grey suit *over* the shirt.	Spatial	Covering
Dave, a pianist, played it *over* a couple of times.	Time	Repetition
T I'm glad that you're *over* the flu.	Abstract	Completion
He's never had any influence *over* her.	Abstract	Control

As to the order of acquisition, Cho (2002) suggests that learners acquire prepositions of prototypical usage first, and the acquisition order is Spatial usage, Temporal usage and Abstract usage. On the basis of this unidirectionality hypothesis, Japanese SLA research focuses on the benefits of "Image-use" instructions, instead of traditional translation-based ones.

However, Kano (2018) challenges this assumption and reviews the results obtained from previous studies, and suggests that more study is required to investigate what kind of knowledge is in the foreign language learner's brain and whether the student really makes use of "image" to understand and produce the correct prepositional use. The research shows that in some cases the unidirectionality hypothesis does not hold and his qualitative analysis demonstrated that irregularity of acquisition order is observed.

In order to solve the issue of whether the unidirectionality hypothesis holds or not, data-based validation is necessary on the basis of foreign language learner's knowledge of English prepositions, which is obtained online in the regular classroom tasks. Thus, the research questions of the current research are set up as follows:

RQ1: What type of specific prepositional knowledge predicts learner's knowledge of English preposition.

RQ2: What type of specific prepositional knowledge predicts learner's overall proficiency level?

3. Methodology

3.1 Participants

A total of 88 national university in Japan participated in this study. Their CEFR level is A2–C1.

Table 2
Participants' Overall Proficiency Level

CEFR Level	Number of Participants
C1	1
B2	28
B1	30
A2	27

3.2 Dataset

We constructed the dataset by collecting online quizzes that are held regularly in the classroom. The total number of questions is 80. All the questions are multiple-choice questions, where the participants are required to answer the best one among four choices. All the questions are supported by Japanese translations in order to make sure that all the students understand the situation described by the question.

3.3 Random Forest Algorithm

The analysis was conducted by using the statistical programming language R (R Core Team, 2019). We constructed a predictive model where 80 questions are treated as independent variables and TOEFL-ITP score and total score of preposition test as dependent variables. In learning, the number of trees was set to 500.

4. Result and Discussion

Table 3 shows a descriptive statistics of the test scores and TOEFL-ITP scores.

Table 3
Descriptive Statistics

	N	Mean	SD
Total Score of Prep Test	86	48.4	11.4
Score of TOEFL-ITP	86	507.2	50.4

Note. The maximum score of preposition test is 80.

The correlation between total score of Preposition Test and TOEFL-ITP score is $r = .696$, which is interpreted as a strong correlation. (95% CI [lower, upper] = 0.568 0.791)

Then, the result of Decision Tree analyses is given in Figures 2 and 3 below. Figure 2 is for TOEFL as a dependent variable, and Figure 3 is for total score for Preposition Test as a dependent variable.

In Figure 2, the total variance explained is 51.44% for this model.
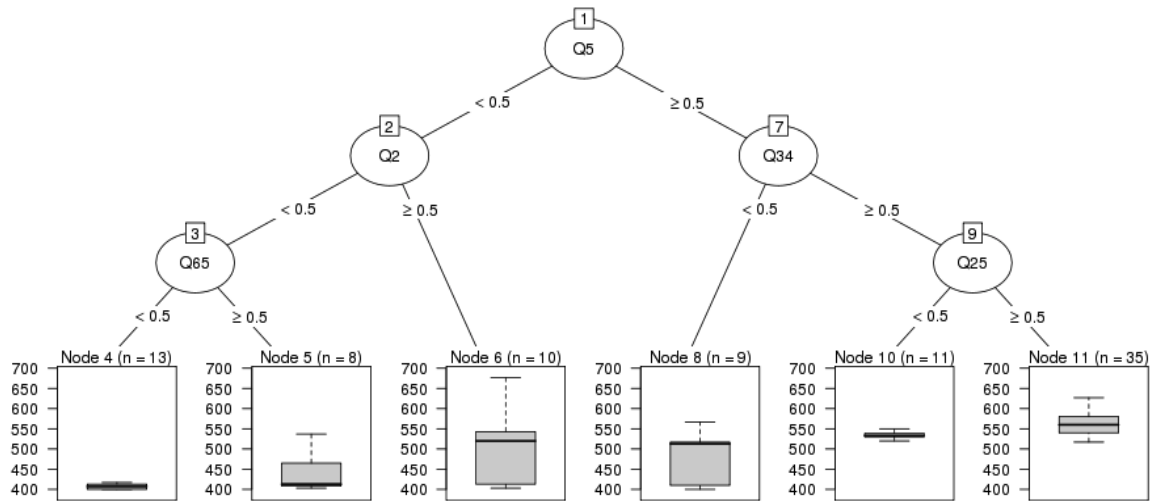
Figure 2. Decision tree and distribution of participants in each node (TOEFL-ITP)

The questions for each node and its value of significance (in this paper, "IncNodePurity" is employed) is described in Table 4 below.

Table 4
Questions and IncNodePurity for TOEFL-ITP

	Question	Usage	IncNodePurity
Q5	Several conclusions could be drawn from the results described ( ). [over, up, to, *above*]	Prototypical	8.516806e+04
Q2	There was a little food left ( ) from the party. [on, in, to, *over*]	Abstract	2.432890e+04
Q34	She has never got ( ) the shock of her mother's death. [*over*, from, into, to]	Abstract	2.446524e+04
Q65	I don't want to talk about it ( ) the telephone. [*over,* in, above, under]	Abstract	2.175742e+03
Q25	I am the new manager and you will be working ( ) me. [below, at, in, *under*]	Abstract	3.613272e+03

Note. The choices are given in square brackets, where the correct answer is underlined.

Now turn to Figure 3 for Preposition Test as a dependent variable. The total variance explained is 80.99% for this model.
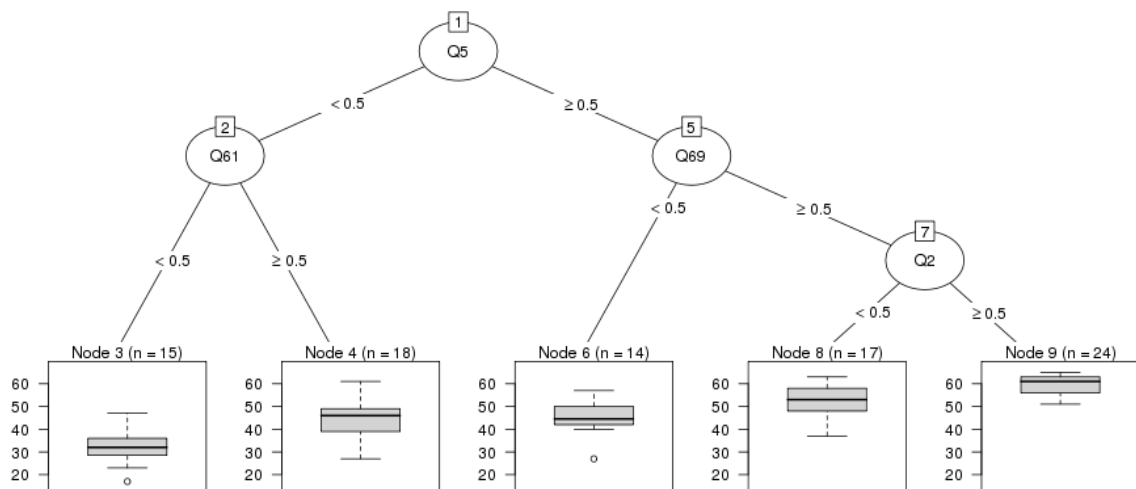
Figure2. Decision tree and distribution of participants in each node (Preposition Test)

The questions for each node and its importance (IncNodePurity) is described in Table 5 below.

Table 5
Questions and IncNodePurity for Preposition Test

	Question	Usage	IncNodePurity
Q5	Several conclusions could be drawn from the results described ( ). [over, up, to, *above*]	*Spatial*	*1374.1549910*
Q61	Such people often experience less stress than those in the rank ( ) them. [*below*, on, around, under]	*Spatial*	*105.2607250*
Q69	I was wearing two sweaters ( ) the green jacket. [below, in, by, *under*]	*Spatial*	*206.9395434*
Q2	There was a little food left ( ) from the party. [on, in, to, *over*]	*Abstract*	*144.2854017*

Note. The choices are given in square brackets, where the correct answer is underlined.

5. Discussion and Conclusion

From the result above, Q5 is a key question to divide upper from lower in both cases. This is a question on "Spatial expression" using above. The implication here is that the understanding and using Spatial Expressions seems to be an important and basic approach. However, the top group in Figure 1 seem to understand a "Metaphorical Expression" of *under*, which is a very difficult kind of expression. As to the knowledge of preposition shown in Table 2, understanding and using the typical "Spatial" uses seems to be the key. So far, it is safe to say that focus on Prototypical (or Spatial) use should be stressed in the instruction to beginners, which seems to be the key to divide whether the student gets upper or lower.

However, on the other hand, all the spatial expressions among 80 questions behave similarly; that is, some spatial expressions seem to be difficult to answer for some reasons. It is thus necessary to investigate what is happening in the students learning process in more details to explore a more decisive concept to explain the acquisition order of prepositions or the validity of unidirectionality hypothesis. It is needless to say that the ideas from linguistics or second language acquisition is also necessary for future learning analytics research.

Acknowledgements

References

Cho, K. (2002). A cognitive linguistic approach to the acquisition of English prepositions. *JACET Bulletin*, *35*, 63-78.

Kano, T. (2018). Issues on teaching English preposition to EFL learners: Focusing on the image schema of English preposition. In Y. Ono & M. Shimada (Eds.) *Data Science in Collaboration, Volume 2*. Tsukuba: General Affairs Supporting Center.

Mark W, Soobin, Y., Hansol, L., & Binbin, Z. (2019). Recent Contributions of Data Mining to Language Learning. *Research Annual Review of Applied Linguistics, 39*, 93–112.

Rüschoff, B., & Ritter, M. (2001). Technology-Enhanced Language Learning: Construction of Knowledge and Template-Based Learning in the Foreign Language Classroom. *Computer Assisted Language Learning*, *14*(3) 219–232.

Ono, Y., & Ishihara, M. (2012). Integrating mobile-based individual activities into the Japanese EFL classroom. *International Journal of Mobile Learning and Organisation*. *6*. 116-137.

R Core Team. (2019). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing.

Tyler, A., & Evans, V. (2003). *The semantics of English prepositions: Spatial scenes, embodied meaning and cognition*. Cambridge: Cambridge University Press.

Warschauer, M., & Healey, D. (1998). Computers and language learning: an overview. *Language Teaching*, *31*, 57–71.

Identifying At-risk Students from Course-specific Predictive Analytics

Chung Lim Christopher KWAN[a*]
[a]*Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University, Hong Kong*
*ceclkwan@polyu.edu.hk

Abstract: Identifying at-risk students in a large class of an engineering mathematics course during the delivery of teaching and learning activities is not an easy task to be accomplished by many instructors, particularly in the first few weeks of their studies. In the paper, course-specific predictive analytics, called the multiple linear regression model, the logistic regression model and the classification and regression tree (CART) model are trained, tested and compared with the use of LMS data in the first semester of the academic year 2017-18 such as the level of achievements in online class activities, the mini-project, the mid-term test, assignments, and the final examination for classifying at-risk students as early as possible during the course of study. A feature selection method is used to select statistically significant variables in the development of multiple linear regression and logistic regression models for enhancing the generalizability of both models. It is found that 3 key variables such as the level of achievements in the 6th online class activity, the mid-term test and assignment 2, which may have pedagogically meaningful information, are crucial for classifying at-risk students. Despite the highest accuracy of the CART model, the logistic regression model significantly outperforms the multiple linear regression and the CART models in terms of the recall and f-measure of the testing set. Instead of selecting 3 key variables, the present logistic regression model which only comprises 2 statistically significant variables such as the level of achievements in the 6th online class activity and the mid-term test can be employed to identify at-risk students for early intervention of their studies once the results of the mid-term test and the 6th online class activity are made available at the end of week 7.

Keywords: At-risk Students, Multiple Linear Regression Model, Logistic Regression Model, Classification and Regression Tree, Recall, F-measure

1. Introduction

Monitoring students' learning is one of the important tasks for an instructor to ascertain how well students have learned during the delivery of teaching and learning. Many assessment methods like assignments, a mid-term test, a mini-project, online class activities and a final examination are designed to measure the achievement of the subject intended learning outcomes (Biggs, 2003; Sazhin, 1998). As assessment can serve as feedback to students, students are sometimes informed of their performance in the online class activities immediately and they often get feedbacks on other types of course works like assignments and the mid-term test after one or two weeks. In a large class, more attention should be paid on their progress and attainment to ascertain how well they are on track during learning and how they need further assistance and improvement for students' learning if at-risk students can be identified early in a semester. Through the application of predictive analytics with the use of data extracted from learning management system (LMS), it is possible to identify at-risk students in class and to predict students' success in a course (Lackey, Lackey, Grady, and Davis, 2003; Olani, 2009).

Marbouti, Diefes-Dux, and Strobel (2015) built three logistic regression-based models to identify at-risk students in a large first-year engineering course at weeks 2, 4 and 9 in a semester. The models were optimized for identifying at-risk students with high prediction accuracy, illustrating the value of creating course-specific prediction models rather than generic ones.

2. Course-specific Predictive Analytics

2.1 Dataset

The dataset of an engineering mathematics course offered in the first semester of the academic year 2017-2018 is used for the present study and extracted from Blackboard LMS for the development of course-specific predictive analytics. There are total 240 observations recorded the level of achievement in each assessment task performed by 240 students.

Regarding the dataset, there are 16 input variables comprising 2 assignments, a mini-project, a mid-term test, and 12 online class activities held in each week of a semester. The online class activities are done in face-to-face (F2F) sessions for recording the number of multiple-choice questions correctly attempted as well as students' attendance. The output variable used in the multiple linear regression (MLR) model is the final examination score, but the output variable used in the logistic regression (LR) and CART models is a binary variable (i.e. 0 or 1) which indicates whether the student is at-risk or not. As the result of the final examination in 2017-18 is well known, an integer "1" can be assigned to the binary variable which represents an at-risk student who fails in the final examination. Conversely, an integer "0" is assigned to a not-at-risk student passing the final examination. The input and output variables are summarized in Table 1. The dataset is split into a training set and a testing set with a ratio of 70:30. Initially, all input and output variables are first used for the development of the models.

Table 1

Input and Output Variables used for the Initial Development of Course-specific Predictive Analytics

Input Variable	Completed by week	Type	Point
Assignment 1	5	Numeric	0 - 15
Assignment 2	11	Numeric	0 - 15
Mini-project	8	Numeric	0 - 20
Mid-term test	7	Numeric	0 - 50
1st Online class activity	1	Integer	0 - 3
2nd Online class activity	2	Integer	0 - 8
3rd Online class activity	3	Integer	0 - 4
4th Online class activity	4	Integer	0 - 6
5th Online class activity	5	Integer	0 - 2
6th Online class activity	6	Integer	0 - 3
7th Online class activity	7	Integer	0 - 6
8th Online class activity	8	Integer	0 - 2
9th Online class activity	9	Integer	0 - 3
10th Online class activity	10	Integer	0 - 3
11th Online class activity	11	Integer	0 - 1
12th Online class activity	12	Integer	0 - 1
Output Variable	**Use**	**Type**	**Point**
Final examination	MLR	Numeric	0 - 100
At-risk student	LR & CART	Binary	0 - 1

2.2 Feature Selection Method

Feature selection is a process of selecting a subset of features or variables which are more correlated to the output or predicted variable, yielding a more generalizable model (James, Witten, Hastie, and Tibshirani, 2013). The subset of features or variables may have pedagogically meaningful information to critically identify whether a student is at-risk or not (Macfadyen and Dawson, 2010). It is found that 3 input variables such as the level of achievements in the mid-term test, assignment 2 and the 6th online

class activity are statistically significant with the p-value of being below 0.05 in the development of MLR model with the use of feature selection.

The non-significant variables are then removed if the p-value of the input variable is not below 0.05. Instead of selecting 3 input variables, the MLR model only comprises 2 statistically significant variables such as the level of achievements in the mid-term test and the 6th online class activity for early identification of at-risk students by the end of week 7.

Despite the fact that the model shows a high accuracy of 0.833 on classifying both at-risk student (True Positive) and not-at-risk student (True Negative), the sensitivity and the specificity are 0.467 and 0.930 respectively. A student is classified as an at-risk student if his/her final examination score is predicted to be below a passing score, P. The confusion matrix for the classification of both at-risk and not-at-risk students is tabulated in Table 2.

Table 2

Confusion matrix for the classification of both at-risk student and not-at-risk students in MLR model (Testing set)

	Predicted Negative (Score ≥ P)	Predicted Positive (Score < P)
Observed Negative (Score ≥ P)	53	4
Observed Positive (Score < P)	8	7

The process of selecting statistically significant variables is still adopted for the development of logistic regression (LR) model. It is found that the above-mentioned 3 variables are statistically significant in the LR model with the p-value of being below 0.05. After removing the non-significant variables (i.e. the p-value of the input variable is not below 0.05), the present LR model only comprises 2 statistically significant variables such as the level of achievements in the mid-term test and the 6th online class activity for the early identification of at-risk students. The confusion matrix of the LR model is computed for the testing set using different thresholds of 0.5 and 0.2 respectively. It is found that the sensitivity is increased from 0.667 to 0.867 and the specificity is decreased from 0.930 to 0.824. The accuracy of the present model is decreased from 0.875 to 0.833. The confusion matrix for the classification of both at-risk and not-at-risk students in LR model with the threshold of 0.2 is depicted in Table 3.

Table 3

Confusion matrix for the classification of both at-risk student and not-at-risk students in LR model with the threshold of 0.2 (Testing set)

	Predicted Negative	Predicted Positive
Observed Negative	47	10
Observed Positive	2	13

All input and output variables are considered in the development of the CART model. The following tree which is based on the use of training set and the complexity parameter of 0.02 is built and shown in Figure 1. Whether a student is at-risk or not can apparently be inferred from the CART tree. For example, a student can be classified as a at-risk student if the score of mid-term test is not above 24.75 and the score of a class activity is not above 1.

The confusion matrix of the present CART model is computed for the testing test. It is found that the accuracy, the sensitivity and the specificity of the present CART model are 0.861, 0.667 and 0.912 respectively. A summary of the confusion matrix is depicted in Table 4.
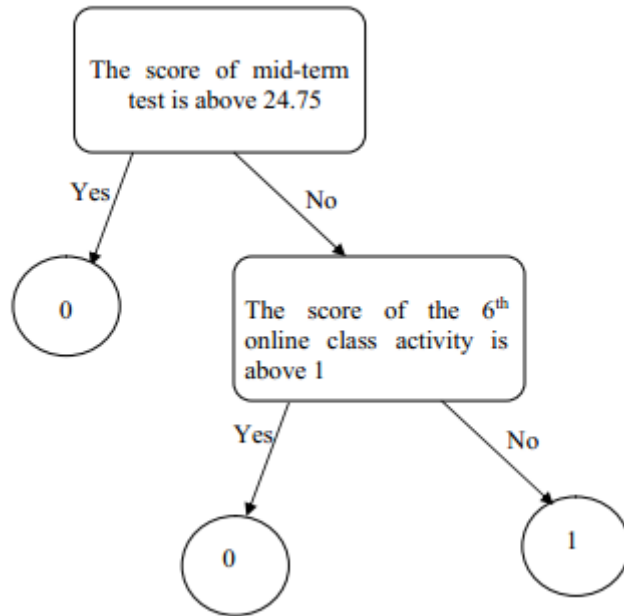
Figure 1. The CART model built with the complexity parameter of 0.02.

Table 4

Confusion matrix for the classification of both at-risk student and not-at-risk students in CART model with the complexity parameter of 0.02 (Testing set)

	Predicted Negative	Predicted Positive
Observed Negative	52	5
Observed Positive	5	10

The performance of the present models is further evaluated in terms of accuracy, precision, recall (i.e. sensitivity), and f-measure as shown in Table 5. Among three present models, it is found that the LR model has both the highest recall of 0.867 and the highest f-measure of 0.684.

Table 5

Accuracy, precision, recall and f-measure of the present models

	MLR	LR	CART
Accuracy	0.833	0.833	0.861
Precision	0.636	0.565	0.667
Recall	0.467	0.867	0.667
F-measure	0.539	0.684	0.667

3. Discussion

The feature selection method is used to select 3 statistically significant variables such as the level of achievements in the mid-term test, assignment 2 and the 6th online class activity in the development of MLR and LR models with the help of the training set. However, the result of assignment 2 can only be made available at the end of week 11. Instead of selecting 3 statistically significant variables, both models merely comprise 2 statistically significant variables such as the level of achievements in the

mid-term test and the 6th online class activity for identifying at-risk students by the end of week 7. In addition, the non-significant variables are removed during the training stage for the purpose of developing the MLR and LR models which can be more generalizable. If the non-significant variables are also included in the models, the models will be less generalizable for prediction.

It is found that 3 key variables such as the level of achievements in the 6th online class activity, the mid-term test and assignment 2, which may have pedagogically meaningful information, are crucial for classifying at-risk students simply because students are required to demonstrate high levels of understanding such as relational and extended abstract for accomplishing these assessment tasks, as distinguished by Structure of Observed Learning Outcomes (SOLO) taxonomy (Biggs and Collis, 1982).

The LR model comprising 2 statistically significant variables such as the level of achievements in the 6th online class activity and the mid-term test can first be employed for the identification of at-risk students and intervention of their studies at the end of week 7. They will be informed immediately by emails, and closely monitored via consultative meetings during the period from week 8 to week 11. The LR model which comprises 3 statistically significant variables such as the level of achievements in the 6th online class activity, the mid-term test and assignment 2 can further be used to decide whether they are still classified as at-risk students or not, once the result of assignment 2 is made available at the end of week 11.

The current course-specific LR model also outperforms the other generic LR model developed by Macfadyen and Dawson (2010) with the use of LMS tracking variables only such as the number of assessments finished, the total number of discussion messages posted and the number of mail messages sent in terms of the accuracy and recall, highlighting the value of creating course-specific predictive analytics as the focus of the research.

4. Conclusion

It is concluded that 3 statistically significant variables such as the level of achievements in the 6th online class activity, the mid-term test and assignment 2, which may have pedagogically meaningful information, are crucial for identifying at-risk students. Despite the highest accuracy of the CART model, the logistic regression model significantly outperforms the multiple linear regression and the CART models in terms of the recall and f-measure of the testing set. Instead of selecting 3 key variables, the present logistic regression model which only comprises 2 statistically significant variables such as the level of achievements in the 6th online class activity and the mid-term test can be employed for early identification of at-risk students and timely intervention of their studies once the results of the mid-term test and the 6th online class activity are made available at the end of week 7.

References

Biggs, J. (2003). Teaching for quality learning at university, 2nd Edition. *Society for Research into Higher education & Open University Press.*

Biggs, J. B., & Collis, K. F. (1982). Evaluating the quality of learning: The SOLO taxonomy. New York: *Academic Press.*

James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013). Linear model selection and regularization an introduction to statistical learning. *Springer.*

Lackey, L. W., Lackey, W. J., Grady, H. M., & Davis, M. T. (2003). Efficacy of using a single, non-technical variable to predict the academic success of freshmen engineering students. *Journal of Engineering Education*, 92(1), 41-48.

Macfadyen, L. P., & Dawson, S. (2010). Mining LMS data to develop an "early warning system" for educators: A proof of concept. *Computers & Education*, 54(2), 588-599.

Marbouti, F., Diefes-Dux, H. A., & Strobel, J. (2015). Building course-specific regression-based models to identify at-risk students. *In The american society for engineering educators annual conference*. Seattle, WA.

Olani, A. (2009). Predicting first year university students' academic success. *Electronic Journal of Research in Educational Psychology*, 7(3), 1053-1072.

Sazhin, S. (1998). Teaching mathematics to engineering students. *International Journal of Engineering Education* 14, 145-152.

WORKSHOP 11 - New Endeavours of Implementing Computational Thinking in K-12 Education

Computational Thinking Development Challenges: Case Studies In Thai Primary Education

Kantinee KATCHAPAKIRIN [*]**, Chutiporn ANUTARIYA**
School of Engineering and Technology, Asian Institute of Technology, Thailand
*st120200@ait.ac.th, chutiporn@ait.ac.th

Abstract: Computational Thinking (CT) has been introduced in the Thai standard curriculum since 2017. In order to effectively support implementation of computing education, it is necessary to understand traditional classroom practices as well as challenges that teachers experience in CT development and assessment. The identification of challenges allows researchers to propose relevant learning enhanced technology to efficiently develop students' CT skill. This study explored practical challenges and their importance in Grade 4th and 5th classrooms in Thai schools by conducting a preliminary survey including case studies and a poll survey. The case studies were carried out to uncover the outlooks and perspectives of teachers on challenges and their current strategies to alleviate those challenges. The poll survey was conducted to measure and identify the top five challenges from the teachers' perspective including: less time in the curriculum, lack of material, limited fundamental knowledge, lack of confidence and student differentiation. Practical strategies adopted in Thai CT Classroom were explored, and relevant learning enhanced technology was recommended for future study, which could be beneficial for researchers and responsible agencies to significantly improve the quality of CT education in Thailand.

Keywords: Computational Thinking, Challenges, Strategies, Thailand Curriculum, Computing Science, Primary education, computer science education; K-12 CS curriculum.

1. Introduction

Computational Thinking (CT) has increasingly become important in all areas of society (Heintz, 2016) and has been considered as a social consensus skill related to problem-solving, systematic and algorithmic thinking (Haseski, 2018). It is suggested to be an essential fundamental skill for everyone like reading, writing, and arithmetic skills (Wing, 2017). Grover (2018) also argued that it should be added as the 5th "C" into the "4C skills of the 21st-century framework" and should be taught to all students. Thus, due to its increasing popularity and criticality to the 21st century workforce, CT has been introduced into the basic education curriculum in many countries (Heintz, 2016). Thailand has also shifted its regard for CT from a specialized skill (Ministry of Education, 2008) to a fundamental skill (Ministry of Education, 2017). It is now considered under Science learning area rather than Occupations and Technology learning area in Computing Science.

In Revised Thai Curriculum, Computing Science subject consists of three main strands: Digital Literacy (DL), Information and Communication Technology (ICT), and Computer Science (CS) (IPST, 2017). DL involves wisdom, safety, and ethic ways to use technology safely, respectfully and responsibly. Students would be taught how to evaluate information and consider how reliable the information is. ICT involves how to use the computers and their applications as tools to create, organize, analyze, and visualize data or other digital content to support decision making. CS emphasizes on thinking, i.e., computational thinking which aims to foster students to be able to solve problems using logics and algorithms. Students should understand the fundamental CS principles and concepts, be able to analyze problems in computational ways, and have practical programming experience to cooperate with computers to solve problems. The implementation of the revised curriculum takes 3 years of roll-out plan. In the academic year 2018, the curriculum was applied for

Grade 1st and Grade 4th, then applied for Grade 2nd and Grade 5th in 2019, and as of the academic year 2020, the curriculum shall be applied for all grades.

To efficiently improve the quality of computing science education, it is necessary to understand how computational thinking was taught in Thai classrooms and what challenges teachers experienced and how they dealt with the challenges. The identification of such challenges could enable proper employment of relevant Learning Enhanced Technology to efficiently develop students' computational thinking skills and to further elevate the Computational Thinking agenda in Thailand education.

This paper reviews existing research in Section 2. Then, Sections 3 and 4 discuss a preliminary field study to elicit practical challenges and their importance in the Grades 4th – 5th of computing science classrooms in Thai schools, and to analyze current pedagogical strategies that Thai teachers adopted. Finally, Section 5 concludes and suggests potential Learning Enhanced Technology research to overcome those important challenges.

2. Related works

2.1 CT Development and Assessment Challenges

This sub-section reviews existing studies related to the challenges that teachers experienced in computing classroom, categorized into three aspects: *teachers*, *students*, and *environment*. We further applied the work of Finger and Houguet (2009) to classify the teacher's and student's challenges into *intrinsic* and *extrinsic* challenges. The former ones are challenges that teachers and students can fully manage by their own while the latter ones are those that they have less control. Table 2 discusses the teacher's challenges, whereas Table 2 and Table 3 respectively summarize student's challenges and environment-related challenges, which can be categorized into material, curriculum, infrastructure and other subcategories.

Table 2

Teacher's Intrinsic and Extrinsic Challenges

Teacher's Challenge	Description
Intrinsic Challenge	
Limited Fundamental Knowledge	Teachers have little subject knowledge and skills. They lack understanding in digital literacy, programming, and troubleshooting (Sentance, 2017). Some teachers misunderstand CT concepts and falsely described CT as the basic use of computers or technology (Ribeiro, 2013; Lockwood, 2017; Bower, 2015; Mouza, 2017; Yadav, 2014; Maruyama, 2017). Educating teachers with relevant knowledge and skills has been a great barrier in many country's education (Heintz, 2016).
Limited Pedagogical Knowledge	Teachers have limited teaching approaches to make Computational Thinking concepts accessible, engaging, interesting and fun (Sentance, 2017; Silapachote, 2018; Black et al., 2013).
Lack of Experience	Teachers learned the topics by themselves. So, they have no experience to bring the topics to life (Lockwood, 2017; Sentance, 2017).
Lack of Confidence	Teachers are concerned about their own knowledge in Computer Science and programming (Lockwood, 2017; Sentance, 2017).
Lack of Time Management	Teachers lack preparation time to refine lesson plans and develop competency in the material (Cho, 2014; Lockwood, 2017; Sentance, 2017).
Extrinsic Challenge	
Less Popularity of ICT Teachers	Lack of trained ICT teachers who have the knowledge and skills to embed CT in school curricula (Barr, 2011).
Low Quality of Building CS Educators	Current undergraduate courses focus on teaching computer science student to use computers and does not consider much about CT. (Ribeiro, 2013).

Table 3

Student's Challenges

Student's Challenge	Description
Intrinsic Challenge	
Limited Computing Literacy Skills	Students cannot memorize common computing keywords. So, they could not read code, reuse code (Basu, 2016) or detect errors (i.e. grammatical, logical or syntactic errors) (Sentance, 2017) that exist within that code.
Lack of Understanding of Topics	Even though students can memorize computing keywords, but they do not understand why and how and when the keywords were used. They had difficulties in understanding the meaning and use of variables, abstraction, functions, conditionals and loops (Basu, 2016; Sentance, 2017; Grover, Pea, & Cooper, 2015).
Low Mathematic Ability	Students lack capability and competence in mathematical concepts e.g. Boolean Algebra, Logical Operators and manipulating numbers (Sentance, 2017).
Limited Problem-solving Skills	Students can memorize and understand the computing concepts, but they cannot apply the knowledge to new problems or other subjects (Sentance, 2017). Students lack abstraction, modeling, debugging skills while they were reading, analyzing and synthesizing problems in order to abstract the essential data to solve a problem (Basu, 2016).
Low Students' Resilience	Students have no resilience to keep trying when something does not work and give up easily. (Sentance, 2017; Mooney, 2014).
Low Engagement and Motivation	Students have low interest and cannot maintain their attention to engage in the classroom (Grover, 2019; Sentance, 2017). Moreover, they do not develop their mastery of the Computing subject outside of school hours (Mooney, 2014).
Extrinsic Challenge	
Differentiation	Students were different. They had different skill and experience in programming. They learned at different pace and learning styles. Computing subject had the most widening gap between students greater than other subjects (Sentance, 2017). The challenge of Differentiation was classified as Students' extrinsic challenge in this study rather than teachers' intrinsic in Sentence work (Sentance, 2017) because it related to students and students have less control on it. However, the extrinsic challenge of one could possibly be intrinsic of others.

2.2 Strategies to overcome the challenges

This sub-section reviews strategies that have been used to overcome the challenges as reported in the literature.

Teacher Workshop. Lockwood (2017) informed that teacher workshops are extremely effective strategies at equipping teachers with relevant subject knowledge and skills and changing teachers' perceptions. Moreover, days-long practical sessions are hugely beneficial to give teachers the confidence and experience to introduce the lessons into their classes. (Falkner, 2015; Morreale, 2012; Pokorny, 2012; Yadav, 2014; Bargury, 2012; Carvalho, 2013). Heintz (2016) reported that a common struggle among countries is training of teachers. Another strategy was proposed, *Online Learning MOOC*. With appropriate MOOC support, Australia and Norway can introduce CT into their classrooms in short time period (Vivian , 2014; Falkner, 2015). However, this strategy mainly overcome only the challenges of *Limited Fundamental Knowledge* and *Limited Pedagogical Knowledge* and cannot reduce the impact of *Lack of Confidence*. *Teacher Network and Community* reportedly has positive impact on teacher's confidence, energetic. For example, Computing at school (CAS) community in England supports teachers to share their teaching ideas and allows experienced teachers to support other teachers. Heintz (2016) stated that participated teachers gain more confidence and the number of isolated teachers is reduced. Falkner (2015) used a Google+ group community to foster collaboration of the MOOC.

Suitable teaching materials were very important for teachers. Many countries developed *Teaching Material repository* as centralized national resources (Heintz, 2016). In New Zealand, they launched "CS Field Guide" as their national free online open-source teaching material repository. Similarly, Norway has started Laer Kidsa Koding (Http://kidsakoder.no/) to provide extensive teaching

material for teachers. In addition, *Contextualization of learning* is to design material that relate computing to other subjects or other real-world activities can support better students' learning (Sentance, 2017) and possibly lessen student *Limited Problem-Solving Skills* challenges.

CT skills can be taught ranging from low level to high level i.e. *Unplugged activities to Practical computerized activities*. A significant proportion of teachers adopt the unplugged approach to support students' understanding in the classroom (Sentence, 2017; Lockwood, 2017). Shuchi (Grover , 2019) suggested using unplugged activities before working in programming contexts in environments like Scratch. However, coding hands-on is an approach in which CT skills can be simulated and evaluated as a student's ability to program a solution to a problem. Using demonstrations, learning interactive lessons, learning through videos are also strategies that teachers suggest (Lockwood, 2017).

Table 4

Environment-Related Challenges

Environment -related Challenge	Description
Material	
Lack of Material	Lack of good quality or age- or grade-appropriate material also poses an environmental challenge. There is also lack of material to contextualize CT other disciplines (Sentance, 2017). Heintz (2016) also support that developing suitable teaching material is a common challenge on introducing CT to all countries.
Curriculum	
Less Time in the Curriculum	School hours were not enough to achieve the expectation of the curriculum.
Lack of CT Assessment Guidelines in the Curriculum	There is little guidance on assessment that can be applied in practical. As the assessment of CT is complicated, assessing the progression of students following instructions was not the mechanism for assessing CT. Teachers should formatively assess students and prepare students for summative assessment tasks (Sentance, 2017). Many researchers (Van, 2001; Roman, 2017; Tissenbaum, 2018) proposed a diversity of CT assessment methods which poses challenges about the appropriate methodology for assessing CT learning in practices.
Infrastructure	
Lack of Resources	Hardware, software resources (e.g. Computers) and Internet services are not adequate to teach (Sentance, 2017; Ribeiro, 2013). Carvalho (2013) reported the poor conditions of infrastructure in Brazilian public schools was an impediment to develop CT skills in computerize activities.
Technical Difficulties in School	There are some technical problems with getting software to work on the school network such as software installation problem, network problem and security problem (Sentance, 2017).
Lack of Support from IT Departments	Unwillingness of technician support is also a great challenge for developing CT (Lockwood, 2017). Sentance (2017) reported that their technician support considers the software may break the integrity and security of the school's computer network therefore they are reluctant to maintain and troubleshoot installed software.
Other	
Parents' Attitude	Parents' attitude toward CT development in primary school influence on children's attitude (Maruyama, 2017).

Since programming is the most challenging part of computer science in schools. There were several interesting strategies proposed to support students. *Collaborative working*. There were a variety of collaborative working strategies that teachers used within the classroom such as peer mentor, pair programming, teamwork and collaboration. Kafai and Burke (2014) defined it as a concept of computational participation. In this context, student who are good at working with coding can support others in the classroom. In addition, students can discuss with peers to find out solutions for specific problems (Passey, 2014). As a result, this strategy could minimize the *differentiation* in students' ability. *Scaffolding programming tasks*. A range of activities supporting students' scaffolding

programming tasks have been proposed; Code walkthroughs (Van Gorp and Grissom, 2001), reading and tracing code (Lopez et al., 2008), use trace tables to help students understand the flow of control and the changing value of variables with in a program, extend and debug code (Sentance, 2017). Lister (Lister, 2011) argued that students need to be able to trace code with greater than 50% accuracy before starting to write their own program. Moreover, writing algorithms in groups, and inserting comments in pairs were suggested by Van and Grissom (Van Gorp and Grissom, 2001) *Classroom teaching assistant.* Cho et al. (Cho et al., 2014) states that a significant proportion of teachers identified the desire of a classroom assistants. Basu (Basu, 2016) identified that the human-provided-scaffolds minimizes the challenges students face over learning time period.
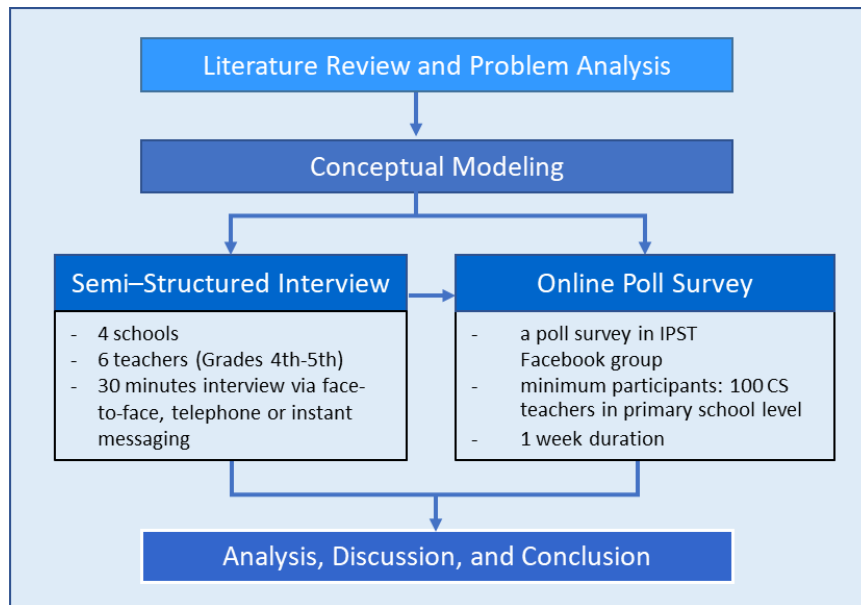
Figure 6. Overview of research methodology.
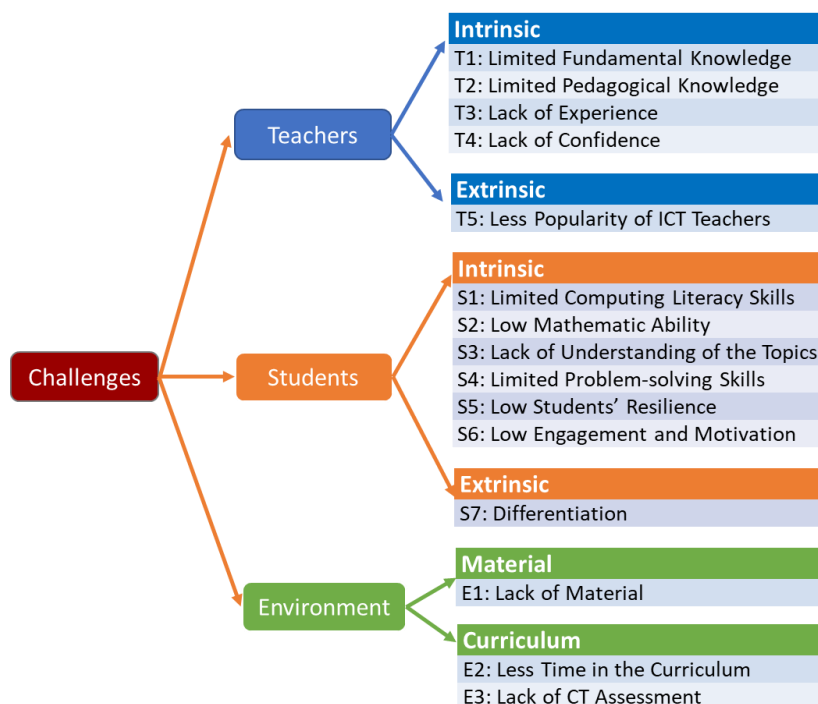
Figure 7. The proposed challenge model.

3. Research Methodology

This study aimed to gain insights into the challenges experienced by teachers during the implementation of computational thinking development within primary school settings in Thailand as well as strategies Thai teachers adopted to deal with those challenges. Given these considerations, 錯誤! 找不到參照來源。 illustrates the proposed research methodology, which initially started by reviewing existing related research and analyzing the problem. Then, a conceptual model defining relevant challenges in Thailand was preliminarily analyzed and developed which comprises 5 teacher's challenges, 7 student's challenges and 3 environment-related challenges (cf. 錯誤! 找不到參照來源。). Next, semi-structured interviews and online poll survey were conducted with in-service computing science teachers to verify the defined challenges and findings. Lastly, the results were analyzed, and conclusions drawn. Sub-sections 3.1 and 3.2 explains the design of the semi-structured interviews and poll survey in details.

3.1 Semi-structured Interview Design

Semi-structured interviews were used as a tool to verify the proposed conceptual model, which defines important challenges involving CT development and assessment in Computing Science subject, and comprise the following primary questions:
  (1) How do you support students to develop their Computational Thinking?
  (2) How can you assess Computational Thinking skills of an individual student?
  (3) What are important challenges in developing Computational Thinking from teachers' view?
  (4) How have you dealt with those challenges?

Table 5 gives an overview of each teacher and his/her school who agreed to participate in the interview. Note that all teachers instructed CT in computing science classes of Grade 4th and Grade 5th and were from four different schools having different sizes and located in different provinces. Section 4 discusses the results and findings obtained from the interview.

Table 5

An Overview of Schools and Teachers Participating in the Study

School	Province	Size	Host	Teachers	Level	Students per Class	CT Tools
1. Provincial#1	Phetchaburi	Medium	OBEC	1. Tommy	G4-G6	40	Scratch
2. Provincial#2	Roi-Ed	Small	OBEC	2. Lilly	G2-G6	<10	Code.org, Robotic, Microbit
3. Bangkok#1	Bangkok	Extra Large	BMA	3. Susan	G4	33	Scratch
				4. Jenny	G5	35	Scratch
4. Bangkok#2	Bangkok	Extra Large	BMA	5. Grace	G4	45	Scratch
				6. Katie	G5	45	Scratch

3.2 Poll Survey Design

In order to generalize and measure the importance of the specified challenges from teachers' perspectives, a poll survey was conducted online in a formal CS primary level teacher community. The community has been established by the Institute for the Promotion of Teaching Science and Technology (IPST) for sharing computing science resources among teachers. The poll asked the participating teachers to identify top three challenges faced while teaching CT using Scratch for Grade 4th and Grade 5th classrooms. The number of participating teachers were around 100.

Interview and Poll Results: Challenges on CT Development in Thai CS Classroom

	Challenges Proposed in the Conceptual model														
	T1	**T2**	**T3**	**T4**	**T5**	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**E1**	**E2**	**E3**
Interview Results: - Number of teachers agreed that the challenges had high impact	5		2	4		6	6	6	6			6	6	4	
Online Poll Results: - Number of votes from online poll	49	20		49	19						20	43	83	93	10
- Poll ranking	3			3								5	2	1	
High Impact Challenges	×			×		×	×	×	×			×	×	×	
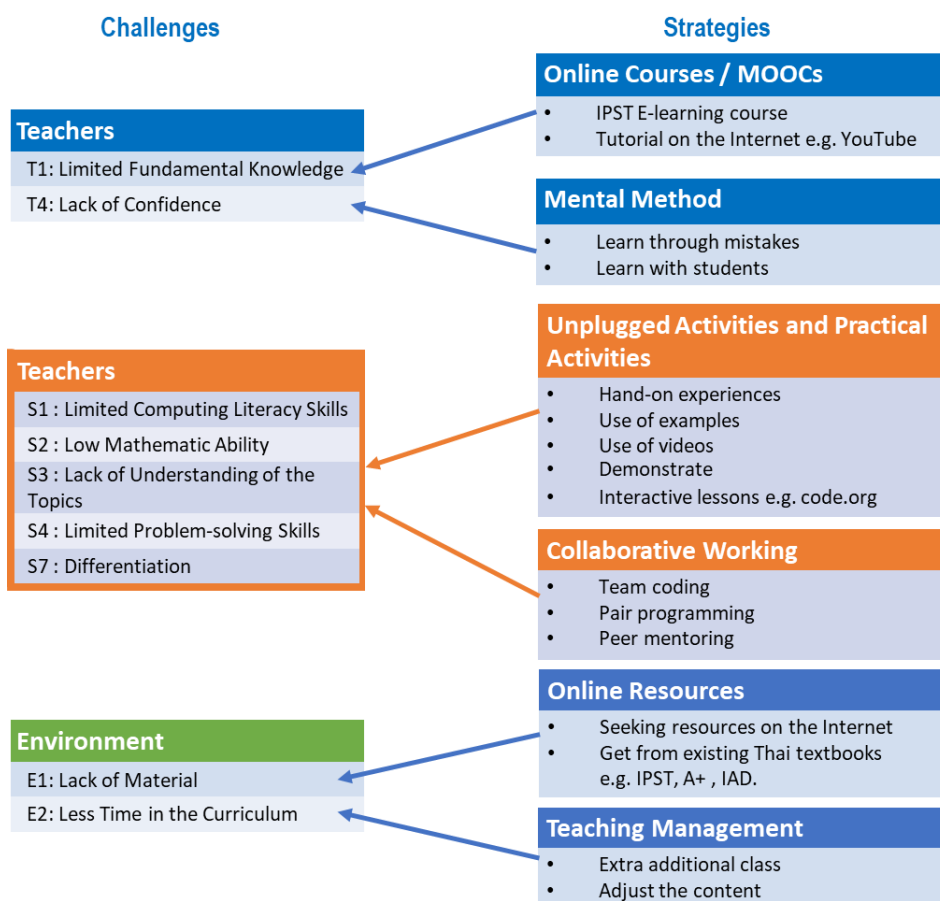
Figure 8. Practical strategies for the important challenges in Thai CT Classroom.

4. Findings and Discussion

The traditional practices for computing science classroom in four Thai schools followed the common sequence of lecturing, demonstration, practice, and evaluation. The process started by teachers giving lectures on CT concepts followed by demonstration of exercises. Students were then allowed to practice exercises either individually or in pair. This whole process was carried out within 30 minutes – 2 hours per week. The level of CT instruction and the level of contextualization varied among schools depending on the different levels of readiness of teachers and schools. The school *Provincial#2*, is an example of a well-equipped school with both teacher's qualification and school environment. Lilly

adopted physical programmable devices and integrated CT with STEM subjects, while the school *Bangkok#1* mostly taught CT using unplugged activities.

Table 5 summarizes the number of teachers who participated in the interview and polls and agreed that for each challenge, it had high impact to the teaching and learning as proposed in the conceptual model. Thus, the challenges supported by all six interviewees and or appeared in the top five poll ranking were selected as the important challenges with high impact. 錯誤! 找不到參照來源。 then reported the strategies that the teachers employed to deal with the challenges. For instance, to handle the teacher's challenge with *limited fundamental knowledge*, the teachers referred to online courses and MOOCs as their practical solutions. Likewise, to overcome the *lack of confidence* challenge, the teachers applied an open-minded approach by accepting mistakes and learning along with the students.

The important challenges related to students included *differentiation*, *limited computing literacy skills*, *low mathematic ability*, *lack of understanding of the topics* and *limited problem-solving skills*. The teachers applied two strategies: (i) unplugged and practical activities such as hand-on experiences, examples, video, demonstrate and interactive lesson, and (ii) collaborative working such as team coding, pair programming and peer mentoring.

For the challenges related to learning environment, *less time in the curriculum* and *lack of material* were discussed as the most important challenges. Several approaches were employed to deal with the first challenge. Interesting ones include (i) spending less time on lecturing and increase more time on experimenting, and hence encouraging students to practice more under their supervision, (ii) adding extra instruction time to cover all contents, (iii) adjusting the contents based on the available time. To cope with the lack of material challenge, searching and reusing resources from the Internet along with the information from available textbooks were adopted as a solution.

Although the CT assessment (i.e., *lack of CT assessment*) was not identified by the conducted survey as an important challenge, it is a central to support students to develop their CT skills (Grover, 2017). This study found that the primary assessment method used in most schools involved evaluating the correctness of the final output. However, Grover (2017) suggested that evaluating simply the final results and disregarding the learning process observation would not support proper intervention and knowledge mastery when applying CT to other problem domains. Only the school *Provincial#2* reported the use of *observation* as an assessment method and the capability to give immediate feedback to students individually. While other teachers reported that it was impossible to have formative assessment and individual feedback due to the class size. Therefore, the bigger the class size, the higher the complexity of CT development and assessment. In addition, to evaluate the students' problem-solving skill, incorrect codes were given to them to debug and correct. It is also found that besides showing the results on computer screen, coding a real, physical robot could better improve student understanding, engagement and motivation. This was evidenced by the school *Provincial#2*, where students paid high attention to study STEM subjects under CT environment.

5. Conclusion and Recommendations

This study aimed to understand CT development challenges that teachers experienced in traditional classroom practices. The challenges in the literature were explored and categorized into three aspects: teachers, students, and environment. Then, we analyzed challenges with the context of the Thai CT classroom. Totally fifteen challenges were selected and included in the designed conceptual model. We validated the conceptual model by conducting semi-structured interviews and a poll survey. The clear set of nine significant challenges on CT development from teachers' perspective were identified: T1: Limited Fundamental Knowledge, T4: Lack of Confidence, S1: Limited Computing Literacy Skills, S2: Low Mathematic Ability, S3: Lack of Understanding of the Topics, S4: Limited Problem-solving Skills, S7: Differentiation, E1: Lack of Material ,and E2: Less Time in the Curriculum. While Less Time in the Curriculum and Lack of CT Assessment were the top two common challenges in the poll survey. In additional, the study found that teaching management, self-learning through online resources and collaborative working are strategies that Thai teachers usually used to overcome the challenges.

To reduce the impact of the challenges, the following relevant research in the area of learning enhanced technology is proposed here as a potential scalable strategy to effectively develop CT skills in students, and thus improving the quality of CT education in Thailand:

- Adaptive and personalized system, which aims to customize learning for each student's strengths, needs, skills and interests in order to support a diversity of students in various dimensions such as learning skills, learning styles, and learning pace.
- CT assessment techniques are also required for efficient CT intervention. The techniques evaluate the process of thinking rather than evaluating the correctness of the final outputs.
- Conversational agent, intelligent agents, computational linguistics, NLP techniques could possibly support students for self-practice out of school hours with proper guidance, and also support teachers for assessing CT skills accurately.
- Digital repository and material recommender system are required to archive and intelligently recommend appropriate learning materials for each student.
- Gamification techniques can benefit student engagement and motivation.

Acknowledgments

References

Anderson, R. E. (1992). Social impacts of computing: Codes of professional ethics. *Social Science Computing Review*, *10*(2), 453-469.

Barr, V., & Stephenson, C. (2011). Bringing computational thinking to K-12: What is involved and what is the role of the computer science education community? ACM Inroads, 2(1), 48-54. https://doi.org/10.1145/1929887.1929905

Basu, S., Biswas, G., Sengupta, P., Dickes, A., Kinnebrew, J. S., & Clark, D. (2016). Identifying middle school students' challenges in computational thinking-based science learning. Research and practice in technology enhanced learning, 11(1), 13.

Black, J., Brodie, J., Curzon, P., Myketiak, C., McOwan, P. W., & Meagher, L. R. (2013). Making computing interesting to school students: teachers' perspectives. In Proceedings of the 18th ACM conference on Innovation and technology in computer science education, (pp. 255-260): ACM.

Bower, M., & Falkner, K. (2015). Computational thinking, the notional machine, pre-service teachers, and research opportunities. Proceedings of the 17th Australasian Computer Education Conference (ACE2015) (pp.37-46), Sydney, Australia.

Carvalho, T., Andrade, D., Silveira, J., Auler, V., Cavalheiro, S., Aguiar, M., ... & Reiser, R. (2013, October). Discussing the challenges related to deployment of computational thinking in brazilian basic education. In 2013 2nd Workshop-School on Theoretical Computer Science (pp. 111-115). IEEE.

Cho, S., Pauca, P., & Johnson, D. (2014, March). Computational thinking for the rest of us: A liberal arts approach to engaging middle and high school teachers with computer science students. In Society for Information Technology & Teacher Education International Conference (pp. 79-86). Association for the Advancement of Computing in Education (AACE).

Falkner, K., Vivian, R., & Falkner, N. (2015, January). Teaching computational thinking in K-6: The CSER digital technologies MOOC. In Proceedings of the 17th Australasian Computing Education Conference (ACE 2015) (Vol. 27, p. 30).

Finger, G., & Houguet, B. (2009). Insights into the intrinsic and extrinsic challenges for implementing technology education: Case studies of Queensland teachers. International Journal of Technology and Design Education, 19(3), 309-334.

Grover, S., Pea, R., & Cooper, S. (2015). Designing for deeper learning in a blended computer science course for middle school students. Computer Science Education, 25(2), 199-237.

Grover, S. (2017). Assessing algorithmic and computational thinking in K-12: Lessons from a middle school classroom. In Emerging research, practice, and policy on computational thinking (pp. 269-288). Springer, Cham.

Grover, S. (2018, February 25). The 5th 'C' of 21st Century Skills? Try Computational Thinking (Not Coding). Retrieved from Edsurge: https://www.edsurge.com/news/2018-02-25-the-5th-c-of-21st-century-skills-try-computational-thinking-not-coding

Grover, S., Lundh, P., & Jackiw, N. (2019, February). Non-programming activities for engagement with foundational concepts in introductory programming. In Proceedings of the 50th ACM Technical Symposium on Computer Science Education (pp. 1136-1142). ACM.

Haseski, H. I., Ilic, U., & Tugtekin, U. (2018). Defining a New 21st Century Skill-Computational Thinking: Concepts and Trends. International Education Studies, 11(4), 29-42.

Heintz, F., Mannila, L., & Färnqvist, T. (2016, October). A review of models for introducing computational thinking, computer science and computing in K-12 education. In 2016 IEEE Frontiers in Education conference (FIE) (pp. 1-9). IEEE.

IPST. (2017). Computing Science Teacher Guides. Thailand: The Institute for the Promotion of Teaching Science and Technology.

Kafai, Y. B., & Burke, Q. (2014). Connected Code: Why Children Need to Learn Programming. MacArthur Foundation Series on Digital Media and Learning. MIT Press.

Lockwood, J., & Mooney, A. (2017). Computational Thinking in Education: Where does it fit? A systematic literary review. arXiv preprint arXiv:1703.07659.

Maruyama, Y., Kanoh, H., & Adachi, K. (2017). A Preliminary Investigation into Parents' Concerns about Programming Education in Japanese Primary Schools. International Association for Development of the Information Society.

Ministry of Education. (2008). The Basic Education Core Curriculum BE 2551 (AD 2008). Kurusapa Ladprao Publishing.

Ministry of Education. (2017). Indicators and content areas in science (revised curriculum A.D. 2017) according to Basic Education Core Curriculum B.E. 2551 (A.D. 2008). Bangkok, Thailand: The Agricultural Co-operative Federation of Thailand Press.

Mooney, A., Duffin, J., Naughton, T. J., Monahan, R., Power, J. F., & Maguire, P. (2014). PACT: An initiative to introduce computational thinking to second-level education in Ireland.

Morreale, P., Goski, C., Jimenez, L., & Stewart-Gardiner, C. (2012). Measuring the impact of computational thinking workshops on high school teachers. Journal of Computing Sciences in Colleges, 27(6), 151-157.

Mouza, C., Yang, H., Pan, Y.-C., Yilmaz Ozden, S., & Pollock, L. (2017 in press). Resetting educational technology coursework for pre-service teachers: A computational thinking approach to the development of technological pedagogical content knowledge (TPACK). Australasian Journal of Educational Technology. https://doi.org/10.14742/ajet.3521

Passey, D. (2014). Intergenerational learning practices—Digital leaders in schools. Education and Information Technologies, 19(3), 473-494.

Pokorny, K. L., & White, N. (2012). Computational thinking outreach: reaching across the K-12 curriculum. Journal of Computing Sciences in Colleges, 27(5), 234-242.

Ribeiro, L., Nunes, D. J., da Cruz, M. K., & de Souza Matos, E. (2013, October). Computational thinking: Possibilities and challenges. In 2013 2nd Workshop-School on Theoretical Computer Science (pp. 22-25). IEEE.

Román-González, M., Moreno-León, J., & Robles, G. (2017, July). Complementary tools for computational thinking assessment. In Proceedings of International Conference on Computational Thinking Education (CTE 2017), S. C Kong, J Sheldon, and K. Y Li (Eds.). The Education University of Hong Kong (pp. 154-159).

Sentance, S., & Csizmadia, A. (2017). Computing in the curriculum: Challenges and strategies from a teacher's perspective. Education and Information Technologies, 22(2)

Silapachote, P., & Srisuphab, A. (2017). Engineering Courses on Computational Thinking Through Solving Problems in Artificial Intelligence. International Journal of Engineering Pedagogy, 7(3), 34-49.

Tissenbaum, M., Sheldon, J., Sherman, M. A., Abelson, H., Weintrop, D., Jona, K., ... & Snow, E. (2018). The state of the field in computational thinking assessment. International Society of the Learning Sciences, Inc.[ISLS]..

VAN Gorp, M. J., & Grissom, S. (2001). An empirical evaluation of using constructive classroom activities to teach introductory programming. Computer Science Education, 11(3), 247–260.

Vivian, R., Falkner, K., & Falkner, N. (2014). Addressing the challenges of a new digital technologies curriculum: MOOCs as a scalable solution for teacher professional development.

Wing, J. M. (2017). Computational thinking's influence on research and education for all. Italian Journal of Educational Technology, 25(2), 7–14.

Yadav, A., Mayfield, C., Zhou, N., Hambrusch, S., & Korb, J. T. (2014). Computational thinking in elementary and secondary teacher education. ACM Transactions on Computing Education (TOCE), 14(1), 5.

A Programming Learning System Introducing Small Steps Involving Mutual Evaluation

Hideyuki TAKADA[*]**, Ayaka IWASA, Risa MATSUBARA, Yuki TAKEDA, Tsuyoshi DONEN**
Faculty of Information Science and Engineering, Ritsumeikan University, Japan
*htakada@cs.ritsumei.ac.jp

Abstract: In this paper, we propose a programming learning system which incorporates a concept of small steps to nurture the computational thinking. While the project-based programming environment allows children to reach an unlimited goal of their achievements, most of learners often suffer from finding a meaningful project to work and coming up with a way of building programs for their project. In order to scaffold their programming experience, our system gives a step-by-step procedure to build a complete meaningful project, where the entire project is decomposed into small steps in advance. In addition, the system requires learners to ask their peer to check if an ongoing step is correctly completed before proceeding to the next step. In this way, our system allows them to experience the repeated cycle of the computational thinking process while encouraging them to interact each other. We also show our empirical findings obtained by applying this system to a programming workshop. In this workshop, 11 small steps to build a game project were provided to participants with our iPad application. As a result, we observed that they could complete the given project regardless of their programming experience and the system gave them an opportunity to interact with others while they were doing programming.

Keywords: Learning with programming, Computational thinking, Small steps, Mutual evaluation

1. Introduction

Various efforts have been made for several decades to introduce programming to children's learning activities (Papert, 1980)(Resnick & Robinson, 2017). The purpose of doing programming in primary education is not to learn programming itself to be a computer programmer, but to learn *with* programming. Through learning with programming, children are expected to acquire "21st century type skills" such as critical thinking ability and problem solving skills. These abilities have a common factor with the thinking process called "computational thinking" (Wing, 2006). Curriculums incorporating computational thinking are already applied to education in several countries including Australia (Falkner, Vivian & Falkner, 2014), the United Kingdom (Department for Education, 2013), and the United States (Grover & Pea, 2013).

Project-based programming environments such as Scratch (Resnick, et al., 2009) would be a good candidate to be used in a learning activity to nurture the computational thinking. In our experience in organizing a programming workshop for over the last 10 years, however, we often see many children suffering from finding a meaningful project to work, and having difficulty in building a program for what they want to create. In order to overcome this situation, we believe that it is very important to scaffold children's programming experience by guiding them to complete a meaningful project during a programming workshop.

Based on these thoughts, we propose a programming learning support system which enables children to develop computational thinking skills by working on a programming project which is broken down into small steps. This system gives a learning material with a step-by-step procedure to build a project on Scratch, leading children to repeating the cycle of the computational thinking. In addition, the system requires them to ask their peer to check if each of the steps is completed successfully, encouraging them to interact with others. We also present our empirical findings as a result of applying this system to a workshop for elementary school students.

The rest of this article is organized as follows. Section 2 explains the concept of computational thinking, how the mutual evaluation and breaking down of a project into small steps can be incorporated in the process of computational thinking. Section 3 introduces the proposed system and its implementation. Section 4 shows the result of a practical use of the proposed system. Section 5 summarizes the research and the remaining issues for the future research.

2. Programming Learning to Foster Computational Thinking

2.1 Computational Thinking

Computational thinking refers to a thinking process in solving problems. Figure 1 shows the process of computational thinking. Computational thinking aims to solve the entire problem by repeating a cycle of the following three stages: "formulation of a problem," "expression of a solution method," and "execution and evaluation of a solution method." It is known that an original large problem which is difficult to solve as it is can be made easily solvable by breaking it down into small problems.

We believe that programming enables children to repeatedly follow the cycle of Figure 1, leading to the development of computational thinking. In order to successfully turn the cycle of computational thinking, the problem formulation plays an important role. In order to solve a problem, it is necessary to know which part of the problem should be solved first and which part to follow. Even a large, complicated problem can be understood by disclosing it little by little.
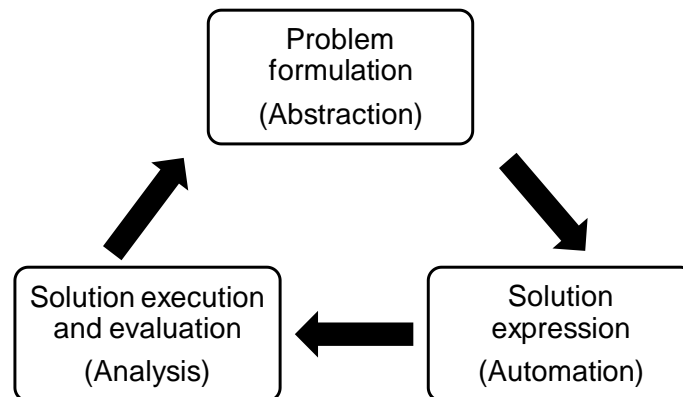
Figure 1. Computational Thinking.

2.2 Mutual Evaluation

It is also important to incorporate a chance of communication with others to a learning activity. If a mechanism to encourage students to communicate with others is introduced in the process of computational thinking, their learning experience will be a rich one.

During programming learning, checking whether programs work properly or not is very important. From the perspective of encouraging students to communicate among them, introducing a mutual evaluation into the "solution execution and evaluation" process of the computational thinking is considered to be effective.

2.3 Breaking Down a Project into Small Steps

"Small steps" are a series of tasks finely defined to resolve a meaningful problem. Breaking down a problem into small steps makes it easier to understand which part of the problem should be solved first and which part to follow. By doing so, the cycle of the computational thinking can be processed successfully. Breaking down into small steps will also provide opportunities of mutual evaluation, which also leads to an interactive learning.

Steps are not necessarily made to be more difficult or complicated as proceeding to later steps, but it is important that each step should be defined as a functional unit to complete a programming project.

2.4 Related Works

The term, *worked example*, demonstrates a step-by-step instruction of how to perform a task or solve a problem (Clark, Nguyen, & Sweller, 2011). Learning from worked examples was found to be an effective instructional strategy in such fields as mathematics, physics, and computer programming (Atkinson, et al., 2000).

We believe that one of the important factors to successfully work on a programming project is the ability of identifying functional components to achieve the target outcome. We see, however, that children often have a difficulty in dividing a whole function into several components, leading to an untidy way of doing programming. Giving them small steps to build a target project would help them understand how to identify the functional components in a real project.

We also introduce the mutual evaluation to check if each step has been completed successfully. Combined with the cycle of solving problems in the computational thinking, the mutual evaluation would play an important role in satisfying a requirement of interactive learning in programming workshops.

3. The Proposed System

3.1 Overview of the System

3.1.1 Structure of Steps

In this research, we assume that children work on a project of making a game on a graphical programming environment, Scratch. Programming on Scratch is performed by assembling blocks each of which corresponds to a specific instruction or function.

We choose a game project and break it down into small steps so that the function such as moving characters and making a hit judgement can be structured in order. An example of a step is given in Figure 2. One step consists of a functional statement (e.g. "Let the bear move to right") to be achieved and necessary blocks (e.g. "when the flag clicked," "forever" and "change x by 10") to assemble.
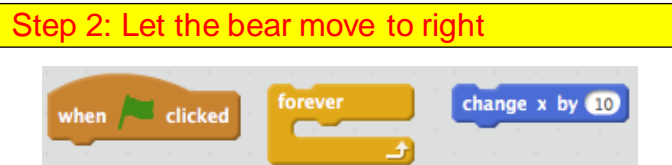
Figure 2. An Example of a Description for a Step.

3.1.2 Introduction of Mutual Evaluation

In order to enhance the programming experience working on a project with small steps, we introduce a function which allows children to proceed to the next step only after confirming the current step is completed successfully. This function aims to execute and evaluate the solution method properly and conduct an interactive learning. This function gives a screen for children to request others to check if the project is successfully completed or not. Unless other children input a password on the screen, he/she cannot proceed to the next step.

3.2 Overview of the System

This system consists of the following six screens.
- Log-in screen
- Project screen
- Test prompt screen
- Check request screen
- Clear notification screen
- Check password input screen

Figure 3 shows examples of each screen. Transitions between the screens are shown in Figure 4.

First, a user logs-in the system. Registered users can log-in from the log-in screen. Unregistered users need to register from "sign-up."

Users can view each of the small steps separately on the screen. On the project screen, description of a step to be completed can be viewed. By pressing the "Done" button, the user proceeds to the test prompt screen. The test prompt screen gives an instruction to evaluate bt themselves if the function is correctly performed or not.

Once the self-evaluation is completed on the test prompt screen, the user can proceed to the check request screen. On the check request screen, functions to be checked and a password will be displayed. By having the password input on the check password input screen of another user's tablet terminal, the user can proceed to the clear notification screen. When asked to check by another user, the user can proceed to the check password input screen from the project screen, the test prompt screen or the clear notification screen. The check password is randomly generated every time when the check request screen opens.
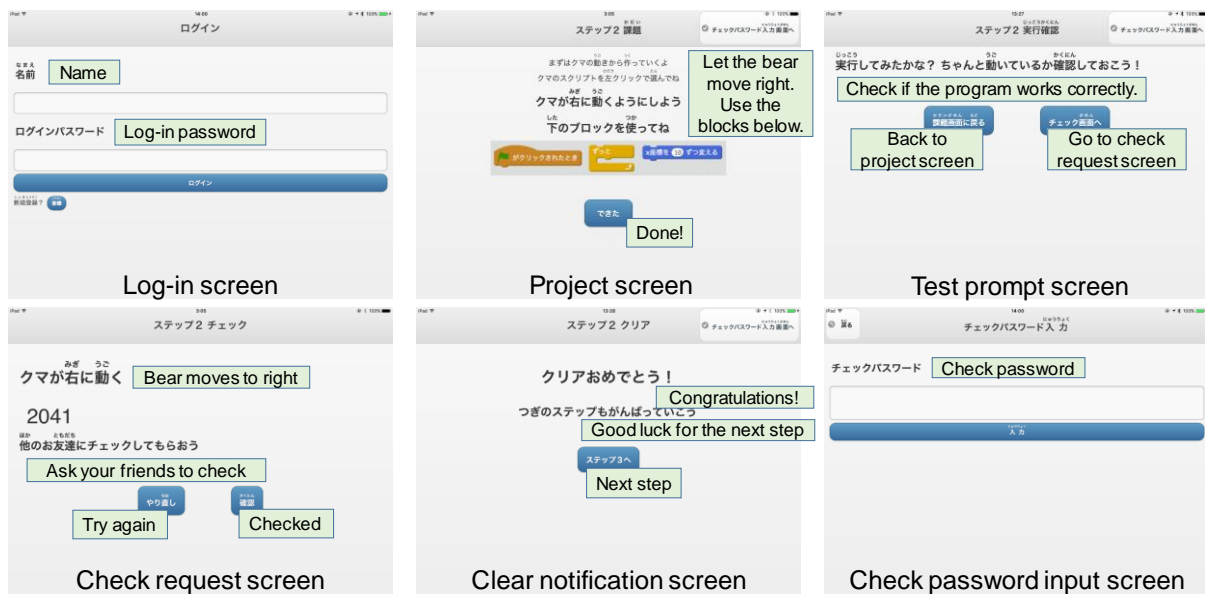
Figure 3. Screen Examples of the System.
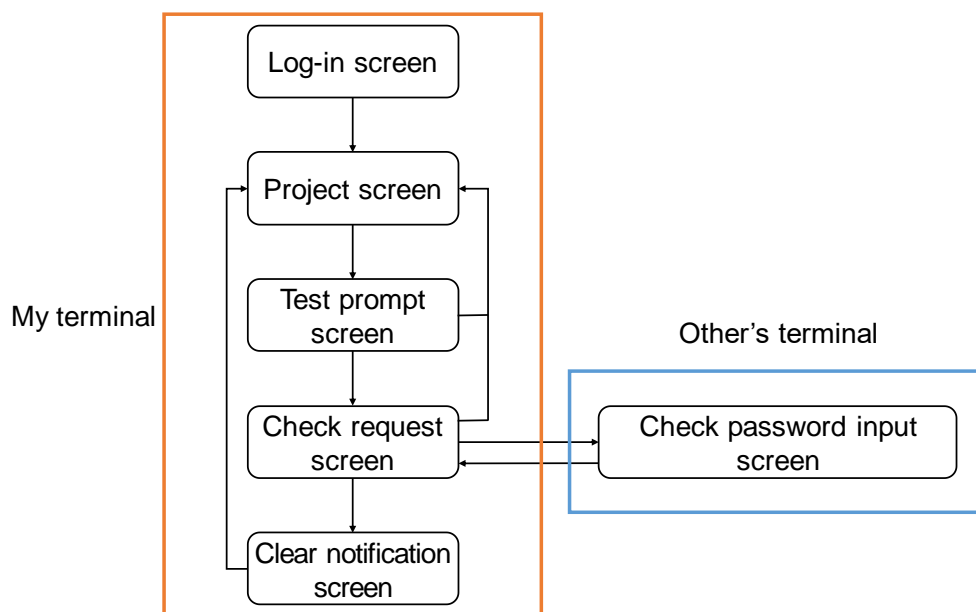
Figure 4. Screen Transitions.

3.3 Practical Implementation of the Proposed System

The system consists of a client application for browsing and checking the task steps, and a server-side application for managing the project contents and user information.

Because schools and workshops have different terminals with different operating systems, we aimed for multi-platform use and developed the system with Monaca (`https://monaca.io/`) which accommodates the multi-platform development. HTML5 and JavaScript were adopted for an application development on Monaca.

The server side environment is implemented on the NIFCLOUD mobile backend which can be integrated with Monaca. The server manages the user information and the status of checking the progress of a project using the database function.

4. Evaluation

This section explains a practical application of the proposed system to a programming workshop and shows our experiences.

4.1 The Process of Making the Proposed System into Practice

We have implemented the proposed system at a programming workshop organized by a non-profit organization called "Super Science Kids."

The system was evaluated from its usage log, recorded videos and questionnaires conducted after the workshop. Two terminals, a laptop for programming with Scratch and Apple's iPad for using the proposed system, are assigned to each of the participants.

4.2 Contents of the Workshop

In this workshop, participants worked on a project under a topic of "Let's make a snow game!" The screen of this project is shown in Figure 5. This game uses a background image and sprites included in the standard installation of Scratch. In this game, a player moves the bear with the left and right arrow keys while catching snowflakes falling randomly. Every time when the bear touches the snowflake, it gets bigger. When the bear becomes big enough to touch the star, The game is completed. The bear also gets smaller repeatedly in every ten seconds.
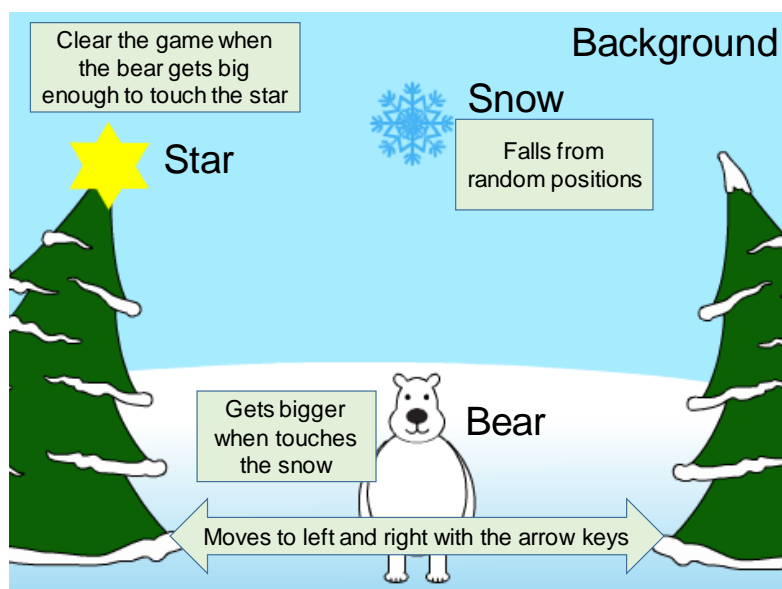
Figure 5. The Snow Game Screen.

We broke down the programming process of this game into small steps and deployed them as a material to be shown in the proposed system running on iPad. Table 1 summarizes the task steps. The game can be created by completing these 11 steps in order.

Table 1

Small Steps of the Task

Step	Task
1	Paste the background and the character
2	Make the bear move to the right
3	Make the bear move to the right only while pressing the right arrow key
4	Make the bear move to the left only while pressing the right arrow key
5	Make the snow fall down
6	Make the snow go up once it falls to the bottom
7	Make the snow fall down from many locations
8	Make the bear get bigger when it touches the snow
9	Make the bear go back to the original size when the system starts the game
10	Make the bear say "game cleared" when it touches the star
11	Make the bear get smaller every 10 seconds

The workshop was held on December 17th, 2017 at Kodomo Mirai-kan located in Kyoto, Japan. Six primary school students (3rd:~2, 4th:~1, 5th:~1, 6th:~2) participated in this workshop. They were given 100 minutes to complete the project.

For this workshop, we made three pairs, each of which was supposed to conduct the mutual evaluation. Participants were paired according to the level of experience of Scratch programming. The characteristics of the pairs are 1) one pair with experienced participants, 2) one pair of beginner participants and 3) one pair with an experienced and a beginner. The participants used the first 30 minutes to learn the basics of programming on Scratch. After that, all participants performed the first two steps together, "step 0" which is a tutorial step to learn how to use the check password of the system and "step 1" which is a task to paste the background and the sprites. From "step 2" each participant followed the given steps. During the programming, university student supporters answered questions from the participants. After all of the participants finished the final step, they filled in the questionnaire.

4.3 Results of the Workshop

4.3.1 Questionnaire Results

Table 2 summaries the content of the questionnaire and its results. There found invalid answers in Q4 and Q7, so they were removed from the results.

Table 2

Questionnaire Contents and Results

Q1	Have you ever used Scratch?				
	Yes		First time		
	3		3		

Q2	Could you proceed the tasks smoothly today?				
	Very smooth	Smooth	Fair	Not so smooth	Not smooth at all
	5	1	0	0	0

Q3	Please write the reasons. (free writing)
	- Because university students helped me - Because I have used Scratch before - Because it was fun - Because it was just for one hour - Because I could ask questions

Q4	Was it useful to be checked by others?				
	Very useful	Useful	Fair	Not so useful	Not useful at all
	3	1	1	0	0

Q5	Please write the reasons. (free writing)
	- Because I could confirm what I was doing was correct or not - Because I could accurately proceed the tasks - Because making mistakes seems really bad - Because I could ask the person next to me when I came across something I do not know - Because even when I had a confident that I completed the task, if we are working together, we can find the mistake in the program

Q6	Did you ask someone when you came across something you do not know? (multiple answers allowed)		
	Other participants	Supporters	Solved by myself
	3	5	0

Q7	Was the application easy to use?			
	Very easy	Easy	Difficult	Very difficult
	3	2	0	0

Q8	Do you want to use the application again?			
	Very much	Yes	No	Not at all
	4	2	0	0

Q9	Please write anything about your thoughts on the application. (free writing)
	- It was a lot of hassle, but I felt great when the "complete" sign appeared on the screen. - It was my first time, but it was good that I could complete. - It was interesting. - I had lots of fun. - I could learn while enjoying.

Regardless of having an experience in Scratch programming, the satisfaction with programming learning using the proposed system was high (Q2). For the mutual evaluation, most of the participants answered that it was useful for proceeding the tasks (Q4).

4.3.2 Log Results

Figure 6 shows a graph showing the progress of steps (Graph 1) and a graph showing time spent for each step (Graph 2). Six participants are shown as A, B, C, D, E and F. Three pairs are shown as Group X (both experienced), Y (both beginners) and Z (an experienced and a beginner). Because step 0 and 1 are not directly related to programming as mentioned before, we do not value them as a result.

From the results of Graph 1, A and B in Group X had a similar progress of tasks. The same is true for C and D in Group Y. On the other hand, E and F in Group Z had a different progress of tasks. From the results of Graph 2, most of the steps were completed within five minutes. The longest completion time was less than ten minutes. The average time spent on one step, excluding step 0 and 1, was 4.6 minutes.
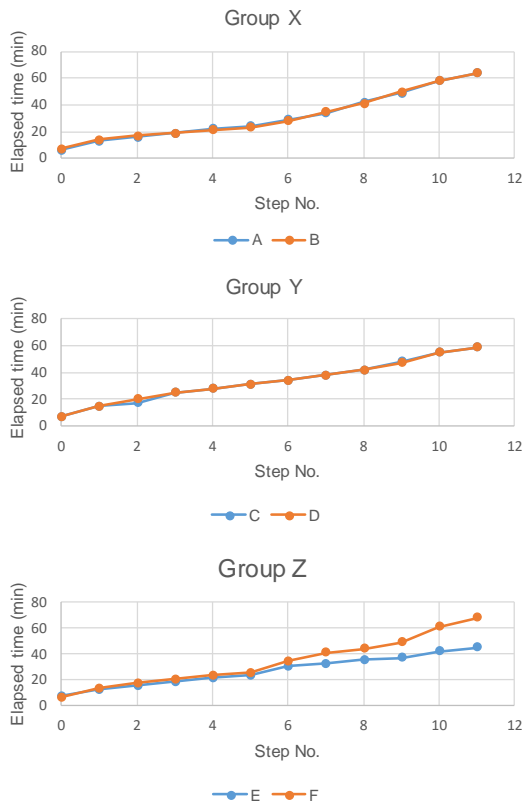
Graph 1: Progress of steps
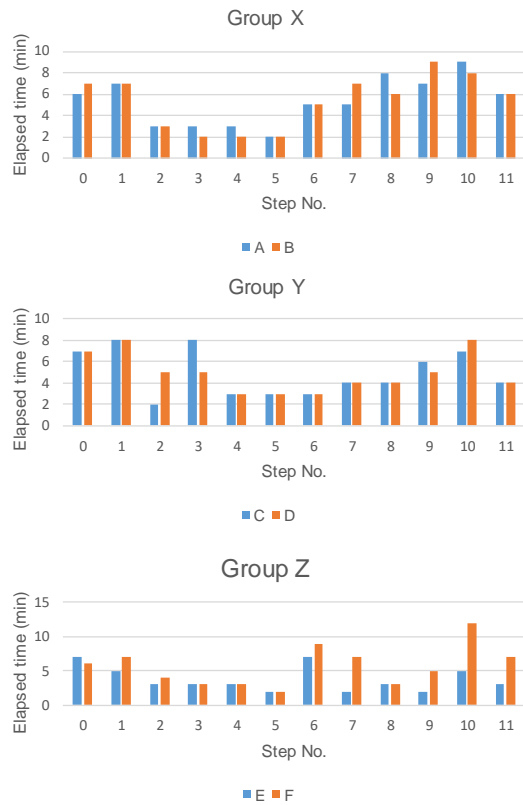
Graph 2: Time spent for each step

Figure 6. Results of Logs.

4.3.3 Observation Results

Two pairs were doing programming while talking a lot. On the other hand, one pair was not talking much except while performing the check. The two pairs who talked a lot in pairs were staying close to teach each other as can be seen in Figure 6. They also could find out why the program did not work well. Every time when they complete a step, they were having conversation to share their enjoyment.
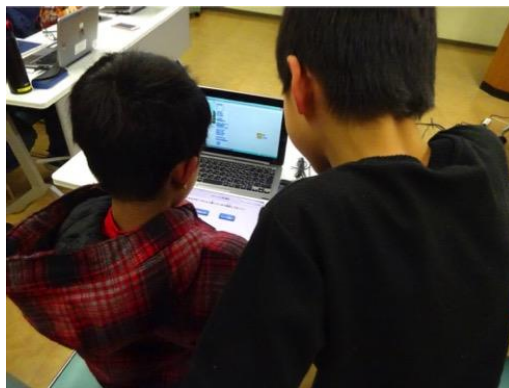
Figure 6. Teaching Each Other.

4.4 Discussion

We observed that children shared their enjoyment in pairs when they completed the steps. The two pairs (Group X and Y) which talked a lot in pairs had almost the same progress of tasks regardless of the individual. From this result, the system could have an effect on participants' feeling of the enjoyment in cooperating and teaching each other.

The pair (Group Z) with few conversations except while performing a check had a different progress depending on the individual. We think that this is because this pair was a group of an experienced and a beginner of Scratch programming. The participants' personality and compatibility might also affect on the conversation frequency.

Even though Group Z did not have a lot of conversation, both participants answered that checking had a positive effect. From this fact, we can say that being recognized objectively by others will lead to a greater sense of accomplishment rather than just completing a task by self-evaluation.

As most of the participants felt that they could proceed the tasks smoothly, we assume that it was effective to present the tasks in small steps. The sense of accomplishment and the time to be spent in one step (4.6 minutes in average) could also lead to participants' feeling of making a smooth progress.

5. Conclusion

In this research, we proposed a programming learning support system that allows children to develop "computational thinking" skills while involving and communicating with others by working on a project broken down into small steps. During the practical implementation at the workshop, we observed that the children did programming while they were feeling an enjoyment and teaching each other. Regardless of having an experience in Scratch programming, all participants were able to proceed the tasks.

Our future work includes the development of a variety of projects to be used in this system. We also have to work on building an authoring tool for creating a project with small steps because our current system requires us to rewrite the application code for a new project to be deployed. The continuous practical implementation and evaluation are also essential to verify the effect of repetitive use of the system.

Acknowledgements

References

Papert, S. (1980). Mindstorms: Children, computers, and powerful ideas. Basic Books, Inc..

Resnick, M., & Robinson, K. (2017). Lifelong kindergarten: Cultivating creativity through projects, passion, peers, and play. MIT press.

Wing, J. M. (2006). Computational thinking. Communications of the ACM, 49(3), 33-35.

Falkner, K., Vivian, R., & Falkner, N. (2014, January). The Australian digital technologies curriculum: challenge and opportunity. In Proceedings of the Sixteenth Australasian Computing Education Conference-Volume 148 (pp. 3-12). Australian Computer Society, Inc..

Department for Education. (2013). National curriculum for England: Computing programme of study.. London, England: Department for Education.

Grover, S., & Pea, R. (2013). Computational thinking in K–12: A review of the state of the field. Educational researcher, 42(1), 38-43.

Resnick, M., Maloney, J., Monroy-Hernández, A., Rusk, N., Eastmond, E., Brennan, K., ... & Kafai, Y. B. (2009). Scratch: Programming for all. Commun. Acm, 52(11), 60-67.

Clark, R. C., Nguyen, F., & Sweller, J. (2011). Efficiency in learning: Evidence-based guidelines to manage cognitive load. John Wiley & Sons.

Atkinson, R. K., Derry, S. J., Renkl, A., & Wortham, D. (2000). Learning from examples: Instructional principles from the worked examples research. Review of educational research, 70(2), 181-214.

WORKSHOP 12 - The 12th Workshop on Technology-enhanced Learning by Posing/Solving Problems/Questions - Analysis and Design of Problems/Questions

A Study of Problem-Based Pedagogy for Fostering English Grammar Acquisition in a Web-Based Context: A Pilot Study

Lu-Fang LIN[a*]
[a]*Affiliation A, National Taiwan Ocean University, Taiwan R.O.C.*
*annalin2038@gmail.com

Abstract: The purpose of the pilot study is to initially explore the impact of the problem-based approach (PBL), a learner centered approach, on English learners' acquisition of English grammar. The target grammar feature is adjective comparison. There were two groups: the experimental group (23 participants) receiving the PBL training, while the control group (24 participants) received teacher interpretation of instructional treatment. After the treatment, the two groups of participants completed the follow-up test. An analysis of covariance (ANCOVA) was conducted to detect if a significant difference existed between the PBL and non-PBL treatments. The ANCOVA results revealed a significant difference between the PBL and non-PBL groups on the first section of the follow-up test score. Implications and future research are also presented.

Keywords: Grammar teaching, English as a foreign language, English comparison sentence, learner-centered approach, problem-based learning, the Internet

1. Introduction

Grammar is an absolutely necessary component of language. Numerous second language acquisition studies and several meta-analyses (Ellis, 2006; Hulstijn & de Graff, 1994; Norris & Ortega, 2006) have suggested that second language (L2) learners should be taught grammar. Constructive learning theory maintains that "knowledge is not received from outside, but that [the learner] constructs knowledge in [his/her] mind" (Alessi & Trollip, 2001, p. 31). Drawing on the constructivists' perspectives, the present study assumed that when L2 learners are asked to participate in a problem-based learning (PBL) activity or to complete a problem-solving task, they may have opportunities to construct their L2 grammar knowledge by themselves, make connections between their prior knowledge with the target linguistic forms, and to further facilitate their understanding of the target linguistic forms. In this way, they also likely undergo the negotiation of the meanings of the specific linguistic forms, and gradually increase control over the use of those forms.

Most junior high school and senior high school students in Taiwan need to take an entrance examination to enter the next educational settings. English is one of the core subjects to determine the totaled score a student could achieve. Therefore, most English instructors are focused on teaching grammatical rules to help the students achieve high scores in the examination. Among a variety of teaching methods, mechanical drills of doing grammar exercises and explicit interpretation of grammatical rules were the major teaching activities in class. "Such conventional curricula lack[ed] multiple dimensions of literacy and also fail[ed] to offer communicative practice" (Lin, 2017a, p. 18). To fill the gap of grammar instruction in the EFL Taiwanese context, Lin (2017a) advocated that PBL can be integrated into English grammar instruction to lead the students to use grammatical rules in a meaningful and communicative context.

At present, the researcher use online teaching materials and utilize a problem-based learning approach in an English course to foster university students' memorization and utilization of English linguistic forms. The results of this study contribute directly to promoting English learning knowledge and skills via the problem-centered learning approach when employing computers in education.

2. Literature Review

2.1 L2 Grammar Teaching Methods

Several scholars of grammar teaching have been examining grammar teaching methods to promote mastery of a second/foreign language (see reviews in Norris & Ortega, 2006). Nassai and Fotos (2004) stated three essential conditions for acquisition of grammatical forms: "(1) learner noticing and continued awareness of target forms, (2) repeated meaning-focused exposure to input containing them, and (3) opportunities for output and practice" (p. 137). Accordingly, grammar can be taught explicitly and implicitly. In this study, most university students had learned English grammatical rules in their previous elementary and secondary educational settings. It seems that teaching the grammatical rules explicitly is redundant. However, most English learners probably forget what they have learned by not keeping in continuous touch with grammar features. Rather than explicit explanation of grammatical rules, the instructor may engage learners in sufficient exposure to English environments and design meaning-focused communication activities. The purpose of the present study was to establish an English learning environment in which the learners may incidentally acquire grammatical rules.

2.2 Problem-Based Learning in a WebQuest-Based Classroom

Problem-based learning (PBL) can be regarded as a problem-posing pedagogic approach. In the context of L2 learning, problems provide resources, guidance, and opportunities for students to learn their linguistic knowledge. By integrating the web-based resources, Lin applied PBL to teaching English in Taiwan and conducted empirical studies (Lin, 2015, 2017b, 2018, 2019). As indicated in Lin's earlier studies, proposed problems are like an axle linking the content of the teaching materials. In a PBL English learning program, the teacher designs a problem based on the teaching materials, and on the other hand, the students are requested to search for information on the Internet to work out the solutions to the problems. Overall, the teacher acts as a facilitator to inspire students to learn English, whereas the students take on an active learning role in reading, listening, speaking and writing English in a comprehensive way.

From the reviewed literature on implementing the PBL approach in the field of education, PBL is effective for enhancing the ability of students to increase the transferability of skills and knowledge from the classroom to situations in the real world (Delialioğlu, 2012). From the reviewed literature, the PBL approach has been applied in various academic fields and documented fruitful outcomes (Boud & Feletti, 2001).

As Lin (2017a, 2019) reviewed, PBL has been used in the EFL context. In the past decades, PBL has been applied to foster English learners' reading and listening comprehension ability, vocabulary acquisition, and writing. More recently, learner affect and metacognition are considered as an essential factor influencing L2 learning outcomes. Another PBL research path pertains to examining whether it can effectively improve learners' willingness to communicate (Lin, 2017b). Moreover, Lin (2019) integrated metacognitive strategies into a PBL English course and found that the PBL participants used problem-solving strategies more than the non-PBL participant; the PBL participants exhibited stronger confidence and lower anxiety while listening to English than their counterparts. PBL research has demonstrated positive instructional outcomes. However, this approach has not been fully developed in English grammar instruction.

With the advancement of digital/information technology, radical changes in human beings' learning are increasing in the cotemporary world. Computers are a vital dimension in literacy which cannot be ignored in language education. In this way, computers have been widely used to enhance learning. Among a great amount of computing, WebQuest, hereafter WQ, is a popular teaching model by which the instructor corporates computer technological tools in the classroom (Dodge, 1998). Several benefits of a WQ learning environment are documented in earlier studies (Ebadi & Rahimi, 2018). Among these benefits, WQ provided an optimal learning environment to promote leaners' problem-solving abilities. When proposing a framework of PBL English pedagogy in this study, the researcher emphasized that computers played an essential role in developing a PBL grammar instructional curriculum. The Internet, one of the most frequently used technological tools, was adopted as a supportive teaching devise in this study.

The purpose of the pilot study is to examine the impact of PBL grammar instruction on EFL learners' learning of adjective comparison (AC) sentences. For the purpose of this study, the following question is addressed:

Is there any significant difference between the effects of intervention (PBL grammar instruction) and non-intervention (non-PBL grammar instruction) on the acquisition of the target grammatical rule, adjective comparison, by university students in Taiwan?

3. Methodology

3.1 Participants

The researcher conducted a project to examine whether PBL could significantly improve English learners' grammar learning. A pilot study was conducted prior to a formal study. The pilot study included 47 undergraduate university students recruited from two English elective courses. The two intact classes were randomly assigned as one experimental group (23 participants), receiving the PBL grammar instruction, and one control group (24 participants) receiving no PBL instruction. Each class met once a week for 100 minutes each week and was taught with the same material.

3.2 Instruments

3.2.1 English Proficiency Test
The researcher adopted the English proficiency (EP) test used in Lin's (2017b) study. The EP test consisted of reading and listening sections. The reading section involved answering 40 multiple-choice question items. The maximum score for this section was 40. The listening section also involves answering 45 multiple-choice question items. The maximum score for this section was 45. One correct response was awarded one point. The total score of the two sections was 85 points. The Cronbach's alpha reliability estimate was .86.

3.2.2 Adjective-comparison Follow-up Test

The present study only focused on three degrees of AC sentences, including positive adjectives (i.e., an adjective that makes no comparison), comparative adjectives (i.e., the comparative degree compares two people, things, activities or qualities), and superlative adjectives (i.e., the superlative degree compares a person, thing, activity or quality with a group)(Learn ESL, 2019).

The purpose of the follow-up test was to check for differences in knowledge of forming the positive, comparative and superlative degrees of adjective comparison between the two treatments. In total, there were three sections. The first section contained five items in which the participants followed the sample to compose the comparison sentence. The sample sentence goes like this:

> Their sport jacket is comfortable and attractive, but our sport jacket is more comfortable and more attractive than theirs.

As shown in the aforementioned sample, the participants needed to complete the underlined part. In this section, the response of one item was given a score of two points if the participants produced a completely correct AC sentence; a score of one point if there was one grammatical error in a sentence, and if there were at least two errors, the sentence was scored as 0.

The second section required the participants to fill in the blank with superlative adjective forms. The third section was a cloze test. A passage contained six blanks, in which the participants filled in the blanks with proper positive, comparative and superlative degrees of adjective forms. In the two sections, the response was scored with two points if the participants answered a complete correct response in the blank. The response was scored with one point if one error was detected. If the participant produced a completely wrong response, the response was scored as 0.

3.3 Data Analysis

An English proficiency test was administered before the treatment and an English adjective-comparison follow-up test after the treatment. The participants were recruited from two English elective courses. The two classes likely differed from each other in their English reading and listening proficiency. Both

English reading and listening proficiency test scores were used as covariates to control for any preexisting differences in the participants' English ability before the treatments. Owing to different numbers of question items in each section of the follow-up test, all testing scores were converted into percentages representing the participants' correct responses relative to the total number of question items on each test. The significant level of statistical results was set to $\alpha = .05$.

3.4 PBL and Non-PBL Treatments

The researcher followed the five-step teaching framework in Lin's studies (2017a) to design the instructional procedures of the two treatments. The PBL teaching scheme was completed in a cycle of five meetings: presenting the problem, examining the problem, re-examining the problem, reviewing the problem, and presenting the solutions (Lin, 2017a, pp. 23-24). The two treatment procedures are briefly presented in the following section.

3.4.1. Instructional Procedure in the PBL Group
During the 5 weeks of instruction, in the first week meeting, the PBL intervention comprised approximately 30 min. of explicit grammar instruction and 70 min. of problem-solving activities; in the last week meeting, each group presented the solutions via the computer. The explicit grammar instruction was to notify the participants of the syntactic patterns of target AC sentences. In this way, the problem-solving activities mostly focused on implicit grammar instruction; that is, the participants undertook incidental acquisition of the target grammar features during the process of working out the solutions to the problem. In order to lead the participants to practice AC sentences, the proposed problem and the website used in the pilot study are presented as follows:

Problem: Historians have reported that the ancient Olympic Games started in 776 BC. How have the Olympic Games changed over the years since 776 BC? What are the differences and similarities between ancient Olympic Games and modern Olympic Games?

Website: Scholastic Teacher's Activity Guide: Origin and History of the Olympic Games. http://teacher.scholastic.com/activities/athens_games/history.htm (retrieved Sep. 10, 2019)

During the treatment, the participants were divided into small groups and were encouraged to undertake small-group discussion. The Internet was used as a supportive learning tool in the present study. Each group of participants needed to have a survey on the Internet. In this way, Internet survey on the computer supported the PBL participants learned how to screen out potential information for the problem and as well practiced synthesizing the information from different Internet resources to work out solutions to the problem.

3.4.2 Instructional Procedure in the non-PBL Group
Participants in this group were provided with explicit interpretations of grammatical rules of AC sentences during the 5-week intervention. They also focused on practicing the grammar exercises. There were no group work and Internet survey activities during the intervention. The researcher displayed the articles on the Internet and the students followed the researcher's interpretations.

4. Results and Discussion

To answer the research questions, descriptive statistics (means and SDs) were calculated, and ANCOVA was used to compare the follow-up test scores of the participants in each group receiving a different type of instruction. The assumption of homogeneity in the regression of the covariates and the dependent variables was first examined. The results showed that the assumption of homogeneity of the regression slopes was not violated (Covariate 1: Reading proficiency: $F = .016$, $p > 0.05$; Covariate 2: Listening proficiency: $F = .252$, $p > 0.05$). Before the intervention, the two groups of participants were similar in their English reading and listening abilities.

In Table 1, the ANCOVA results revealed a significant difference between the PBL and non-PBL groups on the first section of the follow-up test score, $F_{(1, 45)} = 10.964$, $p < .05$. The result revealed that PBL group's adjusted mean score of the third section is significantly higher than the non-PBL group's. That is, the PBL group achieved a significantly higher mean score for the first section

($Mean = 77.927^a$) than the non-PBL group ($Mean = 52.403^a$) on the first section of the follow-up test (see adjusted mean scores of the follow-up test in Table 2).

The significant outcome of the first section of the follow-up test can be attributed to the participants' familiarization with the target grammatical rule in a comprehensive way. Among three sections of question items in the follow-up test, the task of writing AC sentences in the first section can be more complicated than those of writing AC forms in the second and third sections.

Regarding the AC forms, all the participants needed to do was to fill in the blanks with the addition of suffixes or the words "more" or "most" to convey comparison. In the situation of filling in a positive degree of an adjective, the participants did not need to alter the word form in any way. In contrast, when completing the sentence in the first section, the participants likely needed to consider English linguistic knowledge of AC in a comprehensive way rather than the forms of positive, comparative, and superlative adjectives. For example, when combining two simple sentences into one AC sentence, the participants usually needed to utilize English linguistic knowledge of identifying the subject and the object, and the word order of an English comparison sentence.

Table 1

Analysis of Covariance on the Follow-up Test of PBL and Non-PBL Groups

Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Square
Section I	6409.680	1	6409.680	10.964	0.002*	.203
Section II	96.452	1	96.452	.307	.582	.007
Section III	167.399	1	167.399	.506	.481	.012
TOTAL	671.154	1	671.154	2.958	.093	.064

Note. 1. * $p < .05$　　2. PBL = problem-based learning

Table 2

Adjusted Mean Scores of the Follow-up Test

Dependent Variable	Group	Mean	SD	95% Confidence interval	
				Upper bound	Lower bound
Section I	PBL	77.927^a	5.285	67.269	88.585
	Non-PBL	52.403^a	5.164	41.989	62.818
Section II	PBL	77.750^a	3.873	69.939	85.561
	Non-PBL	74.619^a	3.784	66.987	82.251
Section III	PBL	64.341^a	3.977	56.320	72.361
	Non-PBL	60.216^a	3.886	52.379	68.052
TOTAL	PBL	74.291^a	3.292	67.651	80.931
	Non-PBL	66.032^a	3.217	59.544	72.520

5. Conclusion

Holding a belief that English is a lifestyle, the researcher hopes students can learn English and learn to use English in a meaningful and communicative context. Thus, the researcher has applied PBL to teaching English in Taiwan. The present study made a comparison of the effects of PBL and non-PBL on university English learners' acquisition of ACs. The results of the follow-up test showed that the PBL treatment was significantly more effective in terms of learning the grammar features of AC than the non-PBL treatment. In this study, when preparing to present solutions, the PBL participants might have repeatedly rehearsed what they would say or write in sentences. With these mental rehearsals, the students likely familiarized themselves with how to use the AC grammar features in a contextualized situation. The PBL pedagogy continuously engaged the participants in the production of solutions, which gradually evolved not only in meaning but in sentence structures. In this way, the participants likely developed procedure knowledge of ACs in a comprehensive way, and their procedural knowledge could be likely further automatized in a discourse context.

Due to the complexity of grammatical features, one cannot necessarily jump to the conclusion that the students who received the PBL training mastered AC grammatical knowledge and knew how to use it well in different situations. Armed with the results of the pilot study, the instructor may consider use problems as supportive instructional scaffolding, leading English learners to practice using the target grammatical rules. Regarding the measurement of AC grammar knowledge, the researcher would like to construct a writing task to further measure the participants' ability to utilize English linguistic knowledge of AC in the formal study. In addition, the researcher will construct a test to evaluate the learner's ability to judge the correct patterns of AC. The educational significance of PBL addresses goals for English learners that are much broader than the memorization of inert subject knowledge in the textbook (Lin, 2017b). Keeping such goals in mind, the researcher has conducted empirical studies to examine its instructional effectiveness. With the increasing popularity of computer education in all aspects, PBL can be regarded as an optimal teaching method to foster English learning.

Acknowledgements

References

Alessi, S. M., & Trollip, R. (2001). *Multimedia for learning: methods and development*. Boston: Allyn and Bacon.

Boud, D., & Feletti, G. (Eds). (2001). *The Challenge of Problem-Based Learning*. London: Kogan Page.

Dodge, B. (1998). WebQuests: A strategy for scaffolding higher level learning. Retrieved September 3, 2008, from http://webquest.sdsu.edu/necc98.htm

Delialioğlu, Ö. (2012). Student Engagement in blended learning environments with lecture-based and problem-based instructional approaches. *Educational Technology & Society, 15*(3), 310-322.

Ebadi, Saman & Rahimi, Masoud (2018). An exploration into the impact of WebQuest-based classroom on EFL learners' critical thinking and academic writing skills: a mixed-methods study. *Computer Assisted Language Learning, 31*(1), 617-651. https://doi.org/10.1080/09588221.2018.1449757

Ellis, R. (2006). Current issues in the teaching of grammar: An SLA perspective. *TESOL Quarterly, 40*(1), 83-107. Accessed July 29, 2019. https://doi.org/10.2307/40264512

Hulstijn, J. H., & de Graff, R. (1994). Under what condition does explicit knowledge of a second language facilitate the acquisition of implicit knowledge? A research proposal. *AILA Review, 11*, 97-112.

Learn ESL (2019). Three Degrees of Adjectives in English. Accessed July 27, 2019. https://www.learnesl.net/three-degrees-of-adjectives-in-english.

Lin, Lu-Fang. (2015). The Impact of Problem-Based Learning on Chinese-Speaking Elementary School Students' English Vocabulary Learning and Use. *System, 55*, 30-42. https://doi.org/10.1016/j.system.2015.08.004

Lin, Lu-Fang. (2017a). English Grammar Instruction and the Problem-based Learning Approach: A Multiliteracies Perspective, *The International Journal of Literacies, 24* (1), 17-26.

Lin, Lu-Fang. (2017b). The Application of the Problem-Based Learning Approach to English Class: Chinese-speaking Learners' Willingness to Communicate. *International Journal of Education, 9*(3), 1-20.

Lin, Lu-Fang. (2018). Integrating the Problem-based Learning Approach into a Web-based English Reading Course. *Journal of Educational Computing Research, 56*(1), 105-133. doi: 10.1177/0735633117705960

Lin, Lu-Fang. (2019, in press). The Effect a Problem-Based Approach to Teaching Listening Comprehension Ability and Metacognitive Strategy Use. In Astrida Skrinda (Ed.). *Teaching English: Perspectives, Methods and Challenges*. NY, USA: Nova Science Publishers, Inc.

Nassaji, H., & Fotos, S. (2004). Current developments in research on the teaching of grammar. In M. McGroarty (Ed.), *Annual Review of Applied Linguistics* (Vol. 24, pp. 126-145). Cambridge: Cambridge University Press. doi: 10.1017/S0267190504000066

Norris, J., & Ortega, L. (2006). The value and practice of research synthesis for language learning. In J. Norris & L. Ortega (Eds.), *Synthesizing Research on Language Learning and Teaching* (pp. 3-52). Amsterdam: Benjamins.

Supporting Knowledge Organization for Reuse in Programming: Proposal of a System Based on Function–Behavior–Structure Models

Kento KOIKE[a]*, Takahito TOMOTO[b], Tomoya HORIGUCHI[c] & Tsukasa HIRASHIMA[d]
[a]*Graduate School of Engineering, Tokyo Polytechnic University, Japan*
[b]*Faculty of Engineering, Tokyo Polytechnic University, Japan*
[c]*Graduate School of Maritime Sciences, Kobe University, Japan*
[d]*Graduate School of Engineering, Hiroshima University, Japan*
*k.koike@t-kougei.ac.jp

Abstract: It is important to reuse knowledge acquired through problem-solving in programming. To reuse knowledge, it is effective to first understand differences between knowledge items and then to organize that knowledge. Therefore, we propose a method and develop a support system for facilitating knowledge organization in programming. We further examine a model of parts and problem-solving process of parts based on function–behavior–structure aspects. In this paper, we expand a previously developed system to propose an improved system that provides support based on feedback from these models. The aim of this system is to allow learners to consider behavior rather than thinking directly from function to structure.

Keywords: Programming education, knowledge organization, problem framing

1. Introduction

It is important to reuse knowledge acquired through problem-solving in programming. To reuse knowledge, it is effective to first understand the differences between knowledge items and then to organize that knowledge. Therefore, one of the goals in learning to program is to organize knowledge for reuse at an appropriate time.

Recently, the demand for programming education is increasing worldwide. Enhancing intelligent tutoring systems (ITSs) in programming education is therefore very important. For a computer to intelligently support such learning, it is desirable that it be adaptive to individual learning. In ITS research, learning effectiveness is characterized by (A) controlling features of the question or problem to be asked by indexing based on characteristics of target domains (e.g. Hirashima, Kashihara, & Toyoda, 1992; Horiguchi, Tomoto, & Hirashima, 2015), or by (B) making appropriate interventions such as feedback by grasping problem-solving processes based on explainable problem-solving models (e.g. Hirashima et al., 1992; Hirashima, Kashihara, & Toyoda, 1995).

Regarding (A), assuming that problem solving is directed toward acquisition of knowledge required for a solution, descriptions of the programming knowledge itself lead to indexing of the problem. Some studies have utilized structure–behavior–function aspects, combining each aspect to handle knowledge in parts and using them for knowledge descriptions. Taking the example of qualitative physics, behavior can be defined as "multiple input–output relationships with causality in the object structure," and function can be defined as "the terminology assigned representing the function to the behavior" (de Kleer & Brown, 1984). Based on this definition, qualitative physics makes it possible to express phenomena and problem solutions by combining and correcting parts. In ITS, many examples apply structure–behavior–function aspects to descriptions of learning objects (e.g. Kashihara, Hirashima, Toyoda, & Nakamura, 1992; Matsuda, Kashihara, Hirashima, & Toyoda, 1997). A premise of ontology engineering is that "all artifacts are composed of a combination of parts" (Sasajima, Kitamura, Ikeda, & Mizoguchi, 1996). By this, an object is defined as being composed of parts can be processed to convert input to output based on the user's requirements. This makes it possible to express part structures in terms of the relation between their smaller subparts. Furthermore,

ontology engineering has expanded the idea of qualitative physics, giving different definitions for conventional functions and behaviors. Specifically, "behavior" is defined as "state transitions of an object that changes with time, and the result of simulations of the object required by the user," and "function" is defined as "the result of interpreting the function based on the goal of the entire system."

Based on these ideas from ontology engineering, we considered the problem-solving process in programming using these three aspects (Fig. 1) (Koike, Tomoto, Horiguchi, & Hirashima, 2018b, 2018a). First, if the end-state is output from a given initial state of variables provided as input to the source code that is the structure, the difference between the input and the output provided by the structure can be observed as the behavior of the structure. Furthermore, the observed behavior can be interpreted as the function by assuming the goal (context) of the overall system. Therefore, we apply the concept of ontology engineering and express knowledge in programming by treating the structure–behavior–function aspects together as parts. Thus, we proposed a method for facilitating knowledge organizing in programming and developed a support system for that method.

Regarding (B), there have been many attempts to grasp problem-solving processes in programming in terms of the program comprehension or program understanding concepts from system engineering. A number of models have been proposed (e.g., Harth & Dugerdil, 2017; von Mayrhauser & Vans, 1995), but no models that aim at supporting learning have been proposed. In this research, by defining programming knowledge as parts, we approach various elements related to programming that have previously been considered tacit and clarify and organize each element independently of the programming language used. In this way, we try to construct a model of the problem-solving process using parts from the viewpoint of learning and formalize tacit knowledge.

We expect realization of the following by our model of ITS for programming education:
- Adaptive presentation of problems
- Adaptive correction of incorrect judgments
- Grasping of errors in the overall learning process
- Estimation of learner knowledge states
- Encouragement of learning by trial-and-error

In this paper, we expand a previously developed system through these problem framings and propose an improved system. The proposed system has two new functions, one that provides feedback for grasping problem-solving processes and one for generating tasks on a criteria basis. The aim of this system is to allow learners to consider behavior rather than thinking directly from function to structure.
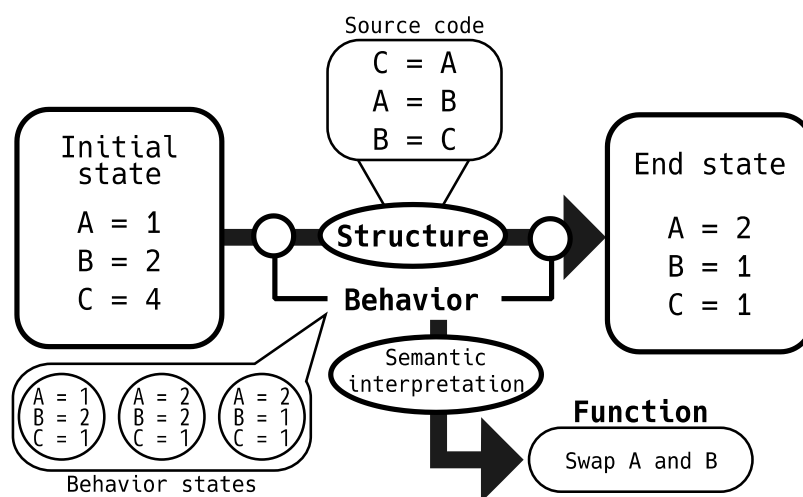
Figure 1. Problem-solving process in programming.

2. Method for Supporting Knowledge Organization and the Developed System

This section introduces the expandable modular statements (EMS) method, a learning method directed at knowledge organization that we previously proposed, and a newly developed knowledge organization support system for this method. Furthermore, we show a system configuration that addresses issues in the previous system.

389

2.1 Expandable Modular Statements Method

EMS has two aspects: construction and expansion (Fig. 2). First, parts that learners should construct are presented as a task, and the learners write code to construct chunks that include meaningful series as parts. Next, parts including the constructed parts are presented as a task, and learners construct larger parts that reuse the previously constructed parts.

In the example shown in Fig. 2, the "swap" parts are constructed by learner writing and combining "$c = a$," "$a = b$," and "$b = c$" in the "make swap" task. Then, in the "make sort" task, learner adding "if $a > b$" to the previously created "swap" expands the "sort" as larger parts. By repeating the construction, reuse, and expansion of such parts in this learning method, the learner is directed toward awareness of relations between each parts, and training for reuse.
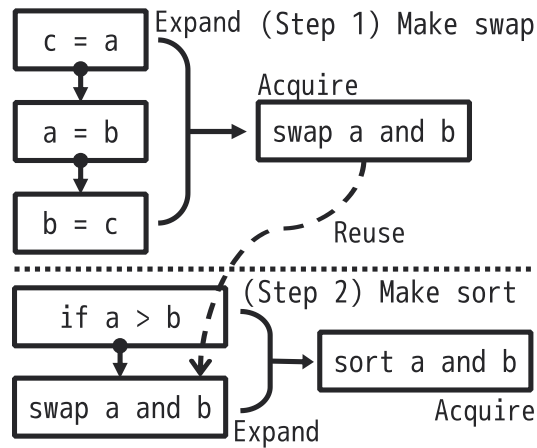
Figure 2. An example of EMS.

2.2 Previous Knowledge Organization Support System

We previously developed a system that supports the organization of knowledge use and EMS. Figure 3 shows the user interface of the previous system. In this user interface, the learner learns based on the EMS method through system assistance. Evaluations of this system showed that it significantly supports learning and code reuse (Koike, Tomoto, Horiguchi, & Hirashima, 2019).
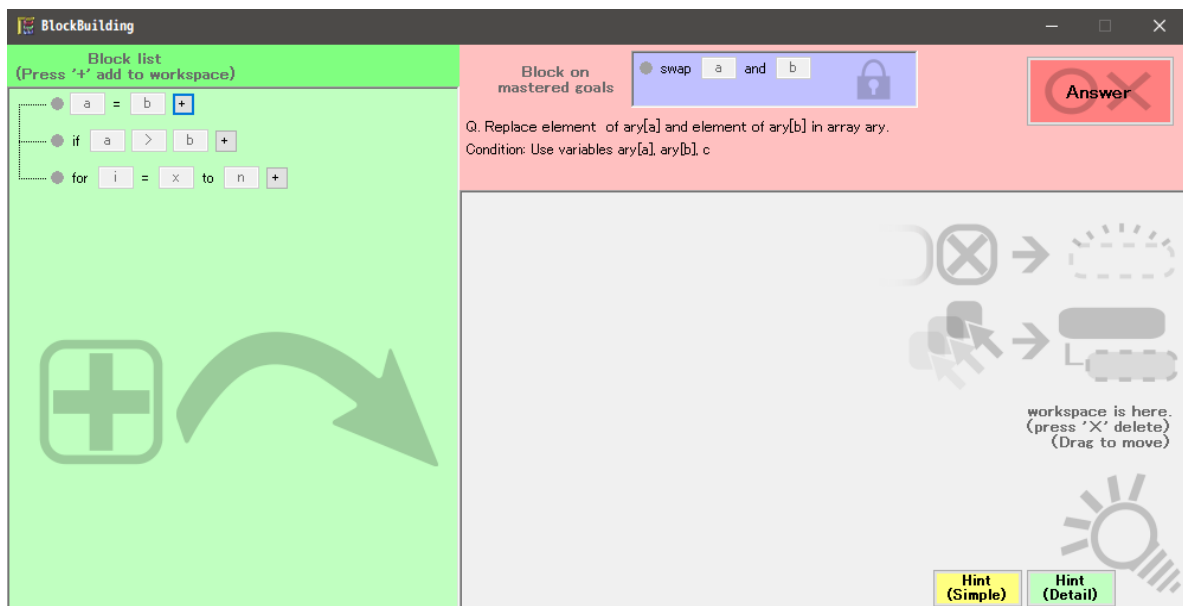
Figure 3. User interface of the previous system.

Figure 4(a) shows the configuration of the previous system, in which problems are presented stepwise in a certain task sequence, and the learner learns according to that sequence. When responding to tasks or pressing the hint button, the system provides feedback to direct the learner. The previous system, however, presents only task sequences that we have subjectively determined. Furthermore, the provided feedback only compares the structure of learner answers with the correct answer to point out deficiencies and excesses.

Therefore, we examined the definition of a parts model as knowledge and a model of the problem-solving process as related to the acquisition and expansion of parts, so that the system can better grasp and support learning (see Section 3). In the newly proposed system, these models are implemented in the previous system to address some issues in that system.

Figure 4(b) shows the configuration of the proposed system, in which tasks can be generated from a system parts database and task sequences can be automatically generated while considering differences between tasks. Based on the problem-solving process, learners can grasp in which processes errors occur when parts are incorrectly constructed or consider which part elements are insufficiently understood. This should provide more adaptive feedback.

(a) Configuration of the previous system.

(b) Configuration of the proposed system.
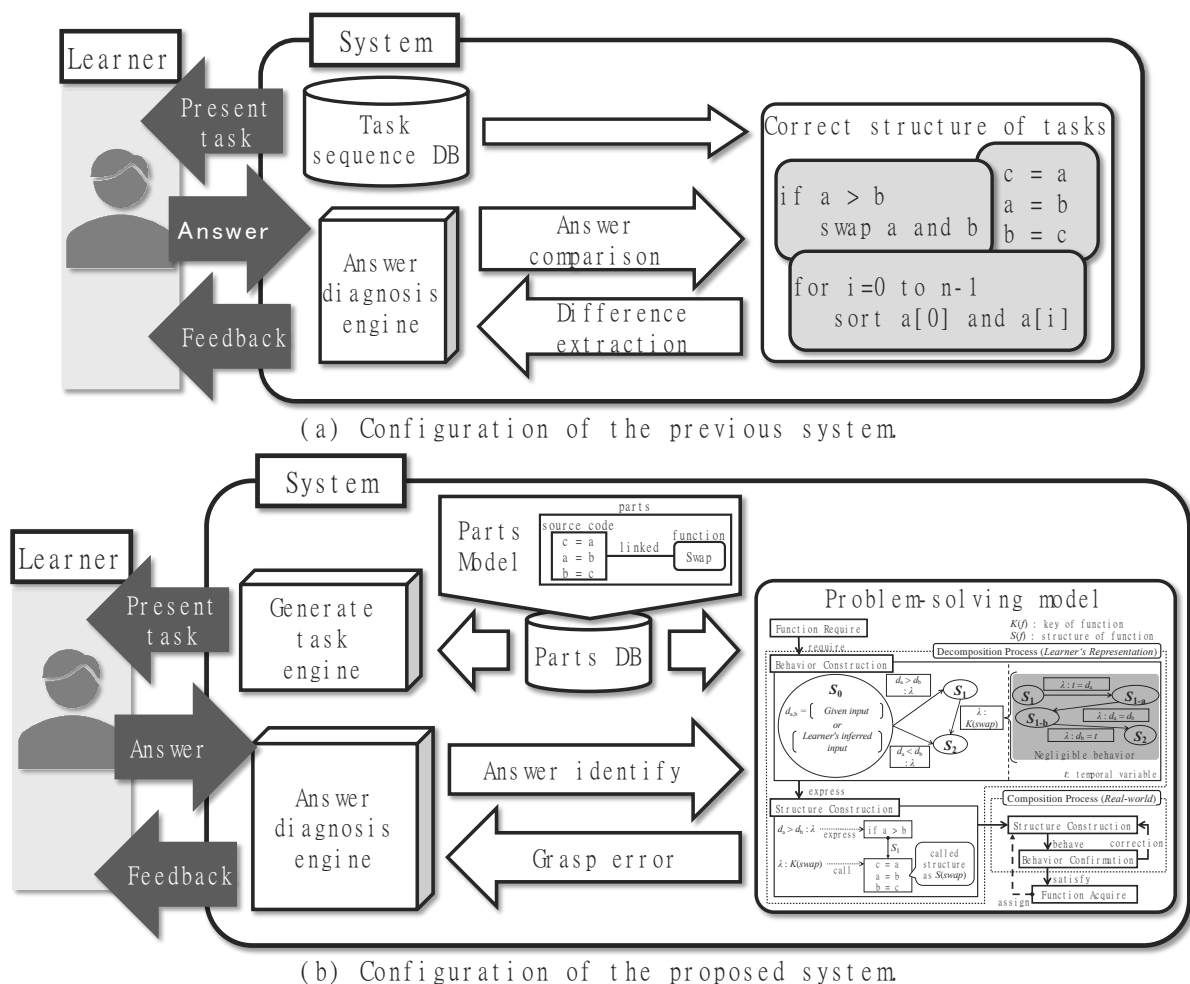
Figure 4. System configurations of the previous and proposed systems.

3. Parts Model and Problem-Solving Process Model

This section outlines the proposed parts model and a model for problem-solving processes based on that parts model.

3.1 Parts Model

To reuse a meaningful series of code as parts, learners must associate stored source code and its behavior. Source code behavior can be categorized as overall behavior or meaning attached to a target behavior according to the code's purpose. For example, in the source code "c = a," "a = b," and "b = c" in "swap," there are state transitions such as "change variable c to the value of a," "change variable a to the value of b," and "change variable b to the value of a." However, only the latter two commands are interpreted as the meaning of the "swap" function, and the behavior "change variable c to the value of a" is not focused upon.

Therefore, in this research we define "structure" as source code, "behavior" as the overall source code behavior, and "function" as meaning attached to behaviors toward the intended purpose. Figure 5 shows the relations between these three elements.
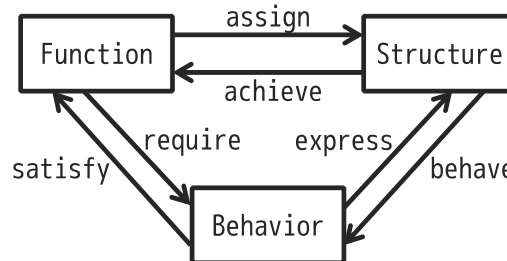
Figure 5. Parts model.

3.2 Problem-Solving Process Model

Figure 6 shows a model of the problem-solving process based on the parts definition. In this research, the problem-solving process related to parts is divided into two processes: "decomposition of required functions" performed as a representation of learners, and "composition of required functions" performed in the real world. In particular, we focus on the decomposition process with the aim of grasping the process by which learner answers are derived in the real world. Therefore, in this model, how each part element is derived in the decomposition process is modeled as a problem-solving process.

The model in Fig. 6 expresses the problem-solving process in a case assuming that the task "sort two variables (sort)" will be accomplished by expanding the previously coded "replace two variables (swap)." First, we derive the behavior required to achieve the "sort" function. In other words, to code the function, the state transition to be performed is derived based on input given explicitly or assumed by the learner. In state transitions, the state is denoted by S and the input is denoted by d. When transitioning from S_0 to the next state, transition conditions and operations are expressed in Fig. 6 as a rectangle on the edge between the current state and the next state S_n. The expression in the rectangle represents "transition condition: operation," and "λ" indicates no operation. For example, the state transition $S_0 \rightarrow S_1$ is performed only when $d_a > d_b$, while the state transition $S_1 \rightarrow S_2$ in the $K(swap)$ operation is performed unconditionally. Here, $K(swap)$ is the meaning of the index that recalls. the "replace two variables" structure and is used to omit the behavior to be represented by reusing the learner's existing knowledge. A learner not having this knowledge cannot achieve this task without assuming the detailed operation shown in the gray part in the upper right. But if the parts of *swap* are known in advance, it is not necessary to consider detailed behaviors.

Once the required behavior is realized, the "Structure Construction" block then constructs the structure by combining parts to express the desired behavior. Parts corresponding to each behavior are combined, but "λ: $K(swap)$" reuses a structure from the learner's existing knowledge based on the *swap* index.

Next, the "Composition Process" block writes out the solved structure in the real world and verifies its behavior. If the structure behavior satisfies the function, the learner assigns the function to the structure and acquires it as knowledge. The learner's knowledge state can thus be expressed as a set of parts (Fig. 7). For example, in constructing the structure in the decomposition process in Fig. 6, the structure is recalled by indexing the parts from which the $K(swap)$ function is created from the learner's existing knowledge. Furthermore, "sorting of two variables" added to the process in Fig. 6 is newly

added to knowledge as *K(2var_sort)*. In the process in Fig. 8, a learner who has acquired "sorting of two variables" from the process in Fig. 6 next aims at coding "determine the minimum value in the array." In this way, knowledge is organized by expanding parts in stages.

The function name *K(name)* used for the index is only a label for distinguishing parts among learners; it has no other meaning.
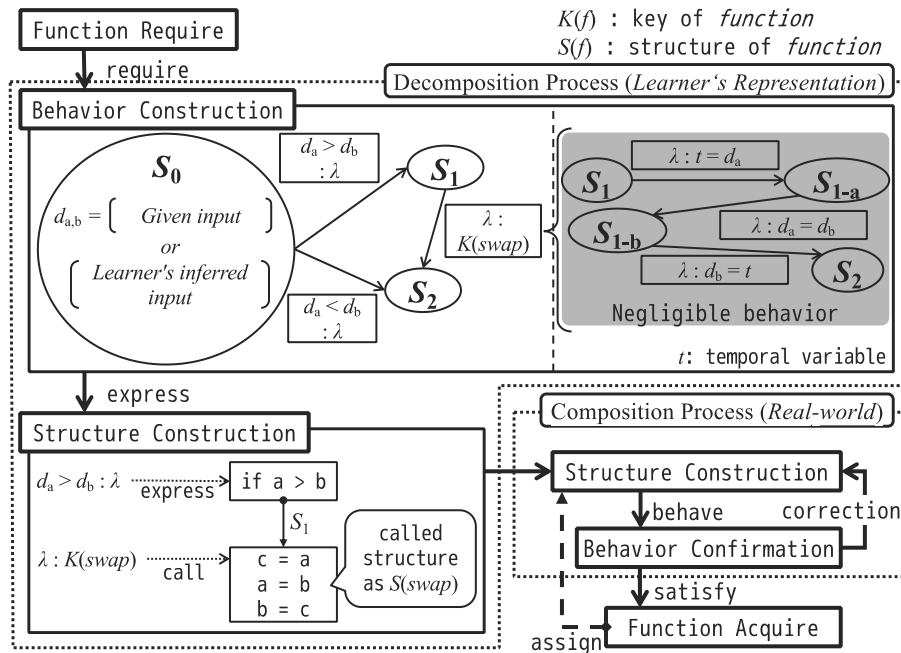
Figure 6. Model of the parts-based problem-solving process (the example of *2var_sort*).
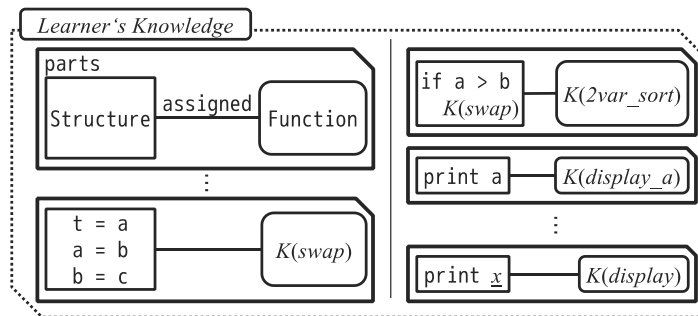
Figure 7. Expression of learner knowledge states.
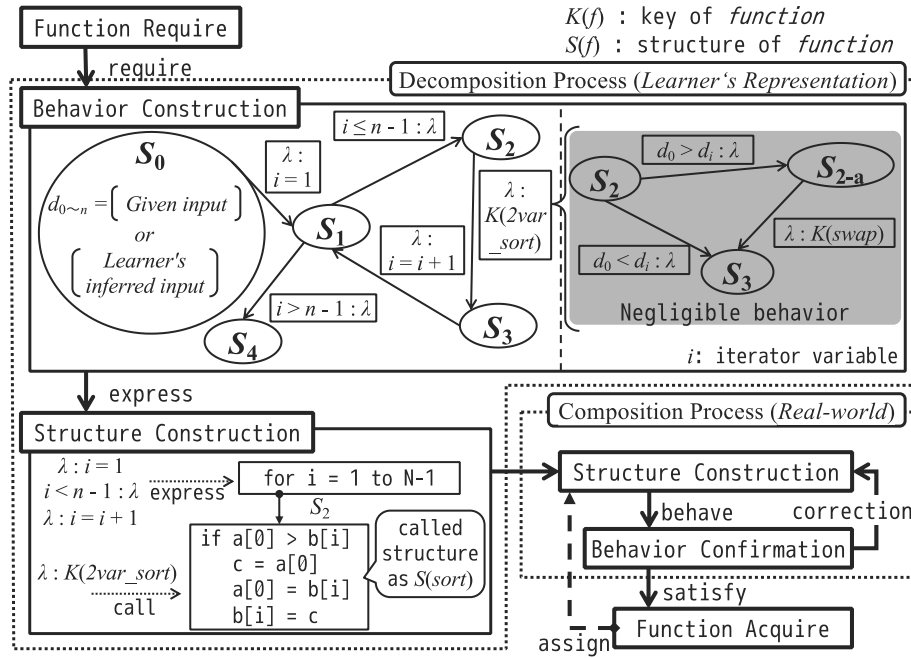
Figure 8. Model of the parts-based problem-solving process (the example of *search_min_value*).

4. Evaluation of Explanations Generated by the Model

We have developed a learning support system with a learning method that promotes acquisition of parts and confirmed its effectiveness. We also verified that system feedback effectively promotes learning. However, the previous system was unable to grasp behaviors. The previous system handles parts as knowledge only within the structure–function correspondence relationship, and system feedback could only point out insufficient points by comparing the structure developed by the learner and that of the correct answer. We consider that adding behavior elements to parts based on the proposed model enables feedback that was impossible in the previous system.

To verify the effectiveness of feedback from the proposed model, we performed an evaluation experiment for comparison with feedback from the conventional system.

4.1 Evaluation Method

Participants were 17 undergraduate and graduate students who have studied programming for at least three years in programming lectures. All participants had acquired basic concepts such as "for" and "if" statements, sorting algorithms, and functions.

The experiment first suggests possible learner errors and two possible explanations for that error (Table 1). The detail of explanation sets is omitted due to space limitations. Each set of explanations was evaluated by five questions (Table 2). One explanation is that from the previous system, and the other is obtained from the proposed model.

The method was evaluated by having participants answer questions using a five-scale response, with the explanation from the previous system as 1 and the model explanation as 5. Participants were also asked to describe the reason for their answers.

Table 1 *Example Explanation Set*

Explanation Set 3	
Problem	Make a function that sorts and outputs two variables
Possible learner error	if a > b a = b b = a print a print b
Explanation from previous system	In line 2, "c = a" is the correct answer.

Model explanation	This function is a combination of "sort two variables" and "output two variables." Therefore, "output two variables" is correct, but in "sort two variables," it is necessary to assign the value of a to a temporary variable before assigning the value of b to a in the second line.

Table 2 *Evaluation Questions*

Questions
(Understanding) When describing a learner's error, which explanation do you think would provide deeper understanding of the program?
(Develop) When describing a learner's error, which explanation do you think would best help the learner develop programs in the future?
(Explore) When describing a learner's error, which explanation do you think would best help learners identify errors in the future?
(Appropriate) When describing a learner's error, which explanation do you think is most appropriate for beginners?
(Difficult) When describing a learner's error, which explanation do you think is easiest to understand?

4.2 Evaluation Results

Table 3 summarizes the experimental results. The number of N indicates the total of each evaluation in four explanation sets by 17 participants. Table 3 showing that the model was highly evaluated in all responses to explanation sets 1 to 4.

Table 4 shows each explanation set and its average value. The number of N indicates participants in each evaluation. In the results for each explanation, the model explanation is generally highly evaluated in all questions.

These results suggest that the proposed model can provide more appropriate feedback that can be realized in the system, suggesting that effective support can be realized through learning of parts under the proposed model. However, this evaluation has mainly two limitations. One is unclear the reproducibility of learners' emotions in the actual learning environment. Another one is unclear the effect on learner skill.

Table 3 *Overview of Results (1: Conventional Explanation – 5: Model Explanation)*

$N = 68$	Understanding	Develop	Explore	Appropriate	Difficult
Average	4.26	4.38	4.37	4.13	4.06
Positive	55	56	58	48	50
Negative	9	6	7	7	11

Table 4 *Results of each Explanation Set (ES)*

$N = 17$	Understanding	Develop	Explore	Appropriate	Difficult
ES-1	4.12	4.59	4.24	4.12	4.12
ES-2	4.47	4.47	4.59	4.06	3.65
ES-3	4.41	4.18	4.12	4.12	4.12
ES-4	4.06	4.29	4.53	4.24	4.35

5. Proposed Knowledge Organization Support System

5.1 Overview

As described in Section 2, we proposed a system for knowledge organization and have developed a support system for it. This section extends this support system and proposes a system that implements the model outlined in Section 3 (Fig. 9).
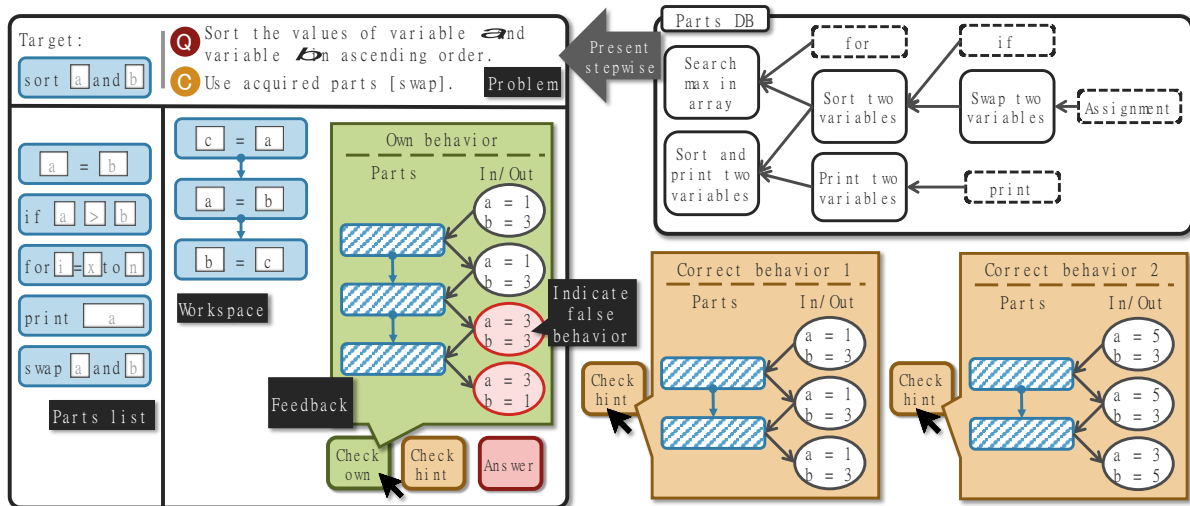
Figure 9. Interface of the proposed system and operation examples.

The proposed system generates behaviors from learner-constructed parts by grasping models of parts and problem-solving processes and furthermore deriving correct behaviors from the structure of parts contained in the system. It is thus possible to provide explicit feedback regarding behavior of the learner's structure and differences with the correct behavior. The goal is to make learners more conscious of implicit behavior and to organize knowledge based on knowledge differences.

In addition, this system improves the fixed task sequence of the previous system, and can adaptively generate task sequences based on the inclusion relation of parts. Consequently, task presentations that were previously subjective are now based on certain criteria.

5.2 Learning and Feedback

This section describes the specific learning flow, using the interface of the proposed system shown on the left side of Fig. 9 as an example. In that example, the learner has already learned how to swap values. First, a problem statement is presented to the learner, and the learner constructs the target structure by combining parts in the parts list in the construction area while following the constraints indicated by the conditions. When the behavior confirmation button is pressed, behavior of the learner's structure is generated as feedback, and errors are indicated in comparison with the behavior generated from the structure of the correct parts, which are stored in the system. When the correct behavior button is pressed, the correct behavior with blank parts in some datasets is presented as shown at the lower right of Fig. 9. These two forms of feedback give learners an opportunity to think about how their own structure should behave.

In the previous system, learning was linked only to the relation between function and structure. The proposed system, however, is expected to transform learning by including behavior from this feedback.

5.3 Task Presentation

As shown at the upper right of Fig. 9, tasks in the proposed system are presented stepwise, aiming toward a final goal for parts based on inclusion relations in a parts database stored in the system. If parts from other sequences are to be synthesized as subsequent parts, the system presents a task from the root of that sequence, promoting the acquisition of other parts to be synthesized. For example, after solving "Sort two variables" task shown the left side of Fig. 9, "Search max in array" task is presented shown the Fig. 10.

However, this research aimed at organizing knowledge already stored for reuse. Therefore, there is no acquisition of primitive parts that the system considers unnecessary, as shown by the dotted line at the upper right of Fig. 9.
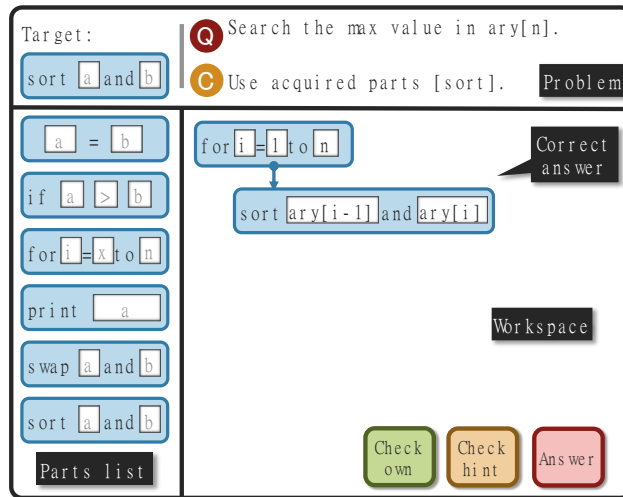
Figure 10. An example of task presenting in the proposed system.

6. Discussion and Future Works

We supported knowledge organization by previously proposing a knowledge organization method aiming at improved reusability of knowledge and by developing and evaluating that system. However, there were issues in problem presentation and feedback in that system. Therefore, we aimed at improvement by using models for parts and for the examined problem-solving process.

This paper proposed a system that improves task presentation and feedback functions by implementing these models in the system. Specifically, we added functions for generating sequences based on certain criteria from a parts database and for suggesting and teaching behaviors. The proposed system can be expected to support knowledge organization while allowing learners to focus on part behaviors.

In future work, we will implement the proposed system and perform evaluation experiments using that system.

Acknowledgements

References

de Kleer, J., & Brown, J. S. (1984). A qualitative physics based on confluences. *Artificial Intelligence*, *24*(1), 7–83. https://doi.org/https://doi.org/10.1016/0004-3702(84)90037-7

Harth, E., & Dugerdil, P. (2017). Program Understanding Models: An Historical Overview and a Classification. In *Proceedings of the 12th International Conference on Software Technologies - Volume 1: ICSOFT,* (pp. 402–413). SciTePress. https://doi.org/10.5220/0006465504020413

Hirashima, T., Kashihara, A., & Toyoda, J. (1992). Providing problem explanation for ITS. In *International Conference on Intelligent Tutoring Systems* (pp. 76–83). Springer.

Hirashima, T., Kashihara, A., & Toyoda, J. (1995). A Formulation of Auxiliary Problems and Its Evaluations. In *Proceedings of 7th World Conference on Artificial Intelligence in Education: AI-ED95* (pp. 186–193).

Horiguchi, T., Tomoto, T., & Hirashima, T. (2015). A framework of generating explanation for conceptual understanding based on "semantics of constraints." *Research and Practice in Technology Enhanced Learning*, *10*(1), 1.

Kashihara, A., Hirashima, T., Toyoda, J., & Nakamura, Y. (1992). Advanced explanation capabilities for intelligent tutoring systems: The explanation structure model (EXSEL). *Systems and Computers in Japan*, *23*(12), 93–107. https://doi.org/10.1002/scj.4690231209

Koike, K., Tomoto, T., Horiguchi, T., & Hirashima, T. (2018a). Proposal of a Framework for Stepwise Task Sequence in Programming. In *International Conference on Human Interface and the Management of Information* (pp. 266–277).

Koike, K., Tomoto, T., Horiguchi, T., & Hirashima, T. (2018b). Proposal of an Adaptive Programming-Learning Support System Utilizing Structuralized Tasks. In *Workshop proceedings of the International Conference on Computers in Education ICCE 2018* (pp. 278–287).

Koike, K., Tomoto, T., Horiguchi, T., & Hirashima, T. (2019). Proposal of the Expandable Modular Statements Method for Structural Understanding of Programming, and Development and Evaluation of a Learning Support System. *Transactions of Japanese Society for Information and Systems in Education*, *36*(3), 190–202. (*in Japanese*)

Matsuda, N., Kashihara, A., Hirashima, T., & Toyoda, J. (1997). An Instructional System for Behavior-Based Recursive Programming. In *Proceedings of Artificial Intelligence in Education 97* (pp. 325–330).

Sasajima, M., Kitamura, Y., Ikeda, M., & Mizoguchi, R. (1996). A representation language for behavior and function: FBRL. *Expert Systems with Applications*, *10*(3–4), 471–479.

von Mayrhauser, A., & Vans, A. M. (1995). Program comprehension during software maintenance and evolution. *Computer*, *28*(8), 44–55.

The Effects of Different Procedural Prompts on Online Student-Generated Question Performance in terms of Cognitive Levels

Fu-Yun YU [a*] & Wen-Wen CHENG [b]
[a b] *Institute of Education, National Cheng Kung University, Taiwan*
* fuyun.ncku@gmail.com

Abstract: The main purpose of this study was to examine the effects of two different procedural prompts on online student-generated question performance in terms of cognitive levels. A total of 41 undergraduates enrolled in an English as a foreign language class participated in this study for four weeks. Questions the participants generated corresponding to the learning material in Zuvio, an online instant interactive system, were analyzed using the revised Bloom's taxonomy to examine the cognitive level dispersion of student-generated questions. Four important findings were obtained. First, as a whole, students-generated questions spread across low, medium, and high cognitive levels, with more than 60% of the generated questions falling in the medium and high cognitive levels. Second, the majority of the questions generated along the 'signal words plus the answer is' procedural prompts were at the medium level whereas most of the questions generated along the 'question stems' procedural prompt were at the low level. Third, the result of the chi-square test found a significant difference between the two different procedural prompts in terms of cognitive level dispersion. Finally, despite that the 'signal words plus the answer is' procedural prompt appeared to be more effective in inducing a comparatively greater percentage of higher-level thinking questions, as compared to the 'question stem' prompt, no questions generated along the 'signal words plus the answer is' procedure prompt were at the highest create level. Suggestions for instructors and future studies are provided.

Keywords: Cognitive levels, online learning activity, procedural prompts, question-stem, signal words, student-generated questions

1. Introduction

Evidence from existing studies for the past decades has provided ample evidence validating the effects of the student-generated questions approach (SGQ) on the promotion of comprehension of the study material (Brown & Walter, 2005; Drake & Barlow, 2008; Hardy, Bates, Casey, Galloway, Galloway, Kay, & McQueen, 2014; Song, 2014), learning motivation (Chin, Brown & Bruce, 2002), and higher-order thinking (Brown & Walter, 2005; Yu & Liu, 2008). Despite SGQ's positive learning effects, obstacles affecting its integration in the classroom have been noted, mainly students' lack of experience with (Moses, Bjork & Goldenberg, 1993; Vreman-de Olde & de Jong, 2004) and confidence in the SGQ task (Yu, 2009).

In light of these obstacles, researchers have proposed different procedural prompts for the support of SGQ activities and have investigated their effects (Rosenshine, Meister, & Chapman, 1996). For instance, King proposed a set of generic question stems targeted to prompt the activation and use of higher-level cognitive processing (e.g., comparison, analysis, prediction, and evaluation, among others) and connection-building between prior and existing knowledge on the part of the learner (King, 1990, 1995). A series of King's studies found the set of question stems (for example, how would you use... to... ? what is a new example of. .. ? how does... affect ... ? what is the difference between ... and... ? what conclusions can you draw about. . . ? how is...related to... that we studied earlier? and so on) to influence elaborated responses and the generation of high-order thinking questions from the students as compared to unguided questioning (King, 1990, 1992). Yu and Pan (2014) found that students provided with 'the answer is' online procedural prompt performed significantly better than their counterparts assigned to

the without prompts group. Yu, Tsai, and Wu (2013) attested the immediate positive effects of immediate scaffolding in the form of generic question stems for the support of online student question-generation activities.

While empirical evidence substantiating the value of the provision of procedural prompts for the support of student learning during SGQ, issues regarding whether there are any differential learning effects among the procedural prompts await investigation. In light of the innate difference associated with different procedural prompts in terms of levels of easiness, concreteness, explicitness, and so on, this study has instructional relevance as well as empirical significance. Specifically, the research question posed in this study is: Are there differences between various procedural prompts in terms of directing students to generate questions at different cognitive levels?

2. Methods

2.1 Participants and Study Context

For the purpose of this study, forty-one intermediate-level sophomores (males: 22; females: 19) enrolled in an English as a foreign language class from the College of Management at a National University in southern Taiwan were invited to participate in a 4-week study. Specifically, two types of procedural prompts were targeted: the first one was Stoyanova and Ellerton's (1996) 'the answer is' coupled with signal words (i.e., one of the most frequently used and easily learned procedural prompts) (Rosenshine, Meister, & Chapman, 1996), and the second one was King's (1990, 1992) generic question stems (suggested to prompt higher-order thinking and questioning on the part of the learner). The procedural prompts for SGQ were introduced to the participants to support their language learning.

Zuvio, an online instant interactive system, was adopted for the SGQ activity via smart-phones, where the students generated questions of different types. The 'Inventions and Discoveries' Unit with four lessons (including a photo story, vocabulary, grammar, and an article relevant to inventions and discoveries, technology, past unreal conditional, and antibiotics) was covered during this study. A brief training session on SGQ with examples and elaborated explanations were provided before the students engaged in the SGQ activities so that they were equipped with the essential knowledge and skills associated with SGQ in the online system.

During the study, two SGQ activities were arranged, with the 'signal words plus the answer is' procedural prompt introduced after the 1st and 2nd lessons for the first SGQ activity and the 'question stems' procedural prompt introduced after the 3rd and 4th lessons for the second SGQ activity. During the first SGQ activity, each of the participants was directed to generate one question corresponding to the two lessons specified along the provided procedural prompt and instruction (see Figure 1), whereas for the second SGQ activity, two questions were suggested to be generated along the provided prompt and instruction (see Figure 2).

Figure 1. Instruction and Procedural Prompt Provided for the 1st SGQ Activity

Figure 2. Instruction and Procedural Prompt Provided for the 2nd SGQ Activity

2.2 Classification of SGQ

The revised version of Bloom's Taxonomy (Krathwohl & Anderson, 2009), which has been widely used for evaluating the cognitive levels of questions in textbooks (Assaly & Smadi, 2015; Tarman, & Kuran, 2015) and assessing SGQ performance (Lameese, Madalyn, Keli, Matthew, Jakob, Christina, 2015) was adopted and operationalized (see Table 1). Two experienced English teachers independently categorized each of the questions the participants generated during the two SGQ sessions along the revised Bloom's taxonomy. To ensure inter-rater reliability, percent of agreement was adopted, which was 82.96% and 84.38% for the 1st and 2nd SGQ activities, respectively.

Table 1
Categories and Operationalized Definitions for the Six Cognitive Levels of SGQ

Dimensions	Definition
Remember	Complete questions with answers by recalling learned information or concepts in the textbook.
Understand	Complete questions with answers by describing learned information or concepts in the textbook.
Apply	Complete questions with answers by using learned information in new examples or situations.
Analyze	Complete questions with answers by identifying causes or analyzing a problem.
Evaluate	Complete questions with answers by making judgments about the information.
Create	Complete questions with answers by synthesizing multiple units of information into new patterns or providing new solution.

2.3 Data Analysis of SGQ

The chi-square test was adopted to analyze if the two integrated procedural prompts directed students to generate questions at different cognitive level distributions. In view of the fact that 33.33% of the cells in the contingency table had a number less than 5, to ensure valid chi-square tests and to comply with the calculation rule (i.e., requiring at least 80% of the cells to have an expected count greater than 5), the cognitive levels were grouped into a low level (by combining the remember and understand levels), a medium level (by combining the apply and analyze levels), and a high level (by combining the evaluate and create levels).

3. Results

3.1 Quantitative Data on SGQ along the Two Procedures Prompts

In total, 123 questions were generated by the participants during the two SGQ sessions. Four important findings were obtained. First, as shown in Table 2, as a whole, while students-generated questions spread across the low to high cognitive levels, more than 60% of the generated questions fell in the medium and high cognitive levels (61%). Second, the majority of the questions generated along the 'signal words plus the answer is' procedural prompt were at the medium level (63.4%), whereas most of the questions generated along the 'question stems' procedural prompt were at the low level (51.2%). Third, the highest cognitive level students generated along the 'signal words plus the answer is' procedural prompt was at the 'evaluate' level, and no questions were generated at the highest 'create' level. Fourth, the results of the chi-square tests further found a significant interaction, x^2 (2, $n = 41$) = 15.381, $p < .001$, Somers' D = .369, indicating that different procedural prompts for SGQ had significant effects on the cognitive level dispersion of the student-generated questions.

Table 2
The Cognitive Levels of SGQ Based on Bloom's Taxonomy

| | | Low level | | Medium Level | | High Level | |
		remember	understand	apply	analyze	evaluate	create
signal words plus the answer is	f	0	6	0	26	9	0
	f	6		26		9	
	%	14.6%		63.4%		22%	
question stems	f	6	36	0	30	6	4
	f	42		30		10	
	%	51.2%		36.6%		12.2%	
Total	(f, %)	48 (39%)		56 (45.5%)		19 (15.5%)	

3.2 SGQ along the 'Signal Words plus the Answer is' Procedure Prompt

Despite the fact that the chi-square tests found different procedural prompts leading to different cognitive level dispersion, as illustrated in Table 3, the participants managed to generate quality questions along the 'signal words plus the answer is' procedure prompt. In addition, students were capable of utilizing the signal words (i.e., what, who, when, where, why, and how) and the different terminologies covered in the lesson for SGQ.

Table 3
Examples of SGQ along the 'Signal Words plus the Answer is' Procedure Prompt

Cognitive levels	Examples of SGQs	Signal words	The answer is
Low (Remember/Understand)	Q: What is your favorite high-tech product in the textbook? A: My favorite product in the textbook is the Robot Vacuum cleaner.	What	high-tech
	Q: Why do people like to use a high-end device? A: Because it's more convenient and innovative.	Why	high-end
Medium (Apply/Analyze)	Why do people think this statue is unique? A: Because it is made of a special material.	Why	unique
High (Evaluate/Create)	Q: How does the robot vacuum work? Is it efficient? A: Yes. I don't waste time on sweeping the floor after I bought it.	How	efficient

3.3 SGQ along the 'Question Stems' Procedure Prompt

It was shown that the participants could generate quality questions along the 'question stems' procedure prompt by referring to the list of generic question stems (see Figure 2 and Table 4).

Table 4
Examples of SGQ along the 'Question Stems' Procedure Prompt

Cognitive levels	Examples of SGQs	Question stem
Low (Remember/ Understand)	Q: Explain how Dutch scientist Antonie discovered the existence of microorganisms? A: He used a microscope to discover the existence of microorganisms.	Explain how…?
	Q: What is the difference between a bacteria and a virus? A: A bacteria can be killed by antibiotics, but a virus can't be killed by antibiotics.	What is the difference between …and…?
Medium (Apply/Analyze)	Q: Explain why antibiotics are not effective against some diseases such as the common cold and sore throats. A: Because antibiotics can't heal diseases resulting from viruses such as the common cold and sore throat.	Explain why…?
High (Evaluate/Create)	Q: Do you agree or disagree with the statement that AIDS will be cured in the future?" "A: I agree AIDS will be cured in the future, but there is still a long way to go.	Do you agree or disagree with this statement about…
	Q: How would you use a vaccine to prevent diseases? A: We can use a vaccine to protect people who suffer from diseases caused by viruses.	How would you use…to…?

4. Discussion and Conclusion

The results of this study confirmed the meta-analysis study of Rosenshine, Meister, and Chapman (1996) indicating that procedural prompts including question stems and signal words are effective in supporting SGQ activities. Through the content analysis of the generated questions, it was further found in this study that the provided procedural prompts are effective in promoting the generation of questions spanning across different cognitive levels. In addition, the two procedural prompts were found to have different effects in terms of directing students to generate questions at various cognitive levels, with the 'signal words plus the answer is' procedural prompt appeared to be more effective in inducing a comparatively greater percentage of higher-level thinking questions (i.e., analyze, evaluate, create), as compared to the question stem prompt. Nonetheless, the fact that no questions generated along the 'signal words plus the answer is' procedure prompt were at the highest create level should be noted.

4.1 Suggestions for Instructors and future Studies

Based on the findings of this study, instructors are advised to carefully consider the integration of a specific procedural prompt while remaining attentive to the level of experience of the students and their degree of familiarity with the SGQ activity.

Due to the small sample size and short duration of this study, the generalizability of the results obtained may be limited. Future studies with a larger sample size, longer duration, and possible order effects can be examined. Moreover, the fact that a high percentage of questions generated along the question stem procedural prompt fell in the low cognitive level (i.e., remember and understand) deserves to be understood because it contradicted what would be expected from generic question stems — prompting higher-order thinking and questioning on the part of the learner (King, 1990, 1995). Also could be further examined is the cognitive levels of SGQs and the generic question stems adopted. In addition, besides the currently investigated procedural prompts, the comparative effects of other

procedural prompts such as 'main idea, 'question types,' and the 'story grammar category' suggested by Rosenshine, Meister, and Chapman (1996) and the 'what if' strategy suggested by Brown and Walter (2005) in terms of inducing students to generate high cognitive level questions in an SGQ activity are worthy of examination. Finally, possible person effects, that is, the effects of different procedural prompts on learners at different academic achievement levels (e.g., English language ability) can be explored.

References

Assaly, I. R., & Smadi, O. M. (2015). Using Bloom's taxonomy to evaluate the cognitive levels of master class textbook's questions. *English Language Teaching*, *8*(5), 100-110.

Brown, S. I., & Walter, M. I. (2005). *The Art of Problem Posing* (3rd ed). New Jersey: Lawrence Erlbaum Associates.

Chin, C., Brown, D. E., & Bruce, B. C. (2002). Student-generated questions: A meaningful aspect of learning in science. *International Journal of Science Education*, *24*(5), 521–549.

Drake, J. M., & Barlow, A. T. (2007). Assessing students' levels of understanding multiplication through problem writing. *Teaching Children Mathematics, 14*(5), 272–277.

Hardy, J., Bates, S. P., Casey, M. M., Galloway, K. W., Galloway, R. K., Kay, A. E., & McQueen, H. A. (2014). Student-generated content: Enhancing learning through sharing multiple-choice questions. *International Journal of Science Education*, *36*(13), 2180-2194.

King, A. (1990). Enhancing peer interaction and learning in the classroom through reciprocal questioning. *American Educational Research Journal*, *27*(4), 664-687.

King, A. (1992). Facilitating elaborative learning through guided student-generated questioning. *Educational psychologist*, *27*(1), 111-126.

King, A. (1995). Guided peer questioning: A cooperative learning approach to critical thinking. *Cooperative learning and college teaching*, *5*(2), 15-19.

Krathwohl, D. R., & Anderson, L. W. (2009). *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. Longman.

Lameese, A., Madalyn, K., Keli, S. Matthew, P., Jakob, S., & Christina, S. (2015). *Ranking of Student-Generated Questions in Bloom'S Taxonomy as a Measure of Student Learning*. Boulder, CO: University of Colorado Boulder.

Moses, B. M., Bjork, E., & Goldenberg, E. P. (1993). Beyond problem solving: Problem posing. In Brown, S.I. & Walter, M.I. (Eds.) *Problem Posing: Reflections and Applications* (pp. 178–188). Hillsdale, NJ: Lawrence Erlbaum Associates.

Rosenshine, B. Meister, C., & Chapman, S. (1996). Teaching students to generate questions: A review of the intervention studies. *Review of Educational Research, 66*, 181-221.

Song, D. (2016). Student-generated questioning and quality questions: A literature review. *Research Journal of Educational Studies and Review, 2*, 58-70

Stoyanova, E., & Ellerton, N. F. (1996). A framework for research into students' problem posing. In Clarkson, P. (Ed.), *Technology in Mathematics Education* (pp. 518–525). Melbourne: Mathematics Education Research Group of Australasia.

Tarman, B., & Kuran, B. (2015). Examination of the cognitive level of questions in social studies textbooks and the views of teachers based on Bloom taxonomy. *Educational sciences: Theory and Practice*, *15*(1), 213-222.

Vreman-de Olde, C., & de Jong, T. (2004). Student-generated assignments about electrical circuits in a computer simulation. *International Journal of Science Education, 26*(7)**,** 859–873.

Yu, F. Y. (2009). Scaffolding student-generated questions: Design and development of a customizable online learning system. *Computers in Human Behavior, 25*(5), 1129–1138.

Yu, F. Y., & Liu, Y. H. (2008). The comparative effects of student question-posing and question-answering strategies on promoting college students' academic achievement, cognitive and metacognitive strategies use. *Journal of Education and Psychology, 31*(3), 25–52.

Yu, F. Y., & Pan, K-J (2014). Effects of student question-generation with online prompts on learning. *Educational Technology and Society, 17*(3), 267-279.

Yu, F. Y. Tsai, H. C., & Wu, H-L (2013). Effects of online procedural scaffolds and the timing of scaffolding provision on elementary Taiwanese students' question-generation in a science class. *Australasian Journal of Educational Technology, 29*(3), 416-433.

Reflection Support System in Ill-defined Problem Solving

Mariko YOSHIOKA[a], Kazuhisa SETA[a*] & Yuki Hayashi[a]

[a] *Graduate School of Humanities and Sustainable System Sciences, Osaka Prefecture University, Japan*
* seta@mi.s.osakafu-u.ac.jp

Abstract: In this research, we focused on research execution activities as a field of ill-defined problem solving and developed a mechanism to grasp learners' thought processes based on interpretation rules and a generic ontology of research activities. The idea behind this mechanism is to prompt learners' awareness of their own thinking processes so as to foster their metacognitive skills. In this paper, we discuss the features of a support system that we developed to achieve this goal.

Keywords: ill-defined problem, reflection support

1. Introduction

In problem-solving activities, the importance of metacognitive skills in obtaining a comprehensive view of one's thought processes (monitoring) and appropriately controlling them is widely recognized (Ge 13, Jonassen 97). Similarly, in research activities, it is important to exercise control as when changing the approach to achieving one's research objective from the viewpoint of "the objective and means seem to be inconsistent with each other" and "it's time to reexamine the experimental method." However, for a learner with undeveloped metacognitive skills, it is not easy to demonstrate or acquire such metacognitive skills. Acquiring metacognitive skills goes hand in hand with execution, but it is difficult for an unskilled learner to execute those skills (Kayashima 2005). The research introduced in this paper aims to facilitate the acquisition of skills for monitoring and appropriately controlling one's thought processes in problem-solving activities.

In problem-solving, the target may be a well-defined problem in which problem formulation and the conditions or procedure leading to a solution are clear. It may also be an ill-defined problem in which the conditions or procedure leading to a solution are unclear or nonexistent. Learning that targets a well-defined problem (e.g., solving a quadratic equation) proceeds by repeating the application of problem-solving operators until reaching a solution that satisfies certain constraints (criteria). Problem-solving operators and their application process can be acquired in this way. On the other hand, learning that targets an ill-defined problem (e.g., research activities) features unclear constraints (criteria) that the solution must satisfy in contrast to a well-defined problem, so the learner must specify the problem (Ge 2013, Jonassen 1997, Masui 1999, Namsoo 2003, Pieger 2018, Rena 2013, Veenman 2006). In addition, while problem-solving operators may be partially given as context-independent meta-knowledge, their application process is generally vague and latent, that is to say, unclear. Consequently, in learning associated with an ill-defined problem, it is considered that the learner reflects on one's own problem-solving process so that an objective that promotes the acquisition of metacognitive operators and their application process comes to be set.

However, a novice unskilled in comprehending the structure of a problem domain encounters difficulty in applying appropriate operators at the appropriate time and even has difficulty in appropriately monitoring and controlling that process (Kayashima 2005). In particular, learning through problem-solving targeting an ill-defined problem is accompanied by more metacognitive difficulties compared with well-defined problems.

In this study, we focus on research activities as ill-defined problem-solving activities. Here, to facilitate the monitoring and controlling of one's thought processes, all assumptions and hypotheses underlying decision-making must be understood before making decisions, such as "I need to examine my assertion and determine whether I am maintaining consistency from a variety of viewpoints." "Is the

basis of my approach valid?" "To what extent should I review or reexamine an assertion that I want to change?" or (when a clear goal lies under unclear conditions) "What should I think about next (on expanding the search space)?" In short, importance should be attached to metacognition (application of metacognitive operators) that targets processes in long-term research activities.

Such operators on the metacognitive level acquire operators and their application process by promoting reflection of one's research process. However, thinking activities in a research process are tacit and unclear, and as a result, looking back and ascertaining all the assumptions and hypotheses or guidelines used at the time of decision-making is a difficult task.

As a form of metacognitive support in research activities within the research field of intelligent learning support systems, Mori et al. (Mori 2019) have proposed a mechanism for partially reducing the ambiguity of operators and the difficulty of their application (searching). This is accomplished by specifying "questions" that require execution of problem-solving operators and by presenting them within the context of research activities performed by novice researchers. Here, the learner can systematically organize the output of one's thinking activities by answering presented questions and forming a chain of questions and answers. The system also provides a stimulus for partial application of metacognitive thinking activities (metacognitive operators) based on part of the thinking context visualized as "questions" and "answers" (problem space searched for by the learner) and on ontology. This can be viewed as a means of support for applying context-independent meta-knowledge as metacognitive knowledge to one's thinking context.

Thus, given a research process expressed by the above thought organization support system, this study considers that promoting reflection of metacognitive thinking applied by the learner might raise awareness about the acquisition of operators on a metacognitive level in the context of one's thinking. To investigate this possibility, we previously proposed a mechanism for manifesting and visualizing metacognitive activities that might be conducted tacitly by the learner and the thought processes (metacognitive activities) that should be followed as determined by the system so as to promote reflection that is conscious of metacognition.

In this paper, we discuss a reflection support system developed on the basis of this idea and its practical implementation.

2. Approach

Given that the research process tends to be tacit in nature and generally based on trial and error, it is not uncommon to fall into a situation echoed by such comments as "Why was I thinking like this? I've lost track of my assumptions and hypotheses." "I've gone off on other thinking activities without noticing that I've deviated from my original objective and assumptions." or "At that time, I thought it was unnecessary to think about that, but I later realized that it was necessary." In this study, we consider it important to prompt an awareness of acquiring operators on the metacognitive level by reflecting on one's way of thinking in the research process in a chain-like, concatenated manner. With this in mind, we set as our objective the development of a reflection support system.

To manifest the thought processes that should be reflected on to provide such support, a mechanism is needed to capture thinking activities in the learner's research execution activities on the meta-level and base level. In this section, we discuss thinking targeted for reflection and describe the mechanism proposed in this study to capture thinking activities.

2.1 Thought processes targeted for reflection

No clear procedure exists in ill-defined problem-solving. As a result, it is not unusual for problem-solving activities to be performed on a day-to-day, impromptu manner with no application of metacognitive-level operators to regulate one's thinking. This state of affairs may lead to reworking or inconsistencies.

In this study, we consider that thought processes that reflect on the way that one thinks and that adjusts activities accordingly can contribute to the acquisition of operators on the metacognitive level. In the following, we focus on three types of thought processes that should be the target of reflection.

(1) Thought process that considers thinking result and validity of reasoning

In research execution activities, reflecting on one's thought processes and on whether a thinking result and the reasoning leading up to that result are valid can help make searching of the problem space more effective. An example of such reflective thinking is as follows: "Reconsidering the learning support method involves a change in the learning goal. Reviewing this change in the learning goal, the basis of a support method, is appropriate, and what's more, the reasoning behind such reconstruction through this review is valid."

    (2) Thought process that's conscious of the validity of metacognitive thinking in the problem-space search process

In research execution activities, it is important to reflect on one's thought processes and to attach conditions to metacognitive thinking. An example of such thinking is as follows: "At first, I could not sufficiently examine my research objective and evaluation method, but since then, I've noticed inconsistencies between them. Thinking about the rationality of the research objective and evaluation method should be a precondition to moving forward with research."

    (3) Thought process that attaches conditions to metacognitive thinking

In research execution activities, it is important to be aware of the validity of metacognitive thinking in the problem-space search process. An example of this type of thinking is as follows: "The research objective and evaluation method should be consistent with each other in the task structure of research execution. When the time comes to think about the evaluation method, thinking about it while being aware of the need for consistency with the research objective is meaningful from the viewpoint of ensuring consistency."

These thought processes focus on the assumptions and hypotheses associated with decision-making. They should be reflected on given their importance in acquiring and refining metacognitive knowledge based on personal experience. On the other hand, they tend to be unconscious in nature and difficult to verbalize even in retrospective reports.

In this study, we take up these thought processes as targets of reflection to raise awareness about the acquisition of operators on the metacognitive level in the context of one's own thinking and to promote their verbalization.

2.2 Mechanism for capturing thinking activities

To raise learner's awareness about the acquisition of operators on the metacognitive level, it is important to focus on thinking activities that should be reflected on in the context of the learner's own thinking and to reflect on thinking results and reasoning, the validity of metacognitive thinking, and the attaching of conditions to metacognitive knowledge as described in section 2.1.

To support such reflection activities, we investigate a method in which the system infers the thinking activities that should be reflected on from the learner's research activities (research execution activities, reflection activities) and presents those thinking activities as stimuli to the learner. To this end, we previously proposed a mechanism for capturing a learner's thought processes using (1) a research activity log, (2) interpretation rules, and (3) ontology of research activities (Mori 2018). The framework for inferring thinking activities in this way is shown in Fig. 1. Here, the system records research execution activities as well as reflection activities in a research activity log and infers the thought processes that the learner should reflect on using interpretation rules and research activity ontology. The following describes each of these system components.

    (1) Research activity log

The interface to the thought organization support system (Mori 2019) developed by Mori et al. is shown in Fig. 2. In the figure, blue and orange nodes denote "questions" and "answers," respectively. This system displays instances of the "question" concept in the ontology of research activities as questions (Fig. 2 (1)). The learner selects such a question or inserts a self-created question thereby expressing the thinking context (problem solution space) of one's research activities.
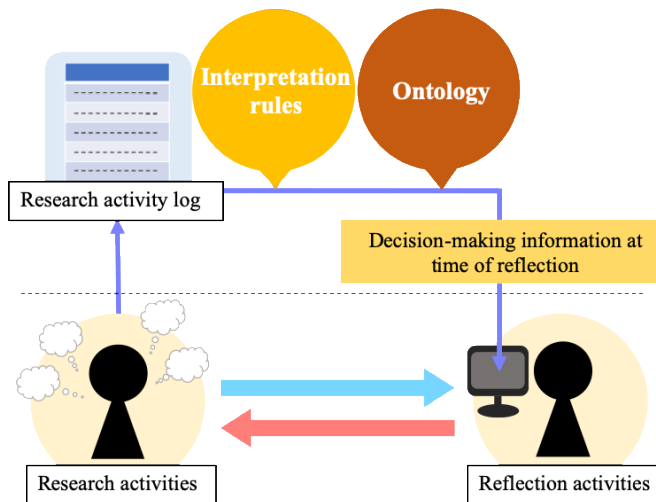
Figure 1 *Framework for inferring research activities*

In this study, we consider that operations performed on this system (node creation, revision, deletion, etc.) correspond to the learner's thought processes and that recording the history of these operations can capture those thought processes at the activity level. The research activity log in the example of Fig. 2 created the question node "What kind of problem did you discover?" and the answer node "Reflection time is short." This answer node was later edited to "There are few opportunities for reflection." The system records operation history in this way.

In addition to operation history, the system in this study also records learner decision-making information that comes into play when interacting with reflection support as a log and records these two types of information as a research activity log.

(2) Interpretation rules

The semantic interpretation of research activity logs on the whole is not necessarily unique. Nevertheless, while keeping this in mind, we specified interpretation rules for interpreting the research activity log and proposed a mechanism for inferring the thought processes for reflection by performing a matching process with the research activity log.

(3) Ontology of research execution activities

We use the ontology of research activities created by Mori et al. to capture task structure in research execution activities. This ontology is specified in a state that enables the concepts required by research execution activities to be computer-readable. It systematizes mainly "metacognitive activities," "cognitive activities," and "actions" organizing them in a form corresponding to "questions." It also specifies sub-activities, input, and output as partial concepts making up each concept. For example, in defining "thinking of an implementation hypothesis (cognitive activity), input can be set as "implementation objective," which is itself the output of the thinking action "thinking of the implementation objective (cognitive activity)," while output can be set to "implementation hypothesis."

At the present stage, it could not be said that the ontology of research activities constructed here is complete in terms of specified concepts. Rather, it is assumed that it will be refined over time through practical use.

3. Reflection Support System

We developed a reflection support system to support learner reflection of thought processes in research execution activities. We implemented this system in a form that links to the thought organization support system of Mori et al. as a precondition. Envisioning that this system would be used in conjunction with daily reflection activities that accompany research activities, we implemented it as a web application accessible via a browser.
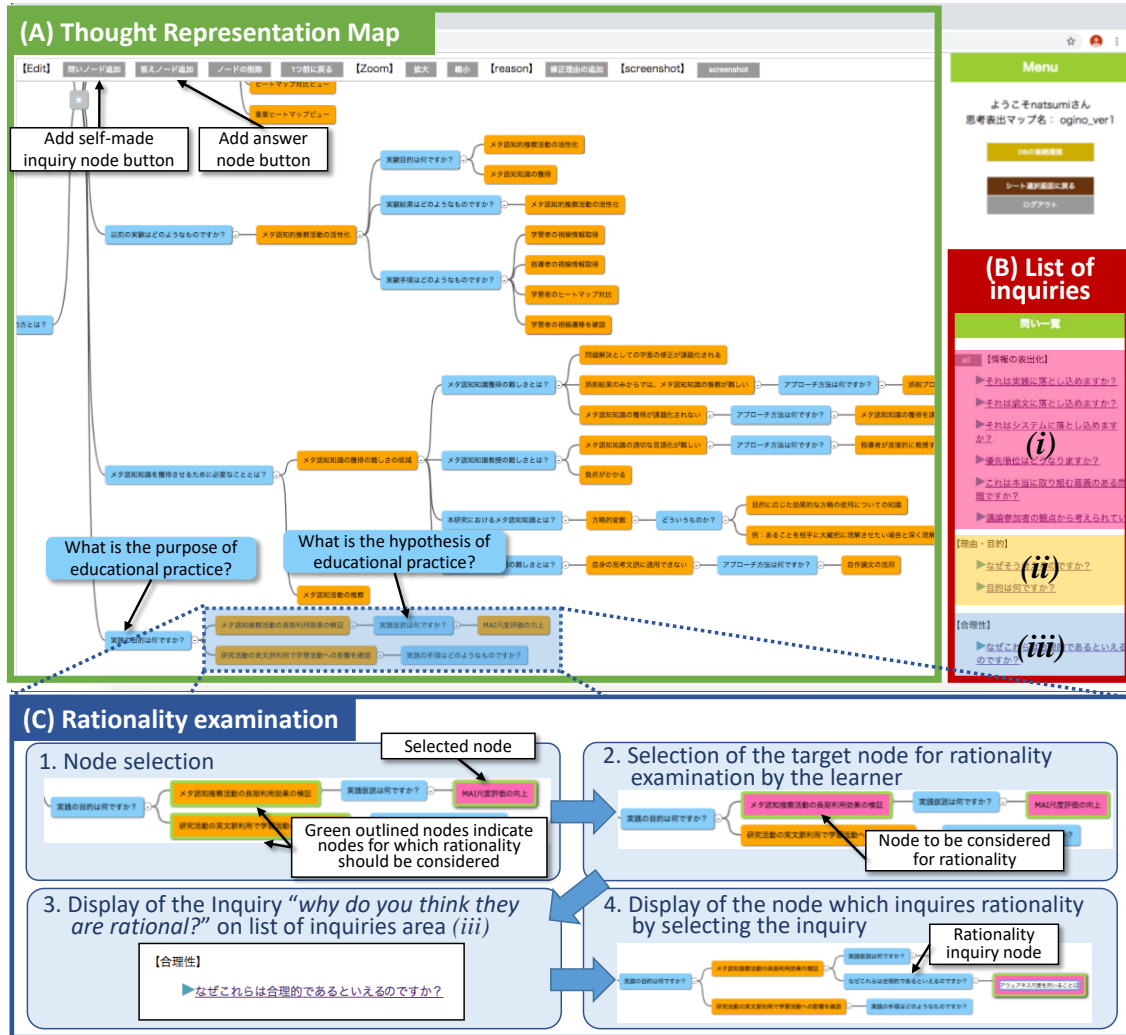
Figure 2 Thought Organization Support System (Mori 2019)

3.1 System configuration

The configuration of the reflection support system proposed in this study is shown in Fig. 3. The system adopts a server/client configuration with the server side using Macintosh, Apache, MySQL, and PHP (MAMP) and Prolog and the client side using HTML and JavaScript. This system consists of a database storing the learner's research execution activities and reflection activities in the form of an operation history (reflection support database built with MySQL), a database connection module for connecting to that database, and the three modules summarized below.

- Thought organization support system module: This module manages the operations of the thought organization support system. It supports organization of the leaner's thought processes by creating question nodes and corresponding answer nodes in a tree format. It also gathers information on the learner's behavior on the system such as the addition, deletion, and editing of nodes and stores that information in the database via the database connection module.

- Matching module: This module gets the research execution activities log (behavior information) stored in the reflection support database and uses it to infer thinking that the learner may have performed but that is not clearly visible in that log. The matching model is described in Prolog format together with ontology of research activities created with the Hozo ontology editor and interpretation rules. Matching this ontology and interpretation rules with the research execution activities log confers interpretations to learner thought processes. The detected activity interval is a natural language sentence to which a template has been applied. The result is used as learner reflection information.
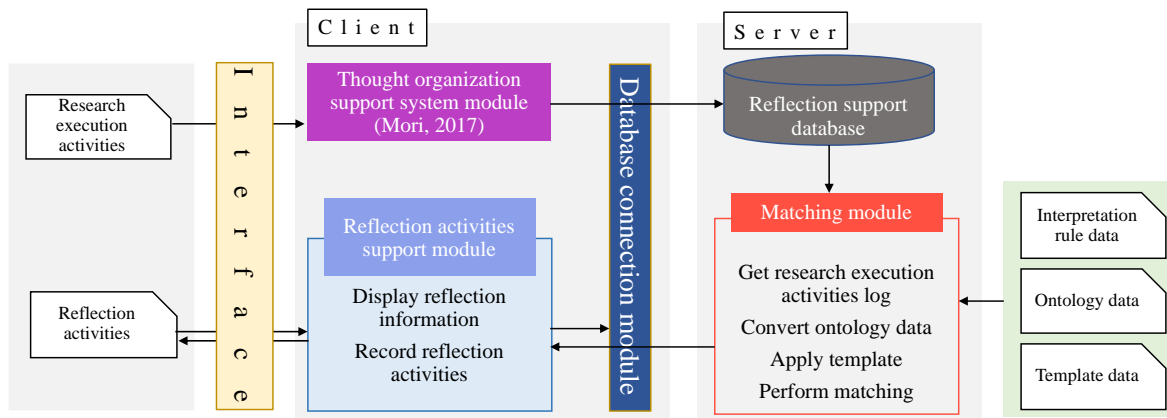
Figure 3 Configuration of reflection support system

- Reflection activities support module: This module supports reflection activities. It gets reflection information and displays that information on the learner's interface. The reflection activities carried out by the learner are recorded as a research execution activities log in the database.

3.2 General

The screen of the reflection support system that we developed is shown in Fig. 4. The learner first performs research activities using the thought organization support system. Then, on selecting a period for reflection, the reflection support system presents the learner with the information shown in Fig. 4. This "reflection information" consists of information promoting awareness of thinking activities as taken up in section 2.1 (Fig. 4 (1)), information promoting the conscious execution of activities (Fig. 4 (2)), and information promoting the attachment of metacognitive conditions (Fig. 4 (3)). The following explains each of these three types of reflection information.

- Reflection information promoting awareness of thinking activities (Fig. 4 (1)): This information suggests thinking activities that the learner is considered to have executed. It is presented with the aim of raising learner consciousness about one's own thinking activities and promoting self-awareness. If the learner acknowledges those thinking activities, they are recorded and made available for later review (section 3.3).

- Reflection information promoting the conscious execution of activities (Fig. 4 (2)): This information suggests thinking activities that should be executed with the aim of raising learner consciousness about thinking activities that should be executed. If the learner acknowledges those thinking activities, they will be recorded. If not, the system will then require an explicit decision in the form of "Will consider later" or "Will not consider later" as a future activity. This decision-making promotes the conscious execution of thinking activities while also promoting the conscious execution of activities judged to be necessary (metacognitive control).

- Reflection information promoting the attachment of metacognitive conditions (Fig. 4 (3)): This information suggests executed activities even though the learner judged them to be unnecessary in the past and asks for the reason why this change in judgment was made. This raises learner's awareness of changes in judgments associated with the execution of thinking activities and promotes the attachment of conditions to metacognitive knowledge as that reason. Here, an example of such reflection activity is "Research objective and evolution method must be rational, but on revising my research objective, I was not able to realize how that change would affect the evaluation method that I had been thinking about." Such reflection is expected to promote the attaching of conditions to metacognitive knowledge within the learner's range of experience and thinking context. This attachment of conditions can be recorded and made available for later review.

3.3 Function for reviewing reflection activities

410

Figure 4 Reflection Support System Screen

The reflection support system includes a function for reviewing the learner's history of reflection activities (Fig. 5). This function makes it possible to clearly capture thinking activities such as the assumptions and hypotheses made in decision-making and the acquisition of metacognitive knowledge based on one's experience. We can expect the reviewing of such thinking activities to enable the creation of a personal research diary that delves into thinking activities that while important are difficult to express.

4. Evaluation Experiment

We are currently conducting an evaluation experiment to assess the effectiveness of the reflection support system described in section 3. In this experiment, 12 members of our research laboratory (10 undergraduate students, and two master's student) were asked to use the system in their daily research activities continuously for about 2 weeks. The following summarizes this evaluation experiment.

In the experiment, we are conducting a questionnaire-based survey in which subjects are asked whether the system helps to contribute to reflection activities, raise awareness of own cognitive activities. In the following, we pick up some comments got in our questionnaire surveys.

Regarding changes of their consciousness of reflective activities, a master student answered after using the system that he got consciousness intending to clarify his own thought in his reflective activities, whereas he answered before using the system that he just wrote a memo of summarization of his daily activities to remind himself of his own activities performed. In addition, he also answered the system makes it easier for him to be aware of implicit and tacit changes of his own consciousness with useful information from the system.

Furthermore, another master student answered after using the system that he also got consciousness intending to trace propagations according to changes of some parts of research contents and check if the consistency of whole research contents is still maintained, as well as he answered before using the system that he especially intended to record changes of some definitions or interpretations in his own research contents. He also answered that the system gives useful information

Please set the reflection history period that you would like to review.

● Today's reflection

○ Set reflection period
From 2019/01/01   To   2019/02/21

Display reflection history

Reflection Day/Time	Reflection Statement	Operation	Future Activity	Re
2019/01/25 08:17:51	With regard to "What kind of problem did you discover?" you reconsidered "Acquisition of metacognitive-level operators is difficult for beginners" changing it to "Being aware of acquiring metacognitive-level operators is difficult for beginners." At this time, with regard to "What is your research objective?" you also reconsidered "Raising consciousness of acquiring metacognitive-level operators" changing it "Raising consciousness of acquiring metacognitive-level operators through reflection support."	Record		
2019/01/25 08:17:51	With regard to "What kind of problem did you discover?" you added "Acquisition of metacognitive-level operators is difficult." At this time, did you reconsider "Raising consciousness of acquiring metacognitive-level operators" with respect to "What is your research objective?"	Considered		
2019/01/25 08:17:51	With regard to "What is your research objective?" you reconsidered "Raising consciousness of acquiring metacognitive-level operators" changing it to "Raising consciousness of acquiring metacognitive-level operators through reflection support." At this time, did you also reconsider "Being aware of acquiring metacognitive-level operators is difficult for beginners." with respect to "What kind of problem did you discover?"	Considered		
2019/01/25 08:17:51	With regard to "What kind of problem did you discover?" you reconsidered "Acquisition of metacognitive-level operators is difficult." changing it to "Acquisition of metacognitive-level operators is difficult for beginners. At this time, did you also reconsider "Raising consciousness of acquiring metacognitive-level operators" with respect to "What is your research objective?"	Considered		
2019/01/25 08:17:51	With regard to "What exactly is this practical procedure?" you added "A 1-week test." At this time, with regard to "What is your practical objective?" you reconsidered "Checking system effectiveness" changing it to "Checking effectiveness of feedback."	Record		
2019/01/25 08:17:51	With regard to "What is your practical objective?" you reconsidered "Checking system effectiveness" changing it to "Checking effectiveness of feedback." At this time, did you also reconsider "A 1-week test" with respect to "What exactly is this practical procedure?	Didn't consider	Will not consider later	
2019/01/25 08:33:07	With regard to "What is your practical objective?" you reconsidered "Checking system effectiveness" changing it to "Checking effectiveness of feedback." You considered the rationality of this with "What exactly is this practical procedure? changing "A 1-week test" to "Perform a prior evaluation after 10 days of operation."	Record		
2019/01/25 08:33:07	With regard to "What exactly is this practical procedure?" you reconsidered "A 1-week test" changing it to "Perform a prior evaluation after 10 days of operation." At this time, did you consider the rationality of that with "Checking effectiveness of feedback" with respect to "What is your practical objective?"	Didn't consider	Will not consider later	
2019/01/25 08:33:07	With regard to "What exactly is this practical procedure?" you added "A 1-week test." At this time, you considered the rationality of that with "What is your practical objective?" thereby changing "Checking system effectiveness" "Checking effectiveness of feedback."	Record		

Figure 5 Review (history) screen of reflection activities

to be aware of own decision-making processes that is difficult to record even in a situation of using thought organization support system.

Therefore, it suggests that learners in reflective activities on their research activities tend to be conscious of their own thought activities using the system rather than behavioral activities without the system.

5. Conclusion

Taking into account the difficulty of reflecting on one's thought processes in the field of ill-defined problem-solving, we proposed a reflection support system for promoting the acquisition of operators on the metacognitive level based on a technique for capturing thought using ontology and interpretation rules.

Going forward, we plan to expand our study by analyzing the results of evaluation experiments more detail with the aim of enhancing the usefulness of the developed system.

References

Xun Ge (2013). Designing Learning Technologies to Support Self-Regulation During Ill-Structured Problem-Solving Processes, International Handbook of Metacognition and Learning Technologies, pp.213-228.

David H. Jonassen (1997). Instructional Design Models for Well-Structured and Ill-Structured Problem-Solving Learning Outcomes, ETR&D, Vol. 45, Issue 1, pp. 65-94.

Kayashima, M., Inaba, A., and Mizoguchi, R. (2005). What Do You Mean by to Help Learning of Metacognition?, Proc. of the 12th Artificial Intelligence in Education, pp. 346-353.

Masui, C., & De Corte, E. (1999). Enhancing learning and problem solving skills: orienting and self-judging, two powerful and trainable learning tools. Learning and instruction, 9(6), 517–542.

Mori, M., Hayashi, Y., and Seta, K. (2019). Ontology Based Thought Organization Support System to Prompt Readiness of Intention Sharing and Its Long-term Practice, The Journal of Information and Systems in Education, 18(1), pp. 27-39.

Namsoo, Shin (2003). Predictors of Well-Structured and Ill-Structured Problem Solving in an Astronomy Simulation.

Pieger, E., & Bannert, M. (2018). Differential effects of students' self-directed metacognitive prompts. Computers in Human Behavior, 86, 165-173.

Rana, D., & Upton, D. (2013). Thinking, Reasoning and Problem Solving. Psychology for nurses, Routledge, 51–58.

Veenman, M. V., Van Hout-Wolters, B. H., & Afflerbach, P. (2006). Metacognition and learning: Conceptual and methodological considerations. Metacognition and learning, 1(1), 3–14.

Questions and Ethical Dilemmas within a Design-Based Research Project

Melvin FREESTONE[*] **& Jon MASON**
College of Education, Charles Darwin University, Australia
* melvinfreestone@gmail.com

Abstract: This paper outlines ethical issues surrounding a Design-based Research (DBR) project to explore the value of questions in digital environments. The context dictates a broad yet defined approach which is not confined to a single entity. Striking a balance between scope and focus has been problematic as the variables are too complex to justify a scientific analytical methodology. We discuss implications for the selection of our research question as well as consequences for our implementation strategies. The humanist foundation underpinning DBR provides inclusiveness together with the required rigor. The ethical dilemmas outlined provide a critique for determining the authenticity of our project.

Keywords: Questions, ethical, dilemmas, digital, scientific, humanist, GGQ

1. Introduction

We are engaged in an interdisciplinary design-based research project (Herrington et al, 2011; Anderson & Shattuck, 2012) to explore the potential of generic generative questions (GGQs) to direct, shape and open-up inquiries in digital environments. A group of twelve GGQs (see Table 1) have been described together with an indicative range of 'curious relations' embedded within each of them (Eris, 2003; IBO, 2000; Freestone, 2018). Taken as a whole, they potentially encompass the gamut of human knowledge, experience and enterprise. Yet they have little meaning until translated into the context and content of particular situations; in the case of this study – climate change.

Table 1

Generic Generative Questions (GGQs) - modified from Freestone, 2018

Generative question	Label	Description
What is it like?	FORM	Everything has a form with recognizable features which can be observed, identified and categorized.
How does it work?	FUNCTION	Everything has a purpose, a role or a way of behaving which can be investigated, described, and trialed.
Why is it like it is?	CAUSATION	Things do not just happen. There are causal relationships at work and actions have consequences.
How is it connected to other things?	CONNECTION	We live in a connected world of interacting systems in which the actions of any individual element affect others.
How is it changing?	CHANGE	Change is a process of moving from one state to another. It is universal and inevitable.
What is the role of place here?	PLACE	Time, space, location, situation, circumstance, and environment affect the ways people and communities can live and work.
Who might be responsible?	RESPONSIBILITY	People are not passive observers. They make choices and assume roles, which affect their lives and that of others.
How might people care for each other?	CARE	Caring for others is a key aspect of healthy communities. It draws on a sense of empathy, understanding and appreciation.
Where is the ethical reasoning?	ETHICAL	Ethical consideration is concerned with moral values and beliefs held and enacted by individuals, communities, and societies.
How is aesthetic sense manifest?	AESTHETIC	Aesthetic sense cultivates and values refinement, expression, sweetness, beauty, flexibility, design, and appeal.
How is the thinking evolving?	THINKING	Thinking is how people make sense of experience as well as create new ideas and ways of doing things. It is seldom static.
What might innovation add?	INNOVATION	To address challenges new or different ideas and ways of acting may be needed. Creativity and imagination are central.

To give online conversations focus, participants are asked to engage in investigations designed to – generate 'question threads' that open-up issues and innovative solutions, reveal possibilities for action around 'question threads', identify resources for particular 'question threads' that add depth to online conversations, and develop networks of people concerned to face up to the responsibility of caring for our world. The process is one of co-construction among participants as well as between participants and the researchers. Co-construction is a typical feature of design-based research as a result of collaboration between practitioners and researchers on all aspects of the iterative processes involved – analysis, design, and implementation (Wang & Hannafin, 2005).

2. Research Question

People who engage in online digital conversations exhibit a diverse range of values, backgrounds. needs, talents, motivations, predilections, capabilities and social practices. To reduce these to a question focused on a single or limited number of variables would be misleading, some might say impossible, and slant the study towards the mind of the researcher instead of the context being explored. Instead, we have identified the question:

Could generic generative questions (GGQs) help to promote deep online conversations around climate change?

We have defined the parameters of this question by expansion not reduction as follows. In what ways might GGQs stimulate consequent questions at different stages in inquiries and enhance the personalisation of investigations, help scaffold dialogues across digital environments and facilitate creative insights for further exploration? Such parameters require discipline. The elaboration is consistent with the growth implicit in the four stages of a DBR project through which research strategies evolve in an iterative way over time (Reeves, Herrington, & Oliver, 2005; Dede 2004).
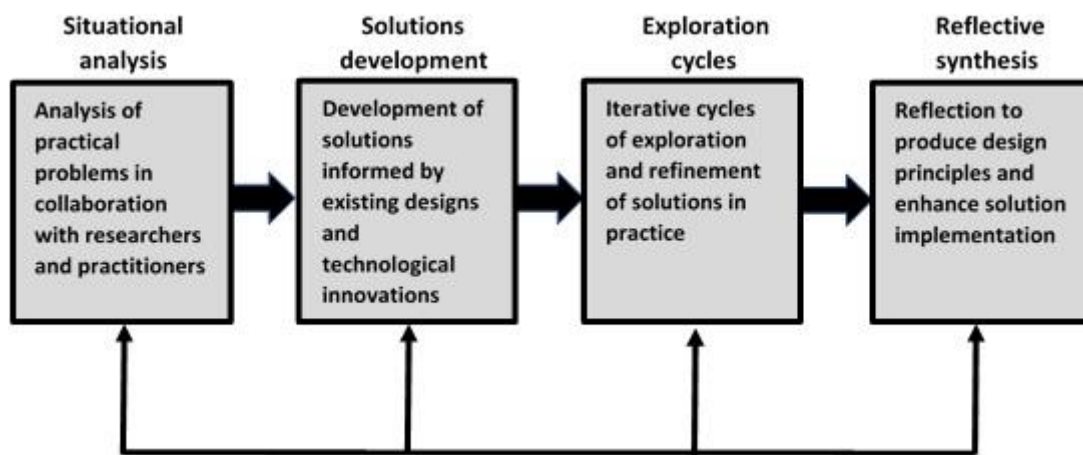
Figure 1. Design-based Research Process - modified from Herrington et al, 2011

Our research question is not a proposition or a hypothesis to be tested through a process of falsification (Popper, 1959) that is typical of scientific inquiry processes. Instead, it represents a starting point for developing a sense of how GGQs might direct, shape and open-up inquiries. To date, we have analysed practical problems related a questions approach to inquiry and developed a 'big picture' of possibility for exploration through an iterative series of online conversations around climate change. From there we intend to synthesise principles that might enhance inquiry-based activity in digital environments, and perhaps inquiries in general.

Key dilemma – Deciding when to define by reduction or expansion.

3. Shaping Reality

While there is an increasing range of evidence-based research strategies driven by developments in big data, there is likewise a growing range of options in research methodologies (Davies, 2016; Delamont, 2012; Gwyther & Possamai-Inesedy, 2009). Making an appropriate choice for the challenge at hand, given its complexity and diversity, presents a challenge. We also recognise that in choosing a DBR approach, our decision shapes reality or a least potentially skews research towards the assumptions on which it is based (Allender, 1991). Mitroff and Kilmann (1978) identified four world views, summarized in Figure 2, that affect the degree to which insights into reality are revealed or disturbed by the methods employed. For us, DBR offers a mixed approach that can generate new theory while being grounded in design processes and action-based methods focused on solutions as well as opportunities for deep learning.

ANALYTIC SCIENTIST	CONCEPTUAL THEORIST
• A search for **truth** • Quantitative methods	• A search for **understanding** • Qualitative methods
PARTICULAR HUMANIST	CONCEPTUAL HUMANIST
• A search for **connection** • Humanist methods	• A search for **change** • Action-based methods

Figure 2. Four World Views

As a humanistic enterprise searching for understanding, change and connection our project raises a raft of ethical dilemmas. Given these dilemmas may be common to many research projects, the co-construction stance we have adopted accentuates the need to share these dilemmas with participants in order to build their trust and confidence in the project.

> **Key dilemma – Using appropriate methodologies.**

3.1 Multiple variables

The complexity of multiple realities among participants engaged in making sense of climate change issues around a set of GGQs is not amenable to a quantitative analysis of variables implicit in an analytical scientists' approach. Instead, our eclectic mix of a search for understanding, change and connection is predicated on a 'big data' outlook; that is, as distinct from 'thin data' around a narrow-delineated set of variables (Geetz, 1973).

An amalgam of 'question threads', mind-maps, persuasive commentaries, analytical digests, and the reflections of participants, as well as observations made by the researcher make up the data set. Our pursuit of sensemaking (Madsbjerg, 2017) among participants makes gathering qualitative data from different angles highly desirable, almost an imperative. The emergent rich pictures reveal insights without the need to calculate around sets of variables.

> **Key dilemma** – Knowing when to seek 'big data' and when 'thin data' is required.

3.2 Interpretative bias

Interpretation biases on the part of the researcher are a critical issue (Kaptchuk, 2003). Our focus on GGQs makes this particularly challenging, none the least because the researcher inevitably has perceptions of the meaning of these questions and their potential application. The pitfalls include:
- Confirmation bias—interpreting evidence that supports the researcher's preconceptions differently from evidence that challenges these convictions;
- Rescue bias—discounting data by finding selective faults in its scope and design;

- Auxiliary hypothesis bias—introducing ad hoc modifications to imply that an unanticipated finding would have been otherwise had the conditions been different; and
- Orientation bias—the possibility that an interpretation or a hypothesis itself introduces prejudices and becomes a determinate of experimental outcomes.

Key dilemma – Identifying biases and taking steps to minimize them.

3.3 Overestimation misleads

Overstating the justification for the choice of methodologies or overclaiming outcomes taints the veracity of conclusions drawn. This issue is accentuated in cases of studies like ours that seek to explore the expression and development of human consciousness, especially when the dynamics of conversations are fast moving. The temptation to embellish or oversimplify within the context of the subject matter being investigated also needs to be avoided, as do undue assertions or extrapolations beyond the reality of the matters being studied.

Key dilemma – Avoiding unjustifiable exaggeration.

3.4 Strategic coherence

Sensemaking among participants, around climate change, stimulated by GGQs is likely to yield a vast array of perceptions, mental imaging and imaginative thoughts. This socio-cultural reality needs to be central to the selection research strategies as well as compatible with the philosophical underpinnings of DBR (Anderson & Shattuck, 2012). Coherence is essential. We believe a combination of Action Research (Kemmis & McTarrart, 1998) and 'Appreciative Inquiry' (Cooperrider, 2016) fulfil this requirement. Dialogues around an agenda of – 'what's the best of what is', 'what could be', 'what should be', and 'what will be' are inherently respectful.

Affording proper respect to the sensitivities of participants, their predilections and their personalities is imperative. The fact that case studies or detailed personal stories of an ethnographic nature are not involved minimizes intrusion on the privacy of participants.

Key dilemma – Looking for strategic compatibilities and consistencies.

3.5 Guiding principles

DBR maximizes legitimacy by shaping data collection, analysis, interpretation and synthesis around real-life contexts, diverse methodologies, multiple iterations, and collaborative partnerships. In so doing, enactment of the ethical principles that follow is of paramount importance.
- Justice to participants – by making them equal partners in the investigations.
- Justification of intentions – by negotiating the content and process of investigations with participants.
- Efficacy of methodologies – by making the intention of a search for understanding, change, and connection explicit to participants.
- Reporting responsibilities – by having participants cite and comment upon all personal material relevant to them.
- Proper use of referents – by accurate citing of comments and sources.

In a co-construction project, these principles create openness and trust, and afford dignity and recognition of personal identities; thereby, encouraging participants to share their thoughts and feelings.

Key dilemma – Making sure justice and equity underpin activity

3.6 Researcher predilections

Barab and Squires (2004), in a critique of DBR, raised the ethical argument "If a researcher is initially involved in the conceptualization, design, development, implementation, and re-searching of a pedagogical approach, then ensuring that researchers can make credible and trustworthy assertions is a challenge". This view is counter-balanced by the claim that the veracity of conclusions is enhanced when the mental-set of the researcher is exposed from the onset and only used as a 'lens' through which observations are made and interpreted. In 2018 the editor of the scientific journal *Nature* stated that the biases, insights and deep understanding of inquiry contexts that researchers possess can be a valuable research tool, especially when researchers and communities work together.

Our focus on exploring multiple realities and sensemaking among participants makes exposing the researcher's assumptions an important aspect of the authenticity of data analyses and the reliability of conclusions derived from them.

Key dilemma – Using researchers experience and expertise judiciously.

3.7 Conceptual coherence

Sensemaking is central to the pursuit of questions (Madsbjerg, 2017; Mason, 2014; Khan and Mason, 2015), which dictates a phenomenological search for multiple realities (Schutz, 1967). Our reflections are thus grounded around five interdependent perspectives. These are: personal consciousness, informed by Husserl (1936) and Heidegger (1962); temporal interpretations, informed by Schutz (1967) and Eberle (2010); mental modelling, informed by Lakeoff (1980) and Ricoeur (1978); contextual experiences, informed by Madsbjerg (2017) and Hitzler (2004); and interactive relations, informed by Jarche (2017) and Sporns (2019).

The accent is on qualitative dialogues with no attempt made to quantify either participant responses or the analytical insights of the researchers. The eclectic approach reflects recognition of the complexity of climate change as an issue and the diverse dynamics of participants asking questions.

Key dilemma – Ensuring authenticity and validity

3.8 Privileged responsibility

To seek insights into the sensemaking consciousness of people is a privilege steeped in responsibility. Each person's experience and thoughts are vast, much of which is either shielded from view in the subconscious mind or deliberately undisclosed. This raises crucial issues of the right of non-disclosure and the right to disengage, or to allow open disclosure. Equally important is recognition that conversations need to descriptive and appreciative, not judgmental. The participatory decision-making and iterative nature of DBR processes do much to ensure these rights are both respected and enacted.

The co-construction stance of our project is designed to build on the talents, interests and experience of participants in an environment of mutual respect and recognition.

Key dilemma – Respecting rights of engagement.

3.9 Multiple voices

The collective opportunity and responsibility for diversity of thought and action among participants, and between participants and the researcher, is a central tenant of our modus operandi. Cooperation and collaboration are manifest through sharing and negotiating actions, speculations and conclusions. All participants voices have value and need to be given respect and a non-judgmental hearing. In this way equity for all will underpin the effectiveness of our co-construction project.

At the same time, personal confidentiality is respected by requiring participants' permission for sharing material derived from the project as well as acceptance of content that is relevant to them. Ample opportunity is available to make modifications and additions at any stage, and to put forward

different propositions or interpretations. Participation in conversations on the project's blog is a personal choice without any expectation.

Key dilemma – Having a democratic ethos guide action.

3.10 Personal privacy

The need to protect against undue intrusion on participants' privacy is even present and accentuated when much of the discourse is by means of online environments. Personal anonymity and confidentiality are part and parcel of this responsibility. The potential for politically charged commentaries around issues of climate change heightens this dilemma. Electronic security by means of personal files and passwords together with encryption is essential. As is consent to participate in full knowledge of our project's purposes, processes and intended outcomes. Our project guarantees that these provisions are in place.

The substance of participants' responses, ideas and views, and the like, that emerge from the application GGQs also needs to be handled respectfully. Key is seeking each participant's acceptance before content relevant to them is made available to wider audiences.

Key dilemma – Protecting privacy within openness

3.11 Work recognition

The work of individuals and groups needs to be appropriately recognized and valued in accordance with each persons' wishes and expectations. Such acknowledgement is matter of honesty on the part of our project, the researcher in particular, as well as a means of affording social justice for the contributions of participants. Consultation with each participant is essential to determine how best this should be done and through what avenues; thereby, taking their sensitivities and aspirations in account. Participant contributions are no less valuable than that of researchers.

This is particularly pertinent in our project where work among participants is ongoing and synthetic; and not confined to once off events, even though they may be repeated a number of times. The iterative nature of our project places considerable demands on the commitment and perseverance of participants which requires due recognition.

Key dilemma – Observing rights associated with social justice.

3.12 Cultural appreciation

The application of DBR in a search for understanding, change and connection is a humanistic enterprise. For participants and the researcher affording dignity and respect as well as building on talents and aspirations, in a climate of genuine collaboration, is vital. Particularly important is appreciation of different cultural beliefs, traditions and backgrounds. Indeed, multicultural perspectives and voices are a rich resource in pursuit of insights into sensemaking around the twelve GGQs which form the primary focus of our study.

Depending upon needs, circumstances and intentions asking questions is a sensitive personal or collective act that requires environments where each person is valued in their own right as well as for the ideas they hold. Indeed, it can be fraught in situations where divergent responses to questions including diverse views and attitudes have the potential to generate conflict. The facilitative role of the researchers will be crucial in fostering appreciation of difference and in creating situations where people are valued and treated equitably.

Key dilemma – Recognising and valuing diversity.

3.13 Community understanding

Depending upon situational practices within particular communities the values underpinning our project need to be made clear. In some circumstances, considerable negotiation, in a spirit of openness, may be required to gain acceptance at family or community levels. This does not necessarily mean agreement, rather a sense of thoughtfulness is developed around our intentions and practices sufficient to generate the degrees of freedom required to proceed without undue interference.

When people – design something, build it and own it – personal and collective commitment, and the quality of human interaction, is enhanced. Different perceptions, ideas and values that emerge from the discourse are an invaluable resource. In the case of a DBR project like ours building understanding and appreciation is a two-way process of respectful synthesis between community ideas and understandings and the intentions and practices of the research.

Key dilemma – Respecting cultural backgrounds and beliefs.

3.14 Genuine implementation

Performance of the values and ethical principles expressed in this paper is an ongoing challenge throughout the construction of inquiries and the insights derived from them. The narrative on completion and participant feedback will reveal the extent to which these intentions have been realised.

While this could be said for almost any research project, the exposure created by a co-construction project around GGQs and climate change will likely be transparent.

Key dilemma – Being true to one's word.

4. Conclusion

Research into complex systems in educational settings is increasing in importance (Dondlinger, 2007; Ladyman et al., 2011; Larsen-Freeman, 2016). Indeed, many research communities have come to appreciate that the insightfulness and validity of conclusions drawn tend to be more trustworthy if the diversity of issues as well as their dynamics are accommodated through judicious attention to their potential impact. As a consequence, socio-cultural questions become integral, especially in studies like ours which seek to explore sensemaking in a complex world. Over the last couple of decades, research methodology has seen a shift away from 'siloed' studies confined to specific disciplines, or closely related ones, towards a more integrated approach (The Editor, Nature Biotechnology, 2017).

DBR is a relatively young methodology, though it is 'young' in a context where new methodologies continue to emerge. The challenge to improve descriptions of it and to increase its rigor is ongoing (Easterday et al., 2014). What are the phases in DBR processes, what sets them apart from other forms of research, what are the design issues and characteristics of DBR studies? And in what ways can we better craft the iterative dimension, maybe by incorporating some aspects of scientific inquiry? For all its advantages DBR is not a panacea, it is just an improvement in the repertoire of methods available to researchers.

The role of the researcher in DBR is complex (Christensen & West, 2017). In many ways the role is analogous to that of 'Teachers as Researchers' promoted by Laurence Stenhouse and his team in 70s and 80s (Stenhouse, 1975). The role is fraught with conceptual and operational challenges as well as ethical dilemmas. These include-
- Determining the critical issues within the diversity at hand
- Facilitating the rigorous collection of a wide range of data ('Big data')
- Avoiding the potential to be susceptible to personal bias and favored relations
- Managing multiple roles required including those associated with project management.

Why did we choose DBR to explore possibilities for GGQs to contribute to digital environments? Because it is underpinned by a situated real-life focus and grounded in social interaction. Other salient features are participatory decision making which is implicit in the process and acceptance that insights gleaned are qualitative and contextual rendering applications to other systems by reference, not by statements of apparent certainty. Indeed, the notion of playful uncertainty has excited our imagination

and informed the rationale for our project. The qualitative nature of DBR also mirrors the substance of our research question and its parameters.

With these caveats in mind, our choice to apply DBR to a human system respects complexity and diversity yet presents significant dilemmas. Resolution of these issues is paradoxically at the heart of our justification for adopting this approach. Our answers will determine the moral veracity of our decision.

References

Anderson, T. & Shattuck, J. (2012). Design-based Research: A Decade of Progress in Education Research. *Educational Researcher, 41, 16*

Cooperrider, D.L. (2016). What is Appreciative Inquiry? Retrieved from http://www.davidcooperrider.com/ai-process/

Dede, C. (2004). If Design-Based Research is the Answer, What is the Question? A Commentary on Collins, Joseph, and Bielaczyc; diSessa and Cobb; and Fishman, Marx, Blumenthal, Krajcik, and Soloway in the JLS Special Issue on Design-Based Research, Journal of the Learning Sciences, 13:1, 105-114

Eberle, T.S. (2010). The Phenomenological Life-World Analysis and the Methodology of the Social Sciences. Human Studies, 33, pp. 123-139

Eris, O. (2003). Asking Generative Design Questions: A Fundamental Cognitive Mechanism of Design Thinking. *International Conference on Engineering Design, ICED, 03* Stockholm, pp 12 -21, August.

Freestone, M. (2018). Curriculum Improvisation. *Australian Educational Leader, 40*, 35-39

Freire, P. (1970). *Pedagogy of the Oppressed.* Herder and Herder.

Geertz, C. (1973). *Thick Description: Towards an Interpretive Theory of Culture.* The interpretation of Culture. Basic Books.

Herrington, J., McKenny, S., Reeves, T., & Oliver, R. (2011). Design-based research and doctoral students: Guidelines for preparation a dissertation proposal, *Research Online*, Edith Cowan University Publications.

Hitzler, R. & Eberle, T.S. (2004). Phenomenological Life-world Analysis. In A Companion to Qualitative Research, edited by EW Flick, Ernst von Kardorff and Ines Steinke Trans. Bryan Jenner, Sage Publications, London.

Husserl, E. (1936). *The crisis of European sciences and transcendental phenomenology*. (D. Carr Trans.). Evanston IL: North Western University Press

IBO. (2000). *Making the Primary Years Program (PYP) Happen*. International Baccalaureate Organisation, Geneva, Switzerland

Jarche, H. (2018). Finding community. Retrieved from https://jarche.com/2018/11/finding-community/

Khan, K., & Mason, J. (2015). Sense-making, Mathematics, and Digital Technology. In Roberto Dillon and Lee Ming Tan (Eds), Teaching and Learning with Technology, Proceedings of the Global Conference on Teaching and Learning with Technology, Singapore. World Scientific Publishing.

Kemmis, S & McTaggart, K., (eds.), (1998). The Action Research Planner, Geelong: Deakin University Press.

Lakeoff, G. & Johnson, M. (1980). *Metaphors We Live By*. Chicago: University of Chicago Press.

Madsbjerg, C. (2017). *Sensemaking: The Power of the Humanities in the Age of the Algorithm*. New York: Hachette Books.

Mason J. (2014). Scaffolding Reflective Inquiry – Enabling Why-Questioning while E-learning. *Research and Practice in Technology Enhanced Learning, 7*(3), 175-198.

Mitroff, I.L. & Kilmann, R.H. (1978). *Methodological approaches to social science*. San Francisco: Jossey Bass

Popper K. (1959). *The Logic of Scientific Inquiry*. Hutchinson and Co

Pritchard A. (2009). *Ways of Learning - Learning theories and learning styles in the classroom*. Routledge, London and New York

Reeves, T. C., Herrington, J., & Oliver, R. (2005). Design research: A socially responsible approach to instructional technology research in higher education. *Journal of Computing in Higher Education, 16*(2), 96-115.

Ricoeur P. (1978). *The Rule of Metaphor: Multidisciplinary Studies of the Creation of Meaning in Language.* London: Routledge and Kegan Paul.

Schultz A. (1967). *The phenomenology of the social world*. Evanston, IL: North Western University press

Sporns O. (2019). Network Neuroscience: Mapping and Modelling Complex Brian Networks. University of Indiana, Bloomington. Retrieved from http://www.youtube.com/watch?v=Fsr6FIUOXCc

Wang, F., & Hannafin, M. J. (2005). Design-based research and technology-enhanced learning environments. *Educational Technology Research and Development, 53*(4), 5-23. doi.10.1007/BF02504682

Redefining Question for Curve-Driving Practice Using Augmented Reality and Driving Models

Sho YAMAMOTO[a]* & Yuki MORISHIMA[b]
[a]*Faculty of Engineering, Kindai University, Japan*
[b]*Graduation School of System Engineering, Kindai University, Japan*
**yamamoto@hiro.kindai.ac.jp

Abstract: The purpose of this paper is to suggest a learning support system for curve driving that uses augmented reality (AR) and a model of curve driving. This learning environment focuses on the processes of recognition, judgment, and operation with an aim to enhance driving skills and tackle problems faced while learning how to drive. Driving entails an above cycle that is usually learnt through trial and error while it is practiced initially. Currently in Japan, the driving teacher provides instruction based on the accuracy of the learner's operation, indicating that this learning method is focused on an 'operation.' When the teacher indicates an error in the learner's operation, the learner has to consider the cause of the error by reviewing recognition, judgments, and operation from the teacher's instructions. However, this method of consideration must be inferred and difficult for a novice driver. Moreover, the act of learning recognition, judgment, and operation separately is impossible because humans cannot divide them during driving. In this study, we developed a learning support system that can grasp recognition, judgment, and operation gradually and individually, based on driving models, AR for curve driving, scaffolding and fading, and reflective method. We designed a model of curve driving based on a situation awareness model. The learning environment implemented in this driving model can grasp recognition, judgment, and operation in fixed steps by information displayed in AR and can correct its own recognition, judgment, or operation by reviewing the result of each practice. This exercise will address the constraints and problems faced in tasks that involve learning curve driving; the question of the driving practice can be changed from "How do you drive a curve properly?" to "How do you perform recognition, judgment, and operation when you drive a curve properly?" We also conducted an experiment using the proposed learning support to test its effectiveness.

Keywords: skill learning, driving education, augmented reality, scaffolding, reflective method

1. Introduction

Safety is of utmost importance when one is learning how to drive automobiles. In Japan, when learning how to drive, the learner is instructed to observe the teacher's driving method—that is, pay attention to the method of driving and learn what to look out for. When learning how to drive around a curve, the learner is shown via demonstration, where to slow before the curve and to observe the shape of the curve. The driving instruction and the problem (assignment) can vary according to the instructor and often, the only goal stressed on, when practicing driving, is to drive safely. This emerges as problematic and we disagree with this method of assignment for both learners and teachers.

The ability to drive an automobile requires learning a skill based on practical experience. Therefore, it is natural that instruction be given based on results of the driving operation when learners practically experience the act of driving automobiles. This type of learning often called skill learning. While driving requires comprehension of how to operate a tool (in this case, a car), it also involves learning a cycle of recognition, judgment, and operation (Endsley, M. R, 1995). However, the driver is given the question "How do you drive a curve properly?" This is a very vague question. What learners need to learn is a cycle of recognition, judgment, and operation. Moreover, learning this cycle is very difficult because learners continuously and simultaneously perform recognition, judgment, and operation while they practice driving. To this effect, when teachers provide learners with feedback on the results of judgment, learners cannot necessarily stop driving when done with the judgment, nor can teachers know results of the learner's judgment as it will be practiced at a later time. For this reason,

learner is given a vague question, the assignment of driving practice should be to execute driving operations successfully and evaluate results generally.

We developed a learning environment in which recognition, judgment, and operation can be separately and gradually learned, utilizing a heads-up display (HUD) incorporating AR systems. We designed a model of curve driving based on the situation awareness (SA) model. We then considered a practice based on this model and developed a learning environment using HUD that can grasp recognition, judgment, and operation separately and methodically. This was done in an attempt to refine the problem definition and evaluation of driving training from "operation-based" to "recognition, judgment, and operation based."

Research has largely been based on automatic driving technology in order to realize safe driving (Wei, J. et al., 2013). For instance, there is research on improving accuracy of sensors used in automatic driving (Bojarski, M. et al., 2016). Fully self-driving cars do not require a driver, but low-level self-driving cars require a driver to partially drive. Moreover, full automation can cause cognitive decline of driver and more serious accidents (Parasuraman, R., & Riley, V., 1997). Cars are driven not only for transportation purposes but also for recreation. Therefore, it is important to improve the quality of driving instruction and learning in order to maintain human enjoyment (of driving as a hobby) and ensure road safety.

The following section describes a model of curve driving and learning method based on this model. Section 3 introduces a learning environment for realizing the learning method introduced in section 2. Section 4 compares this study with related studies and section 5 reports results of the practical use of our proposed learning environment. The paper concludes with a summary and suggestions for future applications.

2. Curve Driving Model and Learning Proposal

In order to develop a learning environment that can separately and gradually help learn curve driving through recognition, judgment, and manipulation, we designed a model of curve driving. Based on this model, we show how to realize the learning of recognition, judgment, and operation.

2.1 Curve Driving Model

Driving a car involves dynamic interplay of recognition, judgment, and operation. In the field of Human Factor, the SA model is proposed, which explains the cycle of recognition, judgment, and operation in greater detail (Endsley, M. R., 1995). In this model, the learner at first recognizes elements of external information, then integrates the recognized information and understands the situation, and finally, predicts an operation for approaching a target situation and determines an appropriate operation. Following these four steps, the performance of the decided action is verified, and external information that changed because of the performed action is recognized. Learners will be able to understand this cycle and perform it automatically in driving practice. Motorcycle driving research indicates that the monitoring skill for own driving is important for better driving (Watson, B. C., Tunnicliff, D. J., White, K. M., Schonfeld, C. C., & Wishart, D. E., 2007). In this study, we develop a learning support system for driving practice in curve driving so that learners acquire the driving cycle appropriately.

Figure 1 depicts an instructional textbook from a driving school in Japan on practicing curve driving. The learner is presented with positions and operations necessary for curve driving. The learner repeats driving practice based on this method, and the teacher instructs whether the learner's driving is appropriate or not, while the learner is driving. On the other hand, driving is inherently, a cycle of recognition, judgment and operation. So, the learner has to learn not only operation but also recognition and judgment. Therefore, above learning is not appropriate because the learner is not even asked a question about the driving process. The driving process that the learner has to learn is not given the learner as question clearly.

Therefore, we constructed a model of a curve driving based on SA, as shown in Figure 2. The model of curve driving is described separately in terms of recognition, judgment, and operation, while the elements of each process remain connected. The driver first recognizes the position of the vehicle, the shape of the curve, the vehicle speed, and the distance to the curve in order to determine the appropriate operation at the curve. Then, the driver predicts the appropriate traveling line and the

appropriate traveling speed according to the shape of the curve. Based on the appropriate traveling line and the position of the vehicle, the necessity of steering wheel operation is judged. If the steering wheel operation is required, the degree of steering is also specifically judged. Moreover, by knowing the correct speed required at the curve, the current vehicle speed, and the distance to the curve, it is possible to judge the need for acceleration and deceleration. If acceleration or deceleration is necessary, it is gauged how much acceleration or deceleration needs to be performed. Finally, based on the predicted degree of acceleration and deceleration and the degree to which the steering wheel is turned, these operations will actually be performed and verified. Although these procedures are basically fine-tuned continuously when the driver is driving, we define this granularity model to keep it at a level that humans can understand.

In addition, in Japan, as shown in Figure 1, the above-mentioned cycle is divided into three sections: at the entrance, along the curve, and at the exit. For example, if traveling ahead of the entrance of the curve, the shape of the curve to be grasped becomes the shape of the entrance. When traveling at the entrance of curve, the driver has to be aware of the shape of the curve.
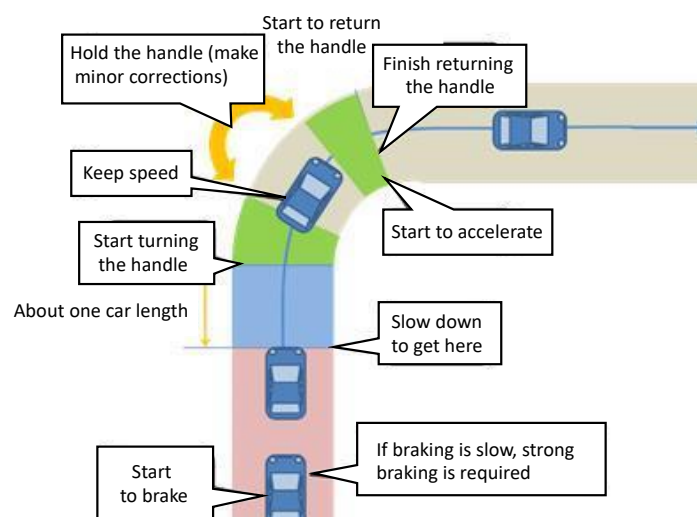

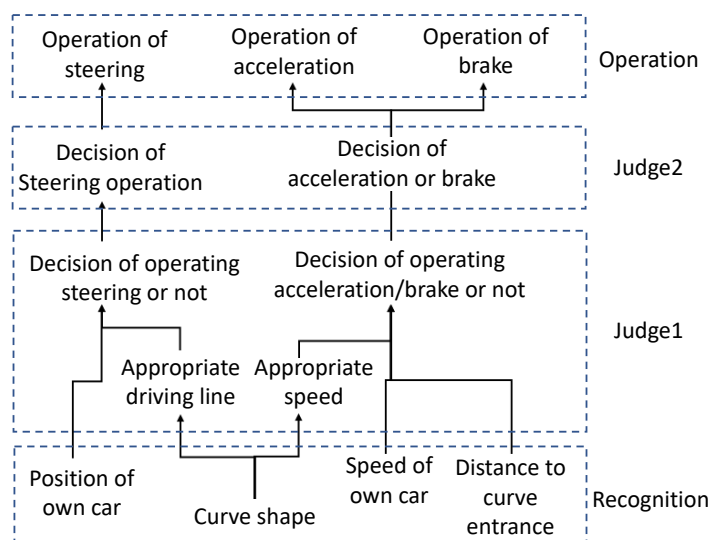*Figure 1.* Instructions of curve driving from a Japanese driving textbook.

Figure 2. Model for curve driving.

2.2 Redefining Question in Curve-Driving Practice and Its Learning Procedure

2.2.1 Design Policy

Curve driving is classified as motor skill learning because it involves movement of the body. Motor skill learning is generally considered a neuronal change that enables organisms accomplish motor tasks faster and more accurately than before (Diedrichsen, J., & Kornysheva, K., 2015). Skill learning, unlike declarative knowledge, cannot be measured in terms that we can verbalize, and instead, the results of learner activity are evaluated. Skill learning is distinguished from normal exercise adaptation. As mentioned above, it is important to review the results of one's own driving when learning how to drive a motorcycle. We believe the same to be true for when learning how to drive a car. Therefore, the core determinants for learning driving skills are: (a) refining the process of motor tasks by understanding the cycle of recognition, judgment, and operation appropriately; (b) the ability to practice the process of motor tasks repeatedly through trial and error; and (c) refining motor skills by reviewing the processes of motor tasks. Learning environment has to give an assignment so that the learner can learn above.

However, at least in Japan, the learning method for driving a car only requires repeated practice of driving, and teaching how to drive based on this model is insufficient. We believe this is why it is virtually impossible for teachers to indicate and correct learner's errors at every step of recognition, judgment, and operation. However, an appropriate exercise for skill learning is to grasp recognition, judgment, and operation and their connections individually, and to understand these processes and repeatedly refine the process of motor skill. Therefore, based on the driving model in the previous section, we propose a learning method that can comprehend recognition, judgment 1, judgment 2, and operation individually and refine the cycle of these steps.

2.2.2 Learning Procedure

In the previous section, we defined the activity of recognition, judgment 1, judgment 2 and operation for curve driving. We also demonstrated that all of these steps can be presented as visual information. Therefore, if this model is implemented in learning environment, it is possible to present this information appropriately using AR. In the proposed method of learning, learners learn each step of the cycle gradually by being presented with information of the next step in advance. Figure 3 shows an instructional diagram of this learning method. At first, the learner practices the operation. At this time, the result of judgment 2 is displayed to the learner. Therefore, the learner does not need to consider recognition, judgment 1, and judgment 2, and can focus only on practicing the operation. In other words, learners are given the question: "What is the proper operation to safely drive this curve?" This method of reducing the learning load on the learner by adding appropriate support during learning is called scaffolding (Wood, D, Bruner, J. S., & Ross, G., 1976; Jackson, S. L., 1996). After driving practice, the learner reviews the driving operation for its effectiveness, and thus improves their operating skills. The information displayed for scaffolding is different along the curve—at the entrance, in the curve, and at the exit. In this procedure, the learner practices curve driving, reviews the learner's practice, and repeats these processes until the skill has been acquired by the learner.

After mastering operation, the learner is then presented with the results of judgment 1, which are acceleration or deceleration or neither, steering wheel operation or not, appropriate travel line, and appropriate travel speed. Therefore, the learner is given the new question: "How is the appropriate degree of acceleration / deceleration and steering operation to safely drive this curve?" This removal of scaffolding in learning is called fading (Jackson, S. L., 1996). In this case as well, the learner reviews own driving operation, and this time, verifies whether or not judgment 2 skill is appropriate. If the learner's operation is insufficient, the learner can return to previous practice.

When the second step of this learning method is completed, the learner is presented with two tasks of recognition relating to curve shape and speed of the car being driven. The learner is required to perform appropriate judgment 1. As for appropriate driving line in Judgment 1, it is appropriate to drive keeping along the left edge of the curve in Japan, so it is necessary to inform the learner about this stipulation in advance. It is also necessary to inform the learner about the basic driving method shown in Figure 1. After driving practice, the learner reviews operations as before for acquiring judgment 1 and practices driving again to refine the skill. At this stage, based on the driving process, the learner acquires the ability to accurately predict parameters for proper curve driving and ground them to real operation.

After the above practice, the learner eventually removes all the scaffolding and practices driving the car as a regular driving student while being aware of the cycle learned above. By repeating this practice, learners can improve driving operations based on the processes acquired up to the previous

step. As for the problem of driving activities in motorcycle driving, it was highlighted that drivers accustomed to driving will drive dangerously based on their own driving experience (Biral, F., Bosetti, P., & Lot, R., 2014). This is because they are familiar with driving operations and are believe that this driving operation is safe as they have never before met with accidents using these driving methods. Considering these factors, this learning method let the learner clarify the elements which should be understand in learning. Thus, this learning method is suggest to be useful in improving the predictive ability during driving and understanding an appropriate cycle for driving.
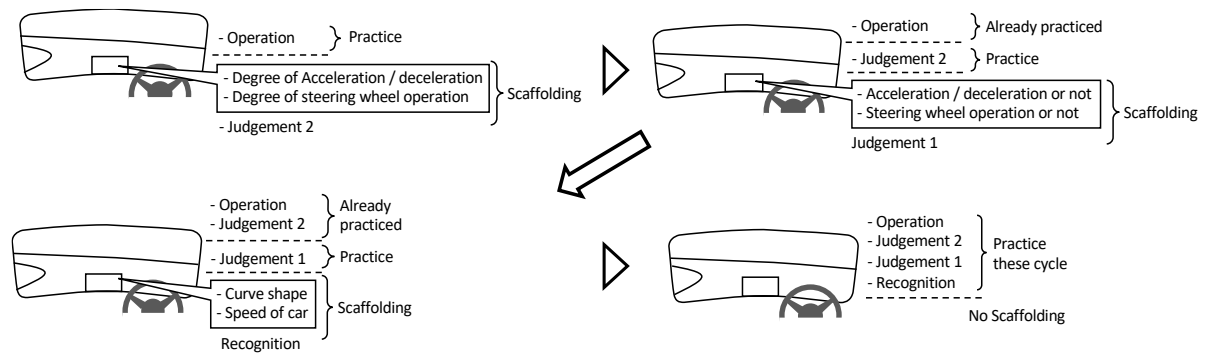
Figure 3. Procedure of suggested learning method.

2.2.3 Reflection on Learning

The feedback generation pattern in each step of the learning process is depicted in Table 1. The operation column indicates the type of driving operation expected of the learner. The position column depicts the position of the car, that is, at the curve's entrance, middle, or exit. Based on these operations and positions, the learner provides reasons for the his/her driving operation during practice. For example, regarding the steering wheel operation at the entrance of the curve, options include: the car position was inside, outside, and no choice. If the learner answers "no choice," it indicates that the driving was appropriate, so no particular feedback is generated. Therefore, it is not described in the

Table 1

A pattern of feedback for learning

Operation	Position	Results of driving	Feedback for recognition	Feedback for judgment	Feedback for operation
Steering wheel	Entrance	Driving position is inside	Recognize the shape of the curve	Judge the proper timing for operation	Operation is early
		Driving position is outside			Operation is late
	Middle	Driving position is inside			Operation is much
		Driving position is outside			Operation is least
	Exit	Driving position is inside		Judge the proper timing for operation	Operation is late
		Driving position is outside			Operation is early
Acceleration / Deceleration	Entrance	Feeling internal force	Recognize the proper speed	Judge the proper timing for operation	Deceleration is late
	Middle	Feeling internal force		Judge the proper degree of operation	Deceleration is not enough
	Exit	Feeling internal force	Recognize the legal speed	Judge the proper timing for operation	Acceleration is late

table. When the learner practices driving and does not use any scaffolding, feedback such as "recognize the shape of the curve" are provided. If the learner is learning judgment and requires driving instructions for the curve's entrance, feedback like "pay attention to the timing of moving the handle" are given. For instance, if the learner answers about driving in the middle of a curve, feedback like "rethink the degree of operation" is given. Finally, if the learner is practicing the operation, the feedback for driving at the entrance of the curve will relate to the operation being early or late. These feedback patterns were created from the model in section 2.1.

3. Design and Development of Learning Support Environment

The interfaces of our learning environment are depicted in Figures 4, 5, and 6. The system was developed using Android Java, and the interface shown in Figure 4 depicts a tablet view. A translucent screen is cast to the HUD (indicated by a white arrow) and positioned directly in front of the driver, as seen in Figure 5. After logging into the system, the learner can select from two options: learn prior knowledge for driving or practice driving step by step. With the first option, the learner is presented with a detailed explanation of Figure 1. When the second option is selected, the learner is required to select which step of the learning described in section 2.2 is to be practiced. The choices are categorized by recognition, judgment 1, judgment 2, and operation.

As this system is intended to be used by teachers at driving schools, information presented in Figure 4 is displayed when the instructor touches the screen on a tablet. The system stores information regarding all the curves of the course that are to be practiced. This software is currently operated using the Gran Turismo 6 simulator and cannot automatically present information for scaffolding based on the actual travel position as the software is not connected to Gran Turismo 6. Therefore, the instructor must change the information displayed for scaffolding appropriately by operating the tablet. Since the information displayed is different for the entrance, middle, and exit of the curve, the instructor must touch the tablet's screen and change information each time the learner moves. However, the information displayed is automatically determined based on the selected step of practice, and the instructor only has to change information for speed using three options: decelerate, maintain, and accelerate. For road use, GPS and Google Maps can be used to automatically obtain speed and curve shape, however, the experiment is yet to be realized from the bioethics viewpoint.
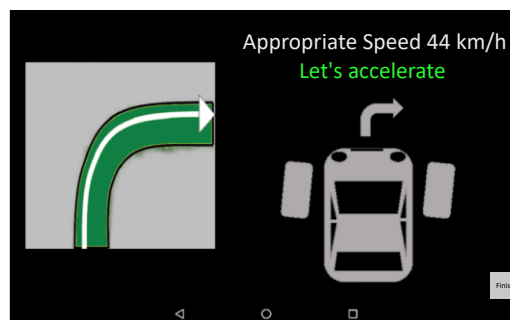
Figure 4. Interface of driving training on an Android tablet.

Figure 5. Interface of driving training on HUD (indicated by white arrow).
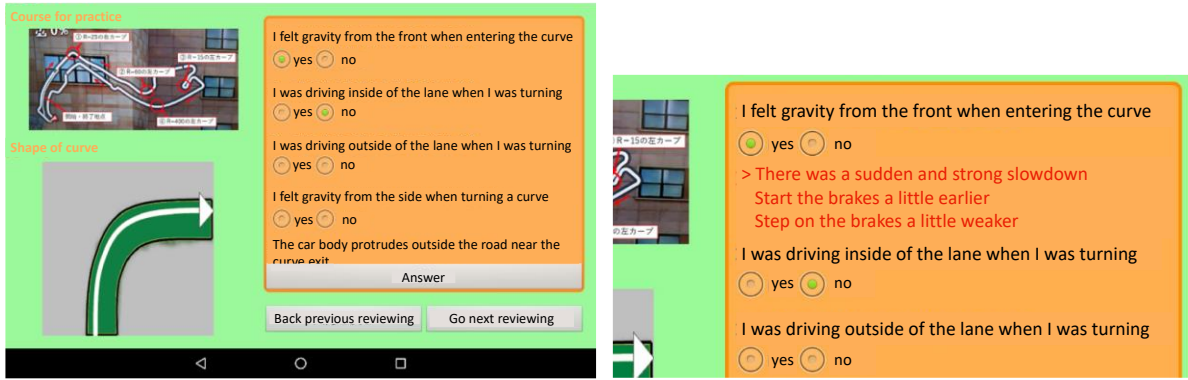
(a) Interface before answer   (b) Interface after answer

Figure 6. Interface for reviewing as reflective method.

Upon completing practice of all curves of the registered course, the screen switches to a review screen for reflection, as seen in Figure 6. In this interface, the learner reviews the quality of driving performed while checking each curve of the course. Feedback is generated based on learner's answers (yes, no, no choice); generating rules are presented in Table 1. For example, if the car is at the entrance of the curve, the question prompted is "I was driving inside of the lane when I was turning" and the learner answers with either yes, no, no choice. After the learner answers all choice, by way of pressing an answer button, the system provides feedback as seen in Figure 6 (b) according to the stage in practice and results of the answer. Upon completion of each practice and review, if the instructor determines that the learner has mastered the selected step, the process moves on to the next step and repeats exercises similarly.

4. Related Works

Simulators are the most commonly used methods of teaching automobile driving as they can realize safe driving practice in virtual spaces as well as create various practice courses for learners (Leitão, J. M., Moreira, A., Santos, J. A., Sousa, A. A., & Ferreira, F. N., 1999; Backlund, P. et al, 2006; Wagner, J., Yao, Q., Alexander, K., & Pidgeon, P., 2013). Additionally, learners can drive repeatedly and safely in virtual spaces and game elements can also be incorporated. The ability to create different courses can allow several lessons for learners. Simulators merely mitigate the limitations of danger that can be experienced in actual learning, with the construction of a practice course and realization of accidents that could occur during driving. Learners can thus safely repeat traditional learning but must also understand and refine driving processes using their own ability. When using a simulator, the assignment of learning is to drive safely, exactly as it is with traditional learning in driving schools. Repeating this learning means that traditional learning is executed safely and efficiently. It is believed that a model for safe driving is implicit in this learning.

With regards to skill learning, the focus is often on correcting body movement (Iwasako, K., Soga, M., & Taki, H., 2014; Diedrichsen, J., & Kornysheva, K., 2015). If it is intended to speed up motion targeted for skill learning, correction of displacement of body motion is an important learning element. However, in activities where decision-making for action is crucial, as in this study, it is important to learn a model for prediction and map the model to real action (Endsley, M. R, 1995). Moreover, some researchers have pointed out that it is important to acquire knowledge for skills in skill learning (Stanley, J., & Krakauer, J. W., 2013).

Various types of information can be presented using HUD. In order to realize safe driving, lane departure misbehavior can be reduced by presenting the travel path of the car using AR (Tonnis, M., Lange, C., & Klinker, G., 2007). Similarly, warnings and indications of potential driving hazards are important technological advances linked to safe driving (Yang, Z. et al, 2018). The effects of displaying information and examining how it is displayed to the driver are being investigated. The presentations usefully equip the driver with information to recognize results of driving. However, polite presentation and partial automation (for example, automatically predicting and displaying dangerous behaviors) may conversely reduce the driver's cognitive ability. That said, it is extremely useful for emergencies, as well as to help the driver carry out appropriate driving.

428

There are many studies on learning support for driving practice aimed at making it possible for learners to safely repeat the vague problem of "How do you do the safe driving?" or easily increase variations of the practice course. Studies on skill learning have evaluated results of learner's action, using myoelectric potential measuring instruments. The conscious problem that arises with these studies is focuses on making learners perform actions accurately and quickly. On the other hand, since most driving assistance systems are designed with the sole purpose of supporting only the driver and not the teacher, it is necessary that the driver understands enough about driving. In this study, the problem of car driving skill learning has shifted to "How do you do the cognition, judgment, operation and its cycle for safe driving". This change is much required. In the proposed system, by setting various constraints on AR, the learner is required to think not only about the operation but also the cognition, judgment, and its cycle. Therefore, this approach greatly differs from other studies.

5. Experimental Use

5.1 Procedure

Ten university students with driving licenses were selected as subjects. A driving simulator as seen in Figure 5 was used, with real car seats and dedicated controllers for the steering wheel, accelerator, and brakes. The HUD was located in the actual installation position, directly in front of driver. The school's bioethics committee certified the experimental use of Gran Turismo 6 software for Play Station 3, which helped to create a more authentic driving environment. As a first step evaluation of this research, the purpose of this experiment was to verify if the exercise was meaningful for learning, at least for drivers who had already obtained a driving license.

Table 2
Questionnaire on the proposed driving practice administered to subjects

	Questions about the driving exercise
#1	Will the step by step flow of this driving exercise from System 1 → System 2 → System 3 → System 4 help you master curve driving?
#2	Will the step by step flow of this driving exercise from System 1 → System 2 → System 3 → System 4 help you master curve driving more effectively than conventional practice?
Questions on the operation practice function	
#3	Did the presentation on appropriate speed help you practice curve driving?
#4	Did the presentations on acceleration, deceleration, and appropriate speed judgment help you practice curve driving?
#5	Did the presentation of information on steering wheel operation help you practice curve driving?
Questions on judgment 2 practice function	
#6	Did the presentation of information on appropriate speed help you practice curve driving?
#7	Did the presentations on acceleration, deceleration, and appropriate speed judgment help you practice curve driving?
#8	Did the presentation of information on steering wheel operation help you practice curve driving?
Questions on judgment 1 practice function	
#9	Did the image of the curve shape help you practice curve driving?
#10	Did the displayed appropriate speed help you practice curve driving?
Questions on the reflection function	
#11	Do you think that reviewing your practice using the reflection function of this system will help you in mastering curve driving?
#12	Do you think that presenting driving improvements based on your practice review is helpful in understanding what you are not doing?

As part of the experimental procedure, subjects received an explanation on using the learning environment. Subjects were then required to drive a different course from the experiment in order to get accustomed to driving with the simulator, as it is a significantly different experience compared to driving a real car. After this practice, driving practice generally performed at Japanese driving schools was conducted on the simulator. The courses of different cities were used. An exercise using the learning environment was conducted.

Subjects then answered a questionnaire (summarized in Table 2) on the proposed driving practice. Q1 and Q2 related to learning methods used by the system, Q3 and Q4 related to the system's operation practice, Q6, Q7, and Q8 related to the practice of judgment 2, Q9 and Q10 related to the practice of judgment 1, and Q11 and Q12 related to the reflective method. If subjects positively answered questions, it would verify the proposed learning method and confirm that it deepens understanding as compared to conventional driving instructional and learning practice.

5.2 Results

As seen in Figure 7, subjects reacted positively to all questions relating to learning methods, confirming that this learning method is more effective than learning in driving schools. There were several negative answers relating to learning environment of operation and steering wheel operation. Subjects complained about visual issues due to the small size of the HUD and hard to see the tire angle. A similar problem was reported in relation to the practice of judgment 2. With regards to judgment 1, there were mostly positive answers. All subjects responded that the function of the reflective method was helpful in deepening their understanding of driving. It was difficult to confirm if any inertial force was experienced as this was a simulated exercise and subjects were looking through a digital screen and not the windshield of an actual vehicle. They judged from the driving screen of the simulator. About this reviewing, it is necessary to change the wording in the case of practicing on the simulator and in the case of practicing on a real vehicle. The learning method and driving models were well accepted by subjects. A better learning environment can be developed by refining the system based on these models and functions. Three subjects who were not confident about driving were interviewed, and it was concluded that understanding the driving cycle by the steps in this practice could alleviate their aversion to driving. Therefore, the learning method proposed and learning based on reflection could clarify assignment that were previously ambiguous for learners.
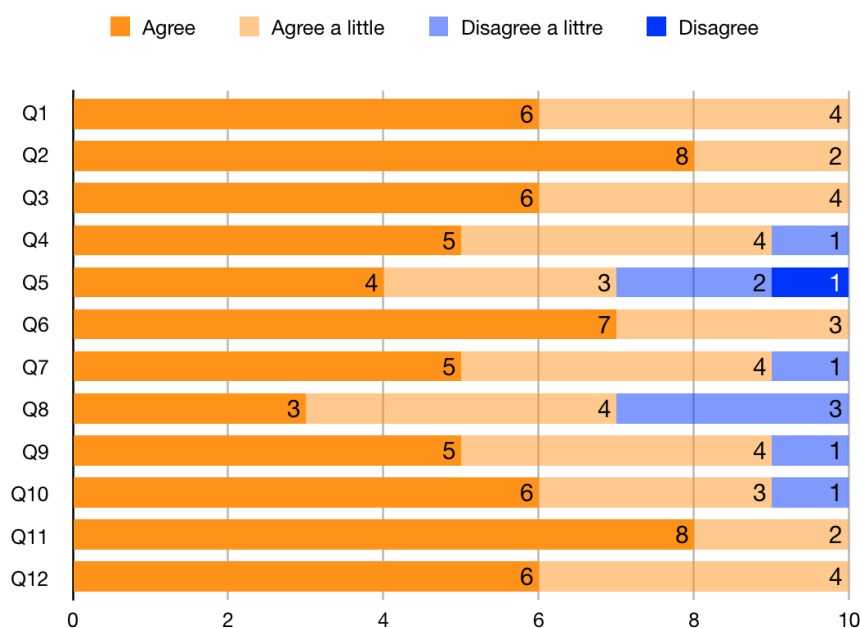
Figure 7. Results of the questionnaire.

6. Summary and Future Works

We developed a learning environment that can individually grasp the driving cycle of the curve, and evaluated its practical use. In Japanese driving schools, learners are given the task of correcting driving errors in order to realize safe driving. Driving is a cycle of recognition, judgment, and operation. However, as this cycle is continuously repeated in driving practice, it is practically impossible to actually learn cognition, judgment, and operation individually. We proposed a learning method to practice recognition, judgment, and operation individually and in fixed steps. For the realization of this system, we defined the model of curve driving and used AR. The study's purpose was to propose a change in the assignment from refining driving operation to individual learning of cognition, judgment, and operation and improved prediction ability for refining driving skill.

Experimental use of this system demonstrated that the proposed practice was more useful for learning driving than conventional driving schools, although it was verified in a simulation environment. This result is because the learner could learn the skills more clearly by redefining the question in learning of curve driving. It was also suggested that learners who were not good at driving could relieve aversion to driving by learning the process of driving more clearly. However, functionality needs to be improved as feedback was insufficient due to the simulation environment and technical difficulties viewing information displayed on the HUD. In the future, we will conduct more rigorous experiments with a larger subject size and consider similar learning in situations where prediction is more important, such as intersections.

References

Backlund, P., Engström, H., & Johannesson, M. (2006). Computer gaming and driving education. *In Proceedings of ICCE'06* (pp. 9-16).

Biral, F., Bosetti, P., & Lot, R. (2014). Experimental evaluation of a system for assisting motorcyclists to safely ride road bends. *European Transport Research Review, 6*(4), 411-423.

Bojarski, M., Del Testa, D., Dworakowski, D., Firner, B., Flepp, B., Goyal, P. et al. (2016). End to end learning for self-driving cars. *arXiv preprint arXiv:1604.07316*.

Diedrichsen, J., & Kornysheva, K. (2015). Motor skill learning between selection and execution. *Trends in cognitive sciences*, *19*(4), 227-233.

Endsley, M. R. (1995). Toward a theory of situation awareness in dynamic systems. *Human Factors*, *37*(1), 32-64.

Iwasako, K., Soga, M., & Taki, H. (2014). Development of finger motion skill learning support system based on data gloves. Procedia Computer Science, 35, 1307-1314.

Jackson, S. L. (1996). The design of guided learner-adaptable scaffolding in interactive learning environments. *In Proceedings of International Conference on Learning Sciences'96* (pp. 575-576). International Society of the Learning Sciences.

Leitão, J. M., Moreira, A., Santos, J. A., Sousa, A. A., & Ferreira, F. N. (1999). Evaluation of driving education methods in a driving simulator. In J. C. Teixeira, W. Hansmann, & M. B. McGrath (Eds), *Proceedings of GVE'99* (pp. 159-164).

Parasuraman, R., & Riley, V. (1997). Humans and automation: Use, misuse, disuse, abuse. *Human factors*, *39*(2), 230-253.

Stanley, J., & Krakauer, J. W. (2013). Motor skill depends on knowledge of facts. *Frontiers in human neuroscience*, *7*, 503.

Tonnis, M., Lange, C., & Klinker, G. (2007). Visual Longitudinal and Lateral Driving Assistance in the Head-Up Display of Cars. *In Proceedings of ISMAR'07* (pp. 1-4).

Wagner, J., Yao, Q., Alexander, K., & Pidgeon, P. (2013). Assessment of an Automotive Driving Simulator to Educate Novice Drivers. *The Chronicle for Driver Education Professionals*. 18-32.

Watson, B. C., Tunnicliff, D. J., White, K. M., Schonfeld, C. C., & Wishart, D. E. (2007). Psychological and social factors influencing, motorcycle rider intentions and behaviour. *ATSB Research and Analysis Report Road Safety Research Grant Report 2007-04, Queensland*

Wei, J., Snider, J. M., Kim, J., Dolan, J. M., Rajkumar, R., & Litkouhi, B. (2013). Towards a viable autonomous driving research platform. *In 2013 IEEE Intelligent Vehicles Symposium* (pp. 763-770). IEEE.

Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of child psychology and psychiatry*, *17*(2), 89-100.

Yang, Z., Shi, J., Zhang, Y., Wang, D., Li, H., Wu, C. et al. (2018). Head-up Display Graphic Warning System Facilitates Simulated Driving Performance. *International Journal of Human–Computer Interaction, 35*(9), 796-803.

A Support System for Learning Physics in Which Students Identify Errors Using Measurements Displayed by a Measurement Tool

Urara UENO[a]*, Takahito TOMOTO[b], Tomoya HORIGUCHI[c] & Tsukasa HIRASHIMA[d]

[a]*Graduate School of Engineering, Tokyo Polytechnic University, Japan*
[b]*Faculty of Engineering, Tokyo Polytechnic University, Japan*
[c]*Graduate School of Maritime Sciences, Kobe University, Japan*
[d]*Graduate School of Engineering, Hiroshima University, Japan*
*m1865002@st.t-kougei.ac.jp

Abstract: It is sometimes challenging for learners of elementary physics to correct their mistaken notions regarding physics concepts. The need to address this phenomenon is illustrated by the existence of common misconceptions such as 'motion implies a force' (MIF), in which learners mistakenly believe that force always acts in an object's direction of motion, as well as educational approaches using error-based simulation (EBS). In a conventional EBS, a learner's mistake is usually output as a physical phenomenon, but there are cases in which the learner's mistake cannot actually be shown. For this reason, we propose an EBS in which measurement information is displayed to the learner in the form of a measurement tool together with the physical phenomenon and shows error in response to the learner's mistake, something the conventional EBS is unable to do. In this paper, we propose an EBS learning exercise using a measurement tool in which the learners themselves must determine the measurement in order to confirm the correct answers. Using this method, it is possible for the learner to use trial and error after getting the wrong answer and eventually find the correct answer. It is also possible to support learning in a virtual experiment environment using a computer. Experiments were performed using a system equipped with the measurement tool, and it was verified that the learners made significant progress learning physics through trial and error.

Keywords: elementary physics education, error visualization, learning support system

1. Introduction

In elementary physics education, learners are often taught mechanical concepts related to phenomenon that they themselves have experienced. The learner thus grasps the concept together with the phenomenon. However, sometimes learners may understand the phenomenon but misunderstand the concept, such as erroneously thinking that force always acts in the direction of motion. It may be difficult for teachers to correct this mistaken understanding through mere verbal explanation during a traditional classroom lecture (Clement, 1982; Hirashima, Shinohara, Yamada, Hayashi & Horiguchi, 2017).

Therefore, it is more effective for learners to combine the learning of physics concepts with actual observation of physical phenomena through the use of experiments. It has been reported that generating simulated physical phenomena on a computer system based on physics problems solved by learners using error-based simulation (EBS) is an effective approach for making learners aware of their mistakes. In a study using a virtual experiment environment, learners learned about physics concepts by selecting a formula for obtaining a certain value and obtaining a value to be used for the formula.

A method was previously proposed for visualizing learners' mistakes by outputting the parameters of load and speed in addition to the observable phenomenon to learners who then attempted to identify the cause of the error based on criteria for error-visualization (CEV) of phenomena (Horiguchi & Hirashima, 2000; Horiguchi & Hirashima, 2001), and to aim at recognition of errors by

learners themselves, because there are difficult answers to visualize by using phenomena in learning using EBS. In this paper, we propose a learning support system in which EBS is combined with a measurement tool and learners use trial and error to determine the magnitude and direction of forces acting on an object. Specifically, the learner is asked to draw force vectors (arrows) for all the forces acting on the object and then observe whether the correct behavior is produced. In addition, learners can set a measurement tool and observe a parameter after inputting the forces using an EBS. This enables them to investigate the parameters displayed on the measurement tool in response to their own errors, to confirm the parameters related to their error as well as the correct parameters, and to grasp physics concepts by connecting these parameters with the simulated phenomena. The learning environment not only provides the environment for measurement tool operation, but also diagnoses learner's behavior and provides the learner with feedback to support the install to measurement tool, and aiming for error-reflection as with the EBS(Hirashima, Noda, Kashihara & Toyoda, 1995; Hirashima, Horiguchi, Kashihara & Toyoda, 1998). We also conducted a preliminary experiment using the proposed system and evaluated how effective it was in improving learning outcomes.

The remainder of this paper is organized as follows. Section 2 describes the EBS, Section 3 describes the use of the measurement tool, Section 4 describes the proposed system, Section 5 provides an evaluation of the experiment, and Section 6 summarizes the work and presents the conclusions.

2. Learning Elementary Physics through Error-Based Simulation

Imai et al. (2008) conducted a study on EBS in which the solution to a force equation was simulated by a drawing. In this EBS, the learner inputs a force, which then acts on the object as represented by an arrow. The system simulates the conditions corresponding to the force that the learner input, and provided there is no error, the correct phenomenon will be displayed. However, if there is an error, an unnatural phenomenon will be simulated instead. For example, in the case of forces acting on a stationary object on the floor (i.e., a downward gravitational force and an upward ground reaction force equal to the gravitational force), when the learner inputs only the downward gravitational force, as shown in Fig. 1 (a), a simulation of the object falling through the floor is generated, as shown in Fig. 1 (b). In this paper, we demonstrate that it is possible to use EBS with a measurement tool to teach the concepts of static systems to junior high school students, and that this system can be used by the students themselves to grasp the concept of Newton's third law of motion through trial and error and retain the acquired knowledge. This learning activity using EBS support the error-visualization important for problem solving, also makes it possible for discovery learning through behavior.

Shinohara et al. (2016) used EBS to conduct lessons on the concepts of motion, velocity, and acceleration and verified the effectiveness of the system in improving students' learning outcomes.

(a) Student's Incorrect Answer   *(b)* EBS's Output
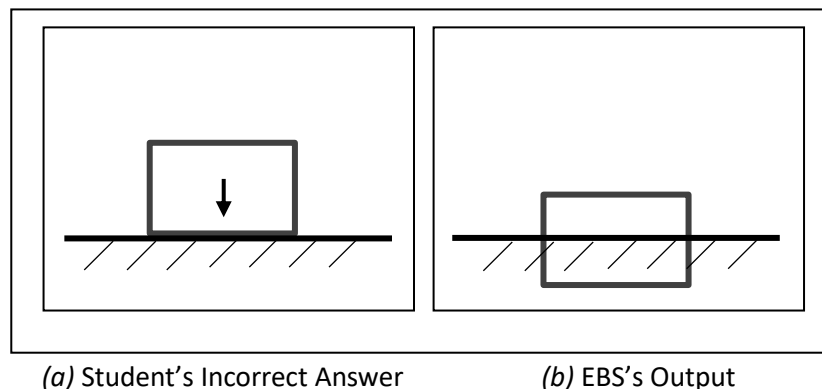
Figure 1. EBS System Concept

3. Use of a Measurement Tool to Indicate Parameters

In an EBS that simulates the behavior of an object in response to force, the simulation may show the correct answer even when the learner erroneously answers due to the resultant force being equal to the correct force when the object is at rest. In such cases, despite the solution seeming to be correct, the learner may still be able to notice their error by looking at the differences between the parameters they input and those of the correct answer.

Another technique has been proposed, in which the values of parameters such as speed and load are visualized using a measurement tool. The authors previously studied a learning support system designed to explore whether it is possible to visualize errors corresponding to learners' input. The system displays a measurement tool to visualize errors when parameters meeting certain conditions are input (Ueno, Tomoto, Horiguchi & Hirashima, 2018).

Figure 2 (a) shows an example of an erroneous answer from a learner who thought that a measurement tool showing the value of a load was an effective form of feedback. Figure 2 (b) shows output in the form of a measurement tool displaying the load. The size of the output parameter is decided based on the force vectors input by the learner and their size and magnitude relations. In the incorrect answer shown in Fig. 2 (a), there is no external force applied to the lower object from the upper object. Therefore, when weight measurement tools are installed, as shown in Fig. 2 (b), the measurement tool corresponding to the lower object displays the weight as being less than the correct value. The system determines what should be observed and provides the appropriate output.

(a) Erroneous Answer   *(b) Output from a Measurement Tool*
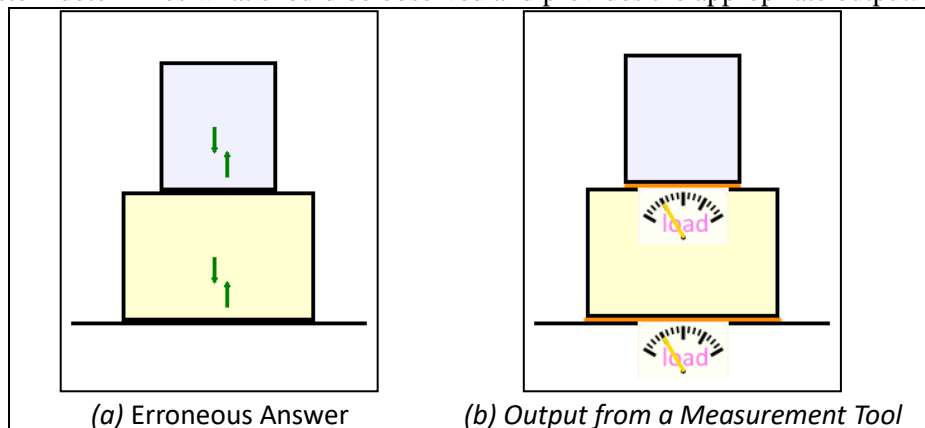
Figure 2. Example of Students' Answers and Output from a Measurement Tool

3.1 Criteria for Error-Visualization (CEV)

Horiguchi et al. (2001) use CEV to explain whether it is possible to understand the differences between correct and incorrect motions in an EBS. In CEV, the difference between the speed of the incorrect motion and that of the correct motion is calculated as "CEV 1" and the difference between the acceleration of the incorrect motion (first derivative of velocity) and that of the correct motion is calculated as "CEV 2". It is possible for a learner to notice an error when the visualization condition of either CEV 1 or CEV 2 is satisfied, although it is easier when only CEV 1 is satisfied than when only CEV 2 is satisfied. It is also easier to notice an error when both conditions are satisfied than when only one of the two is satisfied.

An example of a motion equation problem using EBS is shown in Fig. 3, and a part of the output generated from the equation shown in Fig. 3 at a specific numerical value is shown in Table 1.

In the simulation corresponding to Eq. (B), the block ascends the slope, which is obviously different from the correct behavior corresponding to Eq. (A). The correct and incorrect answers are positive and negative, respectively, and the values of velocity and acceleration satisfy both CEV 1 and CEV 2.

In the simulation corresponding to Eq. (C), the block descends the slope, which is the correct behavior, but the velocity of the block decreases when θ is increased. This behavior is the opposite of what should happen. If the learner recognizes that the block should move faster when the slope is steeper, it is effective for them to observe a condition in which a parameter, namely, inclination, is

changed. In this case, because only the acceleration of the block is different, the answer is incorrect and satisfies only CEV 2. Similarly, for the solution to Eq. (D), it is effective to generate and observe a simulation in which θ = 0 because the block is stationary under the correct conditions (velocity has a value of 0), but the conditions corresponding to Eq. (D) cause the block to move to the left (velocity is positive). In this case, Eq. (D) is an incorrect answer and satisfies both CEV 1 and CEV2 when θ = 0.

As in the above example of the equation of motion, Table 2 shows the conditions for visualizing the solution to the problem shown in Fig. 2 (a). The simulation of both correct answers and incorrect answers is stationary and there is no apparent difference, that is, the rate of change is 0. Such erroneous answers are examples of cases where it is not appropriate to give the learner feedback from a conventional physics EBS.
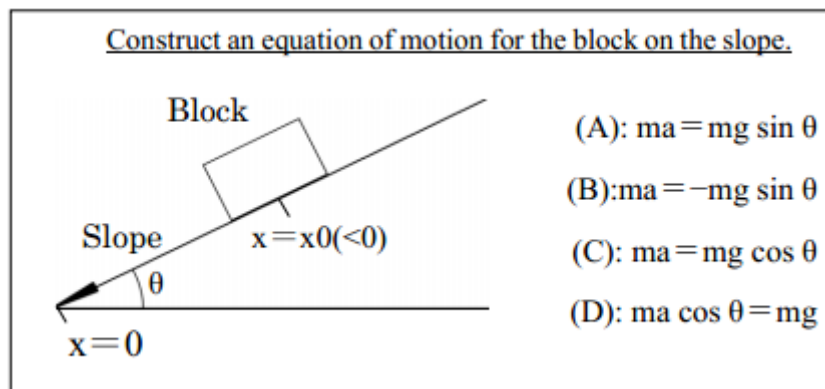
Figure 3. Example of Problem using Equation of Motion

Table 1

CEV Corresponding to the Equation of Motion

formula	Movement of the block (qualitative value)	Acceleration with increasing θ, $0 < θ < π/2$	Acceleration at θ = 0
(A)	down the slope (+)	Increasing (+)	a=0 (0)
(B)	up the slope (−)		
(C)	down the slope (+)	Decreasing (−)	
(D)	down the slope (+)	Increasing (+)	a=g (+)

Table 2

CEV Corresponding to Two Stationary Objects

Answer	Movement of the block (value)	Feedback state
correct answer	stop (0)	feedback not required
Fig 2. (b)	stop (0)	feedback fails to indicate an error

3.2 Measurement tool output that responds to learner s' answers

We previously proposed a method for visualizing errors by displaying the parameters of load and velocity in addition to simulating the behavior of an object based on answers input by the learner. We have shown that it is appropriate to display the measured parameters in cases in which both the solution shown in Fig. 2 (b) and the simulation of the correct behavior and the erroneous answer for a moving object move in the same direction.

Figure 4 shows the diagnostic flow diagram based on the example in Fig. 2.

In the case when the answer results in the measured parameter being displayed, output is presented only in the form of behavior as in the conventional EBS. Output, including the measurement tool, is shown only after the learner confirms that the answer is incorrect and that there is no difference between the simulation and the behavior.
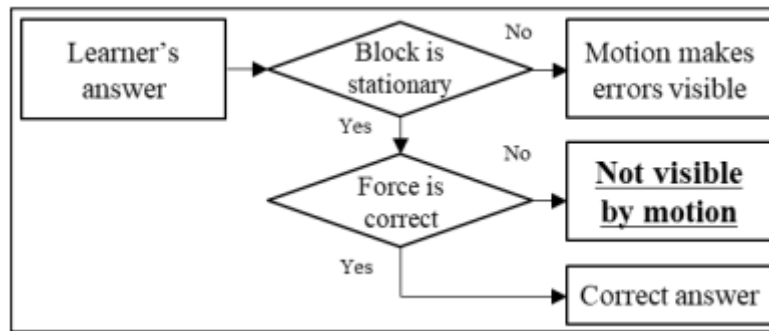
Figure 4. Classification of Learner's Answers in Two-Object Problems

4. Proposed System

In the previous study described in Section 3.2, the system outputs the parameters input by the learner, visualizing the errors with a measurement tool as feedback. In the method proposed in this paper, the measurement tool installation activity is directed as a method for noticing an error in the solution to the force equation through the learner's own trial and error. This is intended to lead the learner to discover the relationship between the force and the parameter's value displayed by the measurement tool and to understand the physics concept.

In the proposed method, the simulation is presented to the learner in the same way as the conventional physics EBS, and the force equation can be solved. After that, the learner installs the measurement tool for the simulation and the correct behavior corresponding to the answer input by the learner is output by the EBS, which confirms the parameters of load, speed, and acceleration applied to the behavior. The aim of these activities is for the learners themselves to use trial and error as they attempt to find the correct answer and decide whether to install the measurement tool.

In the support environment, in addition to the feedback by traditional EBS through behavior, it make feedback with measurement tool. Thereby, as in the case of the conventional EBS, it can be used as a supports the spontaneous discovery of an error for problem solving. This method enables learning effective for through behavior or parameter observations according to the situation. It can also be support the discover learning.

4.1 Virtual Experiment Environment to Support Learning by Designing Physical Experiments

In a previous study on the measurement tool installation problem, Tomoto et al. (2009) developed a virtual experiment environment for the proposed method in which a physics problem was devised. In this experiment, the learner was instructed to select a formula for obtaining a certain value and to obtain a value to be used for the formula from the measurement tool.

In this task, the behavior is presented in an experimental environment, and the value to be determined is specified. Next, a formula for obtaining the value is selected by the learner, and the value to be used in the formula is obtained from the measurement applied to the system's measurement tool. In this way, it is possible for the learner to learn how to apply an abstract formula they were taught to an actual system through a learning process in which the learner figures out the experimental method on their own.

4.2 Interface

The outline of the learning support system of the proposed method is shown using the example problem and the example error shown in Fig. 2. First, as shown in Fig. 5, the behavior is shown along with the problem sentence on the left screen, and the learner is instructed to answer the force equation by using

the arrow on the right screen. After inputting the answer, the force behavior corresponding to the input answer is generated and the feedback is output as in the conventional EBS. In this case, the behavior corresponding to the error in Fig. 2 (a) generates behavior that is the same as the correct one. After that, the screen moves to the measurement tool installation screen shown in Fig. 6 (a) and prompts the learner to install the measurement tool in order to see the measurements of the behavior as well as the force, as shown in Fig. 6 (c). The measurement tool is displayed for both the correct behavior shown on the left side of the screen and the behavior corresponding to the answer input by the learner, and the value is visualized as a parameter based on each force. In the example shown in Fig. 6 (b), the measurement tool indicating load is placed directly under both objects, and if the parameters of the load applied to the object below are confirmed, it can be confirmed that the parameters corresponding to the answer input by the learner, which is shown on the right side, are smaller than those of the load in the correct behavior, which is shown on the left side, and that the parameters of the load in the behavior corresponding to the answer input by the learner are the same.

After the learner confirms the output, including that from the measurement tool, if there is an error in their answer, the system diagnoses whether the value displayed by the measurement tool corresponds to the parameter that changed in response to the error and evaluation the measurement tool based on CEV. When an appropriate measurement tool that can visualize the errors is installed, the learners are encouraged to pay attention to the measurement tool by giving them feedback stating that a measurement tool displaying errors has been properly installed.
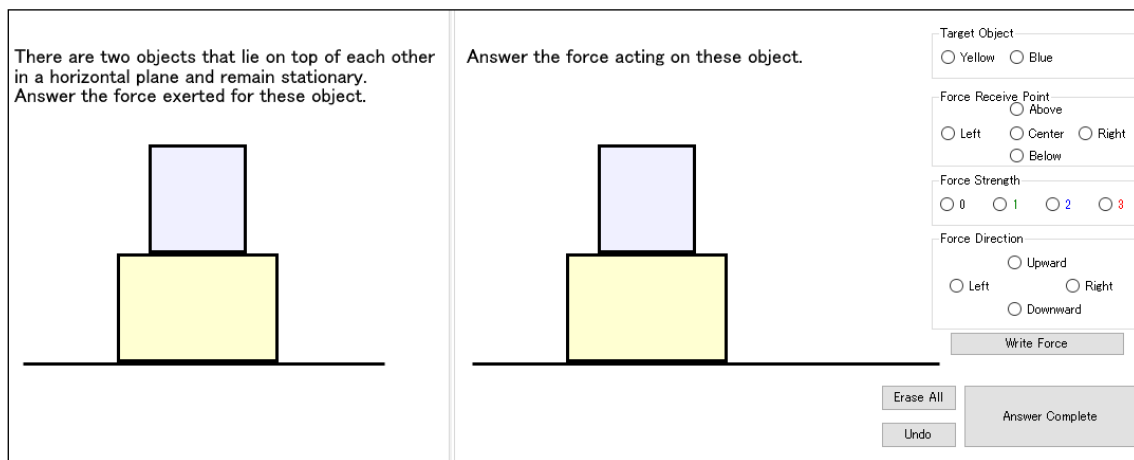
Figure 5. Force Answer Screen
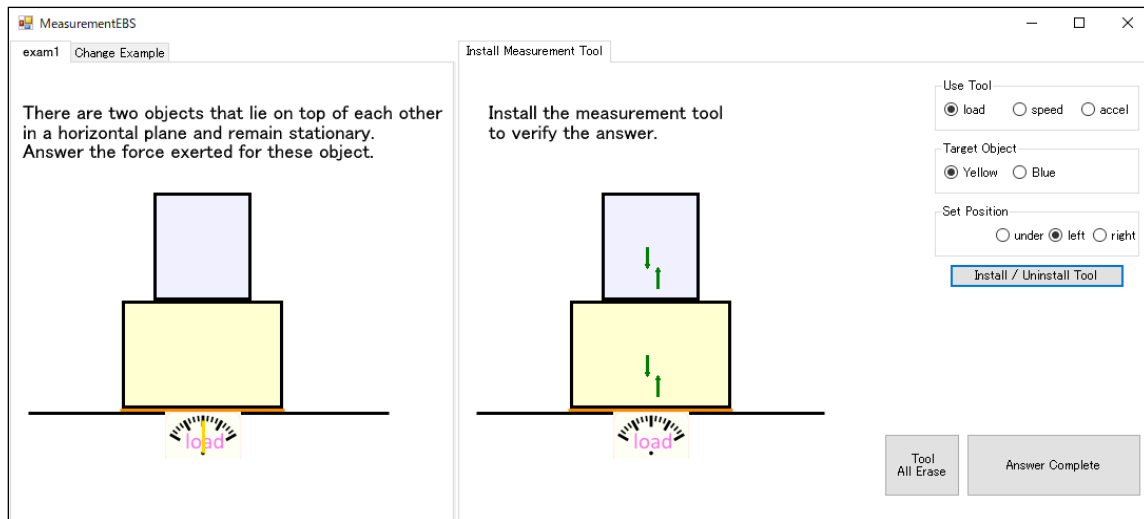
(a) Measurement Installation Screen
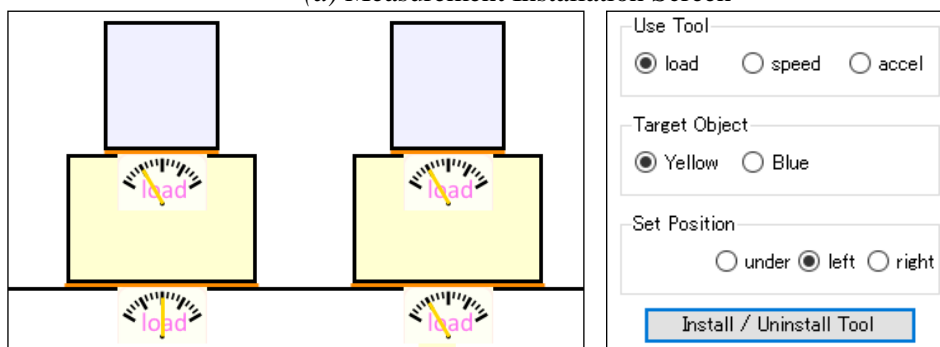
(b) Installed Measurement Tool   *(c)* Selection Screen

Figure 6. Install Tool Screen

5. Evaluation Experiment

5.1 Purpose

In order to investigate whether this system contributed to the learners' understanding of elementary physics, the following experiments were conducted and evaluated by comparing the conventional physics EBS system with the proposed system combining the conventional system with a measurement tool. The results and considerations will be described later.

5.2 Method

To confirm the effectiveness of the proposed system, a system which visualizes only the behavior of the object was used for comparison. Participants were seven university students who had taken physics courses related to engineering. Although this study focused on physics concepts that are taught to Japanese junior high school students, it is challenging even for university students to correctly understand these concepts. Before using the system, we explained the experimental procedure and the method of solving for force using arrows to the participants.

The experimental procedures comprised a pre-test (30 minutes), independent learning using the proposed system (20 minutes), and a post-test (45 minutes). The participants were given a questionnaire at the end of the experiment. The participants were divided into two groups. During the independent learning exercise, Group A performed the measurement tool installation task while using the EBS system whereas group B used only the conventional EBS system and did not perform the measurement tool installation task. The pre-test and post-test were the same format test in 30 minutes, each asking one question about the learning support system and four questions about problems involving the stationary or moving object that the participants manipulated, scored one point per one correct answer. In the

post-test, in addition to the content of the pre-test, a task to make the learner explain the content of the error based on the incorrect answer was performed in 15 minutes.

5.3 Results

Table 3 shows the mean scores of the pre-test and post-test groups at same format test. The mean pre-test score was 3.7 in group A and 3.3 in group B, and the mean post-test score was 6.7 in group A and 5.0 in group B. The scores of both Group A and Group B improved between the pre- and post-test but Group A showed a greater improvement than Group B. It was also shown that the scores of both groups similarly improved between the pre- and post-test when the problem of motion system was divided and compared; here also, Group A showed a greater improvement than Group B.

Table 3

Mean Scores for Group A and Group B

	Group A			Group B		
	pre-	post-	difference	pre-	post-	difference
Mean score	3.7	6.7	3.0	3.3	5.0	1.7
(stationary object)	3.0	4.0	1.0	2.3	2.7	0.4
(moving object)	0.7	2.7	2.0	1.0	2.3	1.3

Examples of explanations for the causes of errors that were given by participants in a post hoc test are shown in Table 4. The subjects in both groups were able to explain the error appropriately in the most test, characteristics of each explanation are shown below. Students in Group B group used the conventional EBS, referring only to force and behavior, to answer the problems, as shown in explanations (4), (5), and (6), indicating that the learning exercise using the conventional physics EBS was effective. On the other hand, the students in Group A who installed the measurement tool identified errors by referring to the mechanical concept of the measurement tool, as shown in explanations (1), (2), and (3). In Group A, 3 out of the 4 participants answered the questions while referring to the parameter of load. In contrast, 0 participants in Group B did so, suggesting that the value displayed by the measurement tool could be understood by relating the input force with the resulting behavior using the proposed method in which the measurement tool was installed. In addition, as shown in explanations (2) and (3), the participants in Group A described what happened based on trial and error, suggesting that trial and error after installing the measurement tool contributed to the nature of their explanations.

Table 4

Example Explanations for the Causes of Errors

Number	Group	Explanation
(1)	A	The object does not move but has no weight, exerting no force on the floor.
(2)	A	When the measurement tool is placed to the right of each object, the indicated parameter becomes 0.
(3)	A	The acceleration of an object increases gradually when the acceleration is measured
(4)	B	Stationary but insufficient force to push object A against object B.
(5)	B	Stationary but lacking the force to push the object as well as the force the wall would use to push back against the object.
(6)	B	The force of a body in uniform motion must be balanced.

6. Summary

As a method for improving the understanding of students learning elementary physics, a learning technique including installation of a measurement tool was proposed. Through trial and error, students attempt to correct their mistakes on their own. Experiments were conducted to verify the effectiveness of the proposed system and the results suggest that the proposed method might increase understanding in learners. In addition, by having students install the measurement tool by themselves, they were given the opportunity to find solutions through trial and error.

The findings are summarized as follows:
- It was suggested that a system in which a measurement tool is installed by the learners themselves while engaged in the learning exercise may encourage the learners to search for solutions using trial and error. This is expected to not only teach the concepts of elementary physics but also the value of trial and error.
- In the description test, students wrote descriptions of their experience with the learning system, providing explanations for the causes of their errors. There were clear differences in the descriptions depending on the system used.

Additional experiments will be conducted in the future in which learners will be given predetermined errors that they must correct by using the measurement tool.

Acknowledgements

References

Clement, J. (1982). Students' preconceptions introductory mechanics. *American Journal of Physics*, 50(1), 66-71.

Hirashima, T., Shinohara, T., Yamada, A., Hayashi, Y., and Horiguchi, T. (2017). Effects of Error-Based Simulation as a Counterexample for Correcting MIF Misconception. *Proceedings of 18th International Conference on Artificial Intelligence in Education (AIED2017)*, 90-101.

Horiguchi, T., and Hirashima, T. (2000). A Method of Creating Counterexamples by Using Error-Based Simulation. *Proceedings of International Conference on Computers in Education (ICCE2000)*, 619-628.

Horiguchi, T., and Hirashima, T. (2001). Simulation-Based Learning Environment for Assisting Error-Awareness: Management of Error-Based Simulation Considering the Expressiveness and Effectiveness. *Transactions of Japanese Society for Information and Systems in Education*, 18(3), 364-376. (in Japanese)

Hirashima, T., Noda, H., Kashihara, A. and Toyoda, J. (1995). A Simulation for Error-Reflection. *Proc. of ED-MEDIA*, 95, 336-341.

Hirashima, T., Horiguchi, T., Kashihara, A. and Toyoda, J. (1998). Error-based simulation for error-visualization and its management. *International Journal of Artificial Intelligence in Education*, 9, 17-31.

Imai, I., Tomoto, T, Horiguchi, T., & Hirashima, T. (2008). A classroom practice of error-based simulation to improve pupils' understanding of mechanics: the "challenge to Newton!" project. *Transactions of Japanese Society for Information and Systems in Education*, 25(2), 194-203. (in Japanese)

Shinohara, T., Imai, I., Tomoto, T., Horiguchi, T., Yamada, A., Yamamoto, S., Hayashi, Y., and Hirashima, T. (2016). Experimental Use of Error-based Simulation for Force on Moving Object in Science Class at Junior High School. *Journal of the Institute of Electronics, Information and Communication Engineers*, J99-D(4), 439-451, (in Japanese)

Ueno, U., Tomoto, T., Horiguchi, T., and Hirashima, T. (2018). Development and Evaluation of a Learning Support System with Error-Based Simulation by means of Speed and Weight Measurement in Physics Expressions. *Proceedings of SIG on Advanced Learning Science and Technology*, 82, 73-78

Tomoto, T., Horiguchi, T., Hirashima, T., and Takeuchi, A. (2009). Virtual Experimental Environment to Support Learning by Physical Experiment Designing. *The Journal of Information and Systems in Education (Translation of Awarded Paper)*, 8(1), 72-83

Design Robot-Programming Activities to Engage students in the Computational Problem Solving Process

Chun-Ping Wu[a]*, Jia-jyun Chen[b] & Shih-chung Li[b]
[a]*Department of Education, National University of Tainan, Taiwan*
[b]*Department of Educational Technology, TamKang University, Taiwan*
*cpwu303@gmail.com

Abstract: This study aims to design a series of robot programming learning activities to engage learners in the computational problem-solving process. The activities were designed based on the strategy of problem-based learning. To reduce any extraneous cognitive load suggested by prior research, the worked-out examples were developed and provided. Additionally, the strategy of concept-mapping was used in three different ways to facilitate students' learning. A pre-and-post quasi-experiment was conducted to explore the effects of the concept-mapping strategy. In total of 75 5th graders from three classes participated in this study for two weeks and the classes were randomly assigned to one of the three intervention conditions. The ANCOVA result supported the significant effect of gender interacting with the intervention on learners' perceived meaningfulness of programming. Implication for future studies were provided.

Keywords: Computational problem-solving, concept-maps, robot programming

1. Introduction

Computational thinking competency is critical. Individual has to develop computational thinking, making use of information technology to support deep learning, to put creative ideas into practice and to construct schema in order to solve various types of problems encountered in daily life and career. Programming education is critical to develop computational thinking because programming language is the tool we use to communicate with information technology and put our thinking into practice. Rather than focusing on "coding", learning specific languages, programming education should facilitate learners in analyzing important problems, proposing solutions and designing the commands for the technology to execute in order to test the proposed solutions (Duncan & Bell, 2014). Therefore, programming education emphasizes making use of syntactic knowledge, conceptual knowledge and strategic knowledge (Bayman & Mayer, 1988) to solve problems. Prior empirical studies supported that the problem-based learning strategy (name PBL, here-after) engaged students in practicing problem-solving, leading to schema construction (Hmelo & Evensen, 2000). Therefore, this study aimed to develop a series of robot-programming learning activities, which are based the problem-based learning strategy, to engage student in computational problem-solving process.

2. Literature review

The PBL centers on the real-world problems, which learners may encounter outside school settings (Hmelo & Evensen, 2000). During the learning process, learners may have the opportunity to play with the given problems and try to apply the newly learned contents to solve the problems. Meanwhile they may observe how to put the learned concepts into practice, which may further enhance their motivation (van Merriënboer, 2007; van Merriënboer & Kester, 2007; van Merriënboer, Kirschner, & Kester, 2003). Similarly, learners, while engaged in PBL activity, are given the opportunity to learn how to make use of programming knowledge to solve computational problems. Furthermore, PBL emphasizes the process of problems-solving and creating solutions. Learners may learn to know "what, why, how

and when to use the learned concepts". This process does not only enable learners to master the learned contents, but also help them to far transfer knowledge into solving more complex problems in the future. More importantly, PBL engages learners in creating solutions. Learners, while engaged in playing with computational problems, may become technology creator, experiencing their technology empowerment during the problem-solving process and observing the meaningfulness of learning with technology.

However, the prior research studies indicated that novice learners, while interacting with the ill-structured problems, usually pay too much attention to the details of the problems, ignoring the important concepts associated with the problem (Corbalan, Kester, & van Merriënboer, 2009). This study designed a series of robot programming learning activities for the elementary school students. Robot programming is new to majority of them. To reduce any extraneous cognitive loads resulted from the activities, worked-out examples were developed in this study to help learners concentrate on critical information. Specifically the worked-out examples included critical reasoning points to approach and observe the problems and diverse aspects to think of solutions.

To enhance learners' interaction with the learned contents, the concept-mapping strategy was also proposed to guide learners to think of important concepts associated with the given problems. According to the cognitive load theory, the instructional strategy may also result in germane cognitive loads. Learners may benefit from the instructional strategy only when the cognitive load brought by the learning activity does not exceed their cognitive capacity (Sweller, 1988). In this study, the intrinsic cognitive load the learners experience may similar and the work-out example may reduce extraneous cognitive load. This study would test whether different ways to use the concept-mapping strategy may result in different levels of germane cognitive loads, which further influence the learners' learning from the computational problem-solving activities. Specifically, the concept map is used either as a presentation tool or as a knowledge representation tool. When it is used as a presentation tool by the instructor, the learners could clearly visualize the important concepts and the knowledge structure. When it is used by learners as knowledge representation tool, learners could recall important ideas or concepts they identified during the learning process. However, novice learners, when they approach a new problem, may experience higher cognitive loads in identifying the concepts and knowledge structure. Therefore, this study proposed another approach, incomplete concept-mapping with some concepts identified in the map, which may reduce the germane cognitive load to avoid exceeding cognitive capacity.

To sum up, this study developed a series of robot programming learning activities and the effect of the concept mapping was explored taking into account of gender difference.

3. Method

3.1 Participants

75 5th grade students from three classes at one elementary school in Taiwan were volunteered to participate in this study. All the participating students have parents' consent forms.

3.2 Research Design

This study included two stages. First, the course, including six units of robot programming learning, was developed using the ADDIE approach. Each unit started with one problem and students worked through the problems in a team of two persons. A learning system were developed to provide worked-out examples to assist students in the problem-solving process. Additionally, the strategy of concept-mapping was used in three different ways (i.e. the teacher used the concept maps as advanced organizer and summary tools; the students listed and map the concepts by themselves from the blank paper, and the students filled in critical concepts in the given concept-map). The lessons plans, learning systems and concept-maps were reviewed by four experts, two professors in the research area of instructional technology and two elementary school teachers who taught kids programming.

Second, a pre-and-post quasi-experimental research was conducted to examine the effects of the scaffolds. Specifically, this study developed three interventions according to the above-mentioned three different ways to use the concept-mapping strategy. The three participating classes were randomly

assigned to one of the interventions. All the participants were taught by the same teachers, using the same learning contents, activities, and learning systems. Due to the time restriction of the participating school, the course was conducted only for two weeks. One week before the course started, the pre-test, including the pre-assessment and perceived problem-solving inventory was implemented. The post-test, including the post-assessment and perceived meaningfulness of programming, was conducted at the end of the study.

3.3 Instrument

To collect participants' performance in the robot programming, two measurements were developed by the first author. The pre-assessment, including 10 multiple-choice questions, measured participants' knowledge of SCRATCH. The averaged difficulty of the pre-assessment is 0.52 while the averaged item discrimination is 0.65. The post-test, including 10 multiple-choice questions, was developed to measure participants' learning in the robot programming after this study. The averaged difficulty of the pre-assessment is 0.6 while the averaged item discrimination is 0.6.

Additionally, since students' perceived problem-solving may also influence their participation in the problem solving activities, this variable was measured by the Problem-solving inventory developed by Heppner and Petersen (1982). The authors translated the measurement into Mandarin and the translated instrument was reviewed by three experts. This instrument was pilot- tested by 85 6th grader students. The inventory include 32 items using 6 point likert scale. The higher score indicates more positive attitude and behavior toward the problem-solving process (Heppner & Petersen, 1982). The reliability reported in this study is .87. Last, participants' perceived meaningfulness of programming was measured at the end of the study using the instrument developed by Kong, Chiu, and Lai (2018). The instrument, measuring meaningfulness of programming, included 4 items, originally using 5 point likert scale. The higher score indicates more positive attitude toward the meaningfulness and value of learning programming (Kong, Chiu, Lai, 2018). The authors translated the measurement into Mandarin and modified into 6 point likert scale. The translated and modified instrument was reviewed by three experts. This instrument were pilot tested by 85 6th grader students. The reliability reported in this study is .95.

4. Results and Conclusion

4.1 Participants Design of the Learning Activities and the Scaffolds

Six units of robot programming were developed and the learning system named "Persistent" was developed by the first author. Unit1 started with a video, demonstrating application of programming in the daily life and explaining why programming is important. Then learners was presented a video demonstrating what mBOT (the robot) could accomplish. The learners were guided to break the accomplishment into smaller tasks and to think of how they could help mBOT to accomplish the tasks. In Unit 2, the learners were asked to build up the mBOT. The learners observed the mBOT and tried to put the components together. They were directed to the learning system to observe the scaffolds if they need help (See Figure1). Before moving to Unit3, the learners observed the video that was presented in Unit1 and wrote down the tasks of mBOT again. In Unit 3~5, they learn how to program the mBOT to accomplish the tasks written by themselves. Learners would work with more complex tasks if they accomplish the above-mentioned tasks. In each unit, they could access the scaffolds if they need help. In Unit 6, the learners need to create one story using two mBOTs as main characters and program the mBOT to accomplish their designed tasks in the stage.

Figure 1. Scaffolds Provided in Unit2.

443

This study developed two kinds of scaffolds. First, the worked-out examples were presented in the system. The purposes of the examples are to guide learners to observe the problems from different perspectives, to provide hints for analyzing problems, to provide hints for proposing solutions, to provide hints for bugs-fixing and so on. All participating learners were allowed to access the learning system any time during the course. Second, the research team identified the concepts associated with the problems embedded in each learning activity and presented the concepts in the format of concept-maps. In intervention condition 1, the teacher used these maps as advanced organizers. In intervention condition 2, the learners identified important concepts and created their own concept maps to demonstrate the relationships among concepts. In intervention condition 3, the learners were given the incomplete concept maps and they need to fill in the concepts. Please refer Figure 2 for the example of the concept map used in intervention 3.
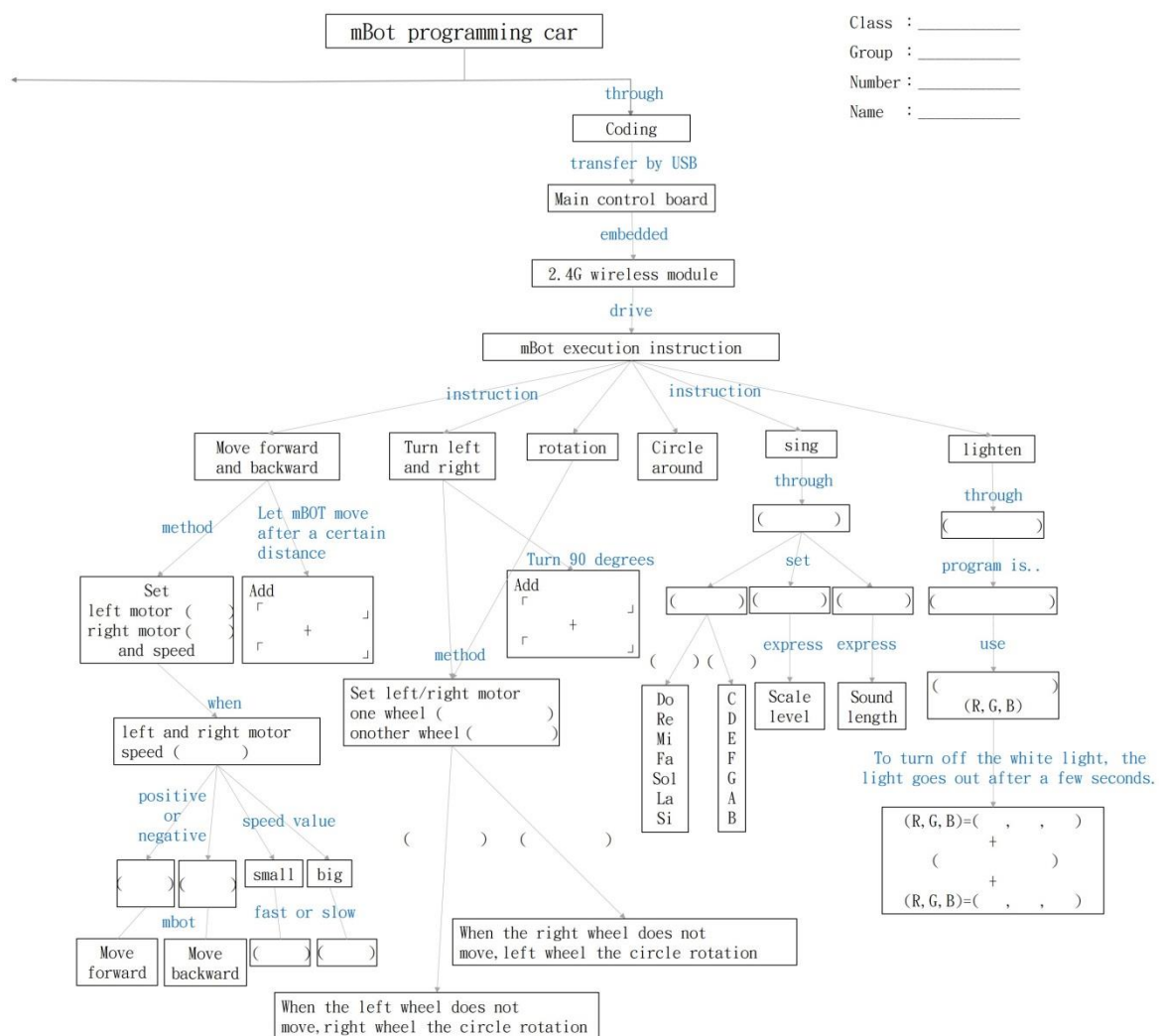
Figure 2. Example of the Concept Map Used in Intervention 3.

4.2 The Effects of the Learning Activities

The descriptive statistics of the four examined variables, including pre-assessment, post-assessment, perceived problem-solving and perceived meaningfulness of programming, are presented in Table 1. As observed, boys scored a little bit higher than girls in all variables. Further analyses, taking into consideration of gender, were conducted.

Table 1

Descriptive Statistics

		Intervention 1 (N=26; b=15/g=11)		Intervention 2 (N=23; b=12/g=11)		Intervention 3 (N=26; b=15/g=11)	
		Mean	SD	Mean	SD	Mean	SD
Pre-assessment	Boy	5.53	2.72	5.83	2.44	5.53	2.72
	Girl	4.09	2.77	4.54	2.29	4.09	2.77
	Total	4.92	2.78	5.21	2.41	5.50	2.51
Post-assessment	Boy	6.60	2.38	6.58	2.50	6.60	2.38
	Girl	6.09	1.57	4.81	1.66	6.09	1.57
	Total	6.38	2.06	5.73	2.28	5.84	2.79
Perceived problem-solving	Boy	4.36	0.78	4.23	0.92	4.36	0.78
	Girl	3.83	0.53	3.96	0.71	3.83	0.53
	Total	4.14	0.72	4.11	0.82	4.31	0.69
Meaningfulness	Boy	5.65	0.57	5.02	1.53	5.65	0.57
	Girl	3.77	1.94	4.65	1.65	3.77	1.94
	Total	4.85	1.60	4.84	1.56	5.05	0.98

First, using the ANCOVA to control the effects of the pre-assessment, the effect of gender interacting with the intervention on students' programming performance in the post-assessment was not supported (F=1.08, *p=.35).* Second, the scores of perceived problem-solving is significantly correlated with scores of perceived meaningfulness of programming (r=.59, *p<.001).* The ANCOVA used the scores of perceived problem-solving as the covariate. The result show that the effect of gender interacting with the intervention on students' perceived meaningfulness of programming reached statistically significance (F=3.17, *p=.05).* The interaction effect was furtherly presented in Figure3. While controlling the effect of perceived problem-solving, the boys perceived programming activities more meaningful than girls especially in the group while the teacher taught the programming using concept maps as an advanced organizer. Instead, girls, while they were asked to fill in the incomplete concept maps, perceived programming activities a little more meaningful than boys
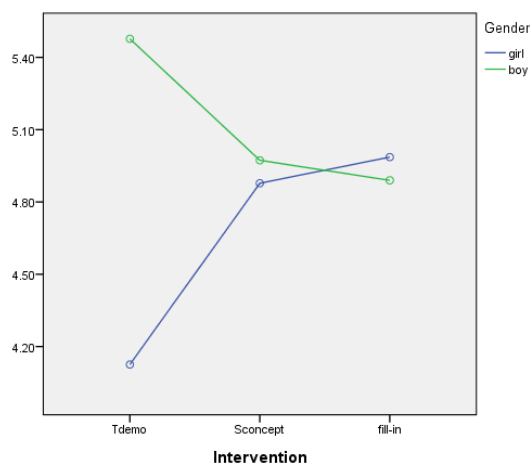
Figure 3. The Intervention-gender Interaction Plot with the Dependent Variable of Meaningfulness

4.3 Conclusion

This study concluded that gender interacting with the intervention significantly influenced learners' perceived meaningfulness of programming. However, such an effect on learners' programming performance was not supported. The study limited to only two-week implementation. Although the participants were engaged in six runs of problem-solving, elementary school students still need to be persistently engaged in the problem-solving process. Future research is suggested to extend the length

of experiment and explore the impact of scaffolds on learners' change of perceived problem-solving and performance in solving computational problems. Furthermore, as PBL emphasizes collaborative learning, future research is suggested to explore whether the composition of teams or learners' attitudes toward collaboration may moderate the above-mentioned effects.

Acknowledgements

References

Bayman, P., & Mayer, R. E. (1988). Using conceptual models to teach BASIC computer programming. Journal of Educational Psychology, 80, 3, 291–298.

Corbalan, G., Kester, L., & Van Merriënboer, J. J. G. (2009). Combining shared control with variability over surface features: Effects on transfer test performance and task involvement. *Computers in Human Behavior, 25*, 290–298.

Duncan, C., & Bell, T. (2015, November). A pilot computer science and programming course for primary school students. In Proceedings of *the workshop in primary and secondary computing education* (pp. 39-48). ACM

Heppner, P. P., & Petersen, C. H. (1982). The development and implications of a personal problem-solving inventory. *Journal of counseling psychology, 29(1)*, 66.

Hmelo, C. E., & Evensen, D. H. (2000). Introduction. Problem-based learning: Gaining insights on learning interactions through multiple methods of inquiry. In D. H. Evensen & C. E. Hmelo (Eds.), *Problem-based learning: A research perspective on learning interactions*. Mahwah: Lawrence Erlbaum Associates Publishers.

Kong, S. C., Chiu, M. M., & Lai, M. (2018). A study of primary school students' interest, collaboration attitude, and programming empowerment in computational thinking education. *Computers & Education, 127*, 178-189.

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science, 12* (2), 257-285.

Van Merriënboer, J. J. G. (2007). Alternate models of instructional design: Holistic design approaches and complex learning. In R. A. Reiser, & J. V. Dempsey (Eds.), *Trends and issues in instructional design and technology* (pp. 72–81). Upper Saddle River, NJ: Pearson/Merrill Prentice Hall.

Van Merriënboer, J. J. G., Kirschner, P. A., & Kester, L. (2003). Taking the load of a learners' mind: Instructional design for complex learning. *Educational Psychologist, 38*, 5–13.

Van Merriënboer, J. J. G., & Kester, L. (2007). Whole-task models in education. In J. M. Spector, M. D. Merrill, J. J. G. van Merriënboer, & M. P. Driscoll (Eds.), *Handbook of research on educational communications and technology*, (pp. 441–456, 3rd ed.). Mahwah, NJ: Erlbaum/Routledge.

WORKSHOP 13 - Design for Choreographies/Ambiance for Global Agile Learning to Foster Future Skills

Design for choreographies/ambiance for global AGILE learning to foster future skills

Tosh YAMAMOTO[a*], Juling SHIH[b] , Benson ONG[c] , Chris PANG[d] , Hui-Chun CHU[e] , Takuro OZAKI[f] , & Yasuhiro HAYASHI[g]
[a]*Center for Teaching and Learning, Kansai University, Japan*
[b]*Dept. of Information and Learning Technology, NUTN, Taiwan*
[c]*Dept. of Business Management, NYP, Singapore*
[d]*Dept. of Business Management, NYP, Singapore*
[e]*Dept. of Computer Science and Information Management, Soochow University, Taiwan*
[f]*IT Center, Osaka Educational University, Japan*
[g]*Dept. of Data Science, Musashino University, Japan*
*ctltosh@kansai-u.ac.jp

Abstract: This workshop will bring the audience to the agile paradigm of learning targeting new at the future generation equipped with the future skills defined by Vision 2020, Horizon 2020 and IFTF. In order to promote the future mindset for education, Critical/Creative Thinking Skills with Tesseractive© mindset will be fully employed during the workshop. Thus, instead of the workshop for dissemination of a new concept or idea for dissemination into academia, this session will bring the participants to a new paradigm of learning ambiance, where actively engaged learners from various countries form global agile teams to conduct PBL in their self-defined projects. The style of the workshop follows the discussion style in the agile framework with combination of hands-on and heads-on sessions with BYOD, i.e., smart phones, pads, and PCs. The participants are encouraged to bring their own devices to jump into the global and agile learning environment.

Keywords: AGILE Learning, Future Skills, critical thinking, creative thinking, Tesseractive© Learning, global PBL, BYOD

1. Introduction

1.1 Rationale

The Oxford University predicts that the 47% of the work will be replaced by AI or robots at the time of singularity in 2045, which is only 26 years from now. As defined by IFTF, the mission of the future design of education is to make students survive and succeed even after the singularity. The 21st Century Skills are defined as the skills composed of Critical thinking, Technology literacy, Creativity, Flexibility, Collaboration, Leadership, Communication, Initiative, Information literacy, Productivity, Media literacy, Social skills with the global mindset. This workshop is the sense-making of the 21st Century Skills to the future curriculum. The goal is to share with the participants the future design of the curriculum incorporating the above mentioned 21st century skills in order for the students to survive even after the singularity.

1.2 Goals

This workshop will walk the participants through the steps to set up a global AGILE learning curriculum for their on-campus students without leaving their own campuses to conduct project-based learning with global team members. In order to foster team-building with empathy and trust, brainstorming, actively engaged discussions for consensus building, the team project management, collaborative learning activities, working on the global team project on the same page throughout the

course, as well as generating the final team report accompanied by the presentation in the virtual learning environment, robust cloud-based learning tools will be introduced with demonstrations.

The enthusiastic participants are encouraged to bring their own mobile devices to get involved in the hands-on and heads-on workshop.

2. Workshop Program

The workshop is organized in the following manner.

2.1 Introduction (By Tosh Yamamoto & Carol H.C. Chu)

2.1.1 Sessions:

- (Heads-on Session) Overview of Online Collaborative Learning
  General Concepts of Global AGILE learning in the realm of Global Liberal Arts
  All members in the team as well as in the course are on the same page of their projects (24/7)!
- (Hands-on Session) Crafting the learning environment to foster the learning environment harnessed with Learning Tools

2.1.2 Summary

With the rationale and the goals of the workshop described above, general concepts of Global AGILE learning in the realm of Global Liberal Arts are elaborated. In such learning environment, everyone must be on the same page 24/7 as the project progresses, including the visualization of the entire process of the progress with the bird's eye view. Learning tools to foster such PBL in global teams are introduced in the hands-on session.

2.2 Course Design (By Tosh Yamamoto, Juling Shih & Chris Pang)

2.2.1 Sessions:

- (Heads-on Session) Course Syllabus e-syllabus (concept)
  Syllabus Preparation to Course Operation – Task-based TBL
- (Hands-on Session) Planning on the course operation

2.2.2 Summary

Having the mission and its associated visions of the institution in mind in the process of the curriculum design, courses are laid out based on the meta-level syllabus and learning modules. Each learning module is composed of: Explanation of the learning module, Objective, Ideal number of learners in a team, Duration of learning, Steps in learning and the associated objectives, Material needed to conduct a good session, How to conduct the Steps in learning, Strategy and Tips, Complementary learning activities, Source, and other pertinent information. In here, designing the meta syllabus with Tesseractive© mindset is the key. The learning modules make full use of visual organizer tools and "gamestorming" toolkit.

2.3 Course Operation (By Tosh Yamamoto, Takuro Ozaki & Benson Ong)

2.3.1 Sessions:

- (Heads-on Session) Course Operation
  Course Operation – Task-based TBL in action
- (Hands-on Session) Implementing the above in the course

FlipGrid®, Padlet®, Trello®, Asana®
NOTE: No legacy LMS technologies will be employed in this framework.

2.3.2 Summary

The course is designed so that all learners and instructors on global campuses can be "on the same page" of learning, 24/7, throughout the course operation. Furthermore, in order to guarantee the concept of "on the same page" of learning, all activities are archived on a single page for view. In this way, learners can view their own progress of learning as well as their teammates' progresses of learning at the same time. In other words, this learning design for choreographies/ambiance for global AGILE learning will foster the future skills defined in this workshop.

2.4 Assessment Strategies (By Chris Pang, Tosh Yamamoto & Maki Okunuki)

2.4.1 Sessions:

- (Heads-on Session) Assessment Concepts in such learning
  MGT Model, Big Data approach to assessment such as NMF, and Learning Analytics
- (Hands-on Session) Designing Assessment Strategies with FINCODA and etc.

2.4.2 Summary

While the traditional evaluation is based on results of learning such as testing, the assessment in this workshop is based on the process of learning from the beginning to the end of a course. Thus, innovative assessment strategies are employed. In the workshop, prominent assessment strategies are shared with participants.

MGT or M-GTA(Modified Grounded Theory Approach) is a text-mining strategy to assess learning, which was originally proposed by Barney Glaser and Anselm Strauss, as a qualitative analysis for grounded-on-data. MGT is a useful for the qualitative assessment for PBL of the social fundamental skills targeting the students of the liberal arts majors. Based on the theory that the major conceptual components are buried in the written data and further, that such conceptual components are minable through a certain procedure, M-GTA takes the following steps for analysis.

(1) Analyzing the written data such as reflective writing and the survey by interviewing.
(2) Creating concepts by considering and interpreting meanings of data and categories of several concepts closely linked.
(3) Analyzing relevance among conceptual components.
(4) Mapping the all conceptual components on a sheet for the holistic view.
(5) Visualizing the learning process and effect of PBL.

NMF (Non-negative Matrix Factorization) is a method of text mining by extracting key attributes/cues of learners in the learning process. The basic idea is composed of the fact that the choice of words in writing crucially vary in the course of learning, that what is not in mind will not appear in words in reflective writing, and the observation that peculiar characteristics may appear when the learner shift to a higher strata of learning.

FINCODA, i.e., Innovation Competence Assessment, is another qualitative assessment tool. In an age of disruptive changes, innovation, as a critical determinant of company competitiveness, underpins the dynamic capacity to create sustainable future growth. FINCODA, the Framework for Innovation Competencies Development and Assessment, was developed in response to this increased competitive pressure organization now face (Peñalver et al., 2018). Progressive organizations recognize that their innovations are a result of their employees. As such, it is important to be able to assess the innovative performance of individuals and teams in such organizations. Similarly, institutions of higher learning can benefit from the ability to assess the development of innovative competence of students.

The FINCODA Innovation Barometer Assessment Tool is a psychometric tool that measures individuals' capacity for innovation. It is an online scale that measures innovation competence for individuals, groups and entire companies. It provides both individual and group developmental reports with five dimensions of innovation competence namely:

1) Creativity: The ability to think beyond tradition to generate or adapt meaningful alternatives.

2) Critical Thinking: The ability to deconstruct and analyze ideas.
3) Initiative: The ability to make decision or carry out actions to operationalize ideas as well as mobilize and manage an implementation team.
4) Teamwork: The ability to work efficiently in a group.
5) Networking: The ability to involve internal/external stakeholders.

The FINCODA project is led by Turku University of Applied Sciences, Finland, and comprised of a consortium of universities and businesses. The development was funded by the EU.

The workshop will go over the basic concepts of the assessment strategies and the participants will go through the FINCODA Assessment.

2.5 Workshop Format

The workshop is composed of (i) a heads-on session for brainstorming among participants, and (ii) the associated hands-on session to foster learning experience of the participants, who will conduct their active learning through team-based PBL in AGILE manner.

The entire workshop is organized with experts in the field of global PBL instructors including the following components:

- Rationale behind global PBL & Essence of ICT-enhanced Learning Environment
- Hands-on/Heads-on Sessions on cloud-based services such as FlipGrid®, Padlet®, Trello®, Google® and so forth.
- Integration of various approaches: consensus building though team-based PBL

3. Workshop Organizers

This section deals with the introduction of the organizers for the workshop. In what follows, names, affiliations, and short biographies of the workshop organizers are listed in order.

3.1 Organizers

A. Dr. Tosh Yamamoto, CTL, Kansai University, Japan

Tosh Yamamoto is a professor at Center for Teaching and Learning at Kansai University in Japan, who has been active in disseminating Tesseractive and AGILE Learning in the global context in the social constructive paradigm. He is also collaborating with the organizers of the workshop here to promote STEM/STEAM enriched with gamification features.

B. Dr. Juling Shih, Dept. of Information and Learning Technology, NUTN, Taiwan

Professor Juling Shih is a professor in Department of Computer Science and Media Technology at National University of Tainan in Taiwan, who is specialized in designing and operating gamification-enhanced STEAM for K-12. She has been active promoting computational mindset to school children through the great Voyage Project. She has been collaborating with Tosh Yamamoto at Kansai University in designing active learning COIL courses to foster global mindset to raise future generation.

C. Professor Benson Ong, Dept. of Business Management, NYP, Singapore

Professor Benson Ong is a professor in Department of Business Management at Nanyang Polytechnic University in Singapore, who is specialized in designing and operating social entrepreneurship courses. He has been collaborating with Tosh Yamamoto at Kansai University in designing social entrepreneurship COIL courses in the realm of SDGs to foster global mindset.

D. Professor Chris Pang, Dept. of Business Management, NYP, Singapore

Professor Chris Pang is a professor in Department of Business Management at Nanyang Polytechnic University in Singapore, who is specialized in designing and planning social entrepreneurship mindset to students as well as societal members. He has been collaborating with Tosh

Yamamoto at Kansai University in designing social entrepreneurship COIL courses in the realm of SDGs to foster global mindset as well as assessment strategies in such courses.

E. Dr. Carol H.C. Chu (Hui-Chun Chu), Department of Computer Science and Information Management, Soochow University

Professor Carol H.C. Chu is a professor in Department of Computer Science and Information Management at Soochow University in Taipei, who is specialized in designing and planning computational thinking mindset to students and implementing gamification to higher education. She has been collaborating with Tosh Yamamoto at Kansai University in designing glocal social entrepreneurship COIL courses in the realm of SDGs to foster global mindset as well as gamification strategies in learning.

F. Professor Takuro Ozaki, IT Center, Osaka Educational University

Professor Takuro Ozaki is a professor in IT Center at Osaka Educational University in Japan, who is specialized in designing, planning, and deploying ICT-enhanced learning environment at the institutional level. He is also a specialist in applying new technologies to various levels of learning, i.e., sense-making of cloud services with learning activities for team-based PBL.

G. Professor Yasuhiro Hayashi, Dept. of Data Science, Musashino University

Professor Yasuhiro Hayashi is a professor in Department of Data Science at Musashino University in Japan, who is specialized in designing, planning, and deploying ICT-enhanced cyber learning environment across campuses. He is also a specialist in applying new technologies to various levels of learning, i.e., sense-making of cloud services with learning activities for team-based PBL, not to mention, a specialist in deploying critical/creative thinking in the field of science and engineering.

3.2 *Program Committee*

A list of prospective members of the workshop program committee is given below.

- *Dr. Kazuya Takemata, KIT (International College of Technology), Japan*
- *Dr. Akiyuki Minamide, KIT (International College of Technology), Japan*
- *Professor Elvita Viasih, Kansai University, Japan*
- *Dr. Mihoko Chiba, Konan University, Japan*
- *Dr. Yasuhiro Hayashi, Dept. of Data Science, Musashino University, Japan (Also WKSP Organizer member)*
- *Dr. Yoshinobu Tachi, KIT, Japan*

4. Target Audience

The length of the workshop is planned for a full-day, composed of a morning session and an afternoon session. Target audience for the workshop would be educators with at least three to ten years of instructional experiences in international collaborative learning, as well as with the novice to beginner level of ICT literacy.

Acknowledgements

We would like to thank all the people who spent many hours preparing for the design and planning of this hands-on and heads-on interactive workshop.

References

Anderson, T. (2008). The theory and practice of online learning (pp. 45–74). Retrieved January 20, 2019, from http://www.aupress.ca/books/120146/ebook/99Z_Anderson_2008Theory_and_Practice_of_Online_Learning.pdf.

Davis, L. (2011). Revised Bloom's Taxonomy. Retrieved January 20, 2019, from https://www.slideshare.net/LauraDavis/blooms-taxonomy-made-easy.

Boling, E. C., Hough, M., Krinsky, H., Saleem, H., & Stevens, M. (2012). Cutting the distance in distance education: Perspectives on what promotes positive online learning experiences. Internet and Higher Education, 15, 118-126.

Bonk, C. J., & Graham, C. R. (2006). The handbook of blended learning environments: Global perspectives, local designs. Retrieved January 20, 2019, from https://books.google.com.mx/books?isbn=1118429575.

Bloom's Taxonomy Matrix. https://image.slidesharecdn.com/ldavisbloomspresentation- 110619220714-phpapp02/ 95/blooms-taxonomymade-easy-12-728.jpg?cb=1308521604

Engeström, Y. (1999). Activity theory and individual and social transformation. In Y. Engeström, R. Miettinen, & R.-L. Punamäki (Eds.), Perspectives on activity theory (pp. 506–518). Cambridge, England: Cambridge University Press.

Flavin, M. (2016). Disruptive conduct: The impact of disruptive technologies on social relations in higher education. Innovations in Education and Teaching International., 53, 3-15.

Fry, N., & Love, N. (2011). Business lecturer's perceptions and interactions with the virtual learning environment. International Journal of Management Education, 9, 51-56.

Glazer, H. R., & Wanstreet, C. E. (2011). Connection to the academic community: Perceptions of students in online education. Quarterly Review of Distance Education, 12(1), 55-62.

Graham, C. R. (2006). Blended learning systems. Definition, current trends, and future directions. In C. J. Bonk & C. R. Graham (Eds.). The handbook of blended learning: Global perspectives, local designs, 3–21. Retrieved January 20, 2019, from https://books.google.com.mx/books?isbn=1118429575.

Horizon 2020. (2018). Funding, Tenders. Retrieved January 20, 2019, from https://ec.europa.eu/programmes/horizon2020/en/what-horizon-2020.

INSTITUTE FOR THE FUTURE. (2011) FUTURE Work Skills 2020. Retrieved January 20, 2019, from http://www.iftf.org/uploads/media/IFTF_FutureWorkSkillsSummary_01.gif

Kozma, R. B. (Ed.). (2003). Technology, innovation and educational change: A global perspective. Eugene: International Society for Technology in Education International Association for the Evaluation of Educational Achievement.

Lajoie, S. P., Hmelo-Silver, C. E., Wiseman, J. G., Chan, L. K., Lu, J., Khurana, C., et al. (2014). Using online digital tools and video to support international problem-based learning. Interdisciplinary Journal of Problem-Based Learning. https://doi.org/10.7771/1541-5015.1412.

Law, N., Pelgrum, W. J., & Plomp, T. (2008). Pedagogy and ICT use in schools around the world: Findings from the IEA SITES 2006 study (CERC Studies in Comparative Education). Hong Kong: Springer, Comparative Education Research Centre.

VISION 2020. (2014) Vision 2020 – Education. Retrieved January 20, 2019, from http://www.planningcommission.gov.in/reports/genrep/bkpap2020/14_bg2020.pdf.

Waddoups, G. & Howell, S. (2002). Bringing online learning to campus: The hybridization of teaching and learning at Brigham Young University. International Review of Research in Open and Distributed Learning, 2(2). Retrieved January 20, 2019 from http://www.irrodl.org/index.php/irrodl/article/view/52/108.

Yamamoto, T., Watanabe, M., & Okunuki, M. (2017). Academic writing as corpus for assessment of ePortfolio. 2017 Pacific Neighborhood Consortium Annual Conference and Joint Meetings (PNC). Retrieved January 20, 2019, from http://ieeexplore.ieee.org/document/8203 518.

Yamamoto, T. et. al. (2018). "A Proposal for the Global and Collaborative PBL Learning Environment Where All Global Members on Different Campuses Are "On the Same Page" throughout the Process of Learning in the Project". Published in: 2018 Conference on Technologies and Applications of Artificial Intelligence (TAAI 2018), (INSPEC Accession Number: 18366277). (DOI: 10.1109/TAAI.2018.00029)

WORKSHOP 14 - The Applications of Information and Communication Technologies in Adult and Continuing Education

On the Application of the Flipped Classroom in the Teaching of BTI ---Taking the Teaching of *Advanced English* as An Example

Xiao-Mei QIN

Xi 'an Fanyi University, China
maychelle1709@xafy.edu.cn

Abstract: *Advanced English* is a core course for seniors whose major is translation and interpreting. Its teaching content covers a wide range of subjects and genres, which are mainly selected from famous works covering politics, society, culture, literature and many other aspects. The aim is to expand students' knowledge and deepen their understanding of society and life through careful reading and analysis. However, due to the abstruse content of the course, it has greatly affected students' interest and frustrated their enthusiasm, making it difficult for teaching to achieve ideal results. This paper takes the teaching and learning of *Advanced English* classes of 2016 and 2017 in Xi 'an Fanyi University as an example, discusses the specific application of the flipped classroom, and analyzes and evaluates the actual teaching effect, with a view to providing some referential experience for undergraduate translation teaching.

Keywords: BTI (Bachelor of Translation and Interpreting); Advanced English course; Flipped Classroom

1. Introduction

Advanced English is a core course for translation majors at the senior level. The teaching content covers a wide range of subjects and genres, and the course materials are mainly selected from famous works, covering politics, society, culture, literature and many other aspects, which are unfamiliar and difficult to Chinese students for they make English as a second language. The teaching aim is to expand students' English knowledge and deepen their understanding of society and life in English-spoken countries through careful reading and analysis. It also trains students' comprehensive English skills, especially reading comprehension, grammar rhetoric and writing ability. It focuses on training students' understanding and appreciation of articles of different genres, themes and styles, and cultivating students' advanced abilities in listening, speaking, reading, writing and translating, to improve students' comprehensive language knowledge level and practical application ability in an all-round way. It lays a solid foundation for its further development into linguistics, literature, translation and other high-level research directions. However, due to the abstruse content of the course, it has greatly affected students' interest in learning and frustrated their enthusiasm for learning, making it difficult for teaching to achieve ideal results. Therefore, it is a big problem for teachers to learn how to improve the teaching effect of *Advanced English* and realize the established teaching objectives. This paper takes the teaching and learning of *Advanced English* of 4 classes in 2018 in Xi 'an Fanyi University as an example, discusses the specific application of the "flipped class" model, and analyzes and evaluates the actual teaching effect of the flip class, with a view to providing some referential experience for undergraduate translation teaching.

2. Flipped Class and Advanced English Teaching

Flipped classroom is a new teaching mode that has arisen at home and abroad in the past few years. This idea was originally put forward by American teachers Bergmann and Sams. They recorded all the

course contents into teaching videos in advance and posted them on the Internet. The students taught themselves the course contents by watching the videos and finished the related homework. The class time was used to help the students solve the concepts they did not understand (Bergman, &Sams, 2012). In short, turning over the classroom is to change the traditional teaching method and advance the teaching content in the original classroom to be completed by the students themselves before the class. The classroom becomes a place to solve problems, deepen conceptual understanding and carry out cooperative learning (Tucker, 2012). At present, the latest practice and research on flipped classrooms place more emphasis on the role and significance of this teaching mode in encouraging students' active and in-depth learning, increasing the diversity and inclusiveness of teaching methods, and promoting the interaction and communication between teachers and students (Shaffer, 2017). In the traditional "*Advanced English*" class for students in China taking English as a second language, the main speaker is the teacher, and the focus of the teaching is on the transmission of the content. In addition, the class time is limited. Therefore, there is little time left for students to digest and understand the content, which make the teaching effect is not ideal. In the flipped class mode, teachers require students to complete the acquisition of content in advance by watching teaching videos, self-study textbooks or reading designated bibliographies before class, so that what teachers do in class is to spend more time to deepen students' understanding of concepts, interpret doubts, and help students digest and absorb knowledge; Moreover, students can go to the class with questions so as to listen and think deeply about the theory they have learned, instead of passively taking notes or transcribing the teacher's PPT content, thus making the class truly a place to "solve problems and improve conceptual understanding" (Muzyka, & Luker, 2016).

3. Teaching Design of Advanced English Based on Flipped Classroom

The following will take the teaching of *Advanced English* II for undergraduate students in translation majors of Xi 'an Fanyi University as an example to discuss the specific application and operation of the flipped classroom mode. The course spans one semester, with a total of 18 weeks of lectures, 4 hours a week and 72 hours in total. The number of students in each class is about 40, with a total of four classes. At the beginning of each semester, students are required to clarify the examination assessment for *Advanced English* and to reverse the connotation of the flipped class. All of the videos and materials have been on line, which have been given the task points. If students finish the points, they can get the scores. The more points they make, the more score they get. It can help teachers make the final assessment at the end of the semester. Teachers perfect the homework, examination questions, etc. and make students study online at any time, and try their best to open the discussion function to communicate with students on line at any time. Before class, students need to watch teaching videos online, learn relevant materials and do targeted exercises, and also record their problems in learning. In class, the teacher will first have a quick assessment of the students in order to know the extent of their knowledge by on-line learning, then discuss in groups of 5-7 students to solve the problems left over before class and promote the internalization of knowledge. The last is summary and feedback.

3.1 Teaching Contents

The *Advanced English* is written by Zhang Hanxi and published by Foreign Language Teaching and Research Press. This course aims to make Students require the necessary understanding of the relevant cultural background knowledge of each unit and preview the text before class. They Learn to interpret words and sentences in English; Recognize and distinguish various rhetorical devices in the text; understand the functions and characteristics of various styles in English. Under the guidance of the teachers, the students learn how to analyze and appreciate the writing skills, structure and language features of the article, and they also learn to look up reference books and write notes by yourself. Finally, they can explain some words and sentences in English skillfully, and can accurately point out the figures of speech, the writing skills and structure in the article (See Table1).

The results of this course consist of four parts, including 20% classroom participation, 10% homework, 20% online learning and 50% final test.

Table 1
The Table of Teaching Contents of Advanced English

Week	Teaching contents	Presenters	Assignments
No.1-2	Face to Face with Hurricane Camille	Teacher& students	On-lines questions; Role play
No.3-4	Hiroshima---the "Livest" City in Japan	Group1	On-lines questions; Debate
No.5-6	Blackmail	Group2	On-lines questions
No.7-9	The Trial That Rocked the World	Group3	On-lines questions; Micro-video
No.10-12	The Libido for the Ugly	Group4	On-lines questions
No.13-14	Mark Twain---Mirror of American	Group 5	On-lines questions; Speech
No.15-16	Everyday Use for Your Grandmama	Group 6	On-lines questions; Picture Show
No.17	Review	Students	
No.18	Reports	Each group	Presentation

3.2 Teaching Design

The core elements of flipped class include flip learning, active learning, in-depth learning, cooperative learning, etc. The teaching design of A*dvanced English* is also focusing on these elements. The specific operation and implementation are as follows:

3.2.1 Flipped Learning

Fanya Platform is a campus learning platform developed and customized by Beijing Chaoxing Group in Xi 'an Fanyi University. Teachers and students can carry out teaching interaction, resource sharing and collaborative research through this platform and mobile learning terminal (Learning APP). On the platform, teachers distribute the curriculum links according to the requirements of the curriculum syllabus and the arrangement of the teaching calendar. They make and put in micro-videos, courseware and auxiliary teaching resources in batches and time periods. At the same time, they build modules such as monitoring students' learning tasks, correcting students' homework and discussing problems. Students can learn through account numbers and obtain corresponding formative evaluation results.

At the beginning of each semester, students are required to clarify the examination rules for *Advanced English.* Before class, students need to watch teaching videos online, learn relevant materials and do targeted exercises. After that, they are asked to record their problems. In class, the teacher will first have a quick assessment of the students, then study in groups to solve the problems left over from the study before class, which and promote the internalization of knowledge. Finally, the teacher commented on the students' opinions and made a final conclusion. At the end of each course, we will also set up corresponding extended practical activities, such as debates, speeches, role plays,

micro-movies and other forms to strengthen students' application ability. The reversed classroom of *Advanced English* not only reflects the flexible learning environment, but also realizes the student-centered classroom teaching, which returns the responsibility of learning and the control power to the students.

3.2.2 Deep Learning

Flipped class is a teaching mode that can effectively promote deep learning. In-Depth learning is not simply memorizing the content of the course, but "interacting" with the learned content so as to truly grasp its connotation and significance. There are many ways to generate interaction, the most important of which is the problem-oriented strategy of learning by doing, that is, to experience the use of knowledge through operation, production or creation. In the flip class, since the content is completed independently by the students before the class, the teachers have sufficient time to organize various teaching activities for the students to learn by doing in the class, from the simple teaching of theoretical knowledge to the training of theoretical application ability, to cultivate the students' ability and consciousness to discover and solve problems, and finally to complete the transformation from shallow learning to deep learning.

For this purpose, we try to promote interaction between students and what they have learned through various means in designing A*dvanced English*. For example, in learning the 11th "The Way to Rainy Mountain", this is an English essay with great difficulty in designing Indian culture. In order to enable students to better understand the complex emotions expressed in this essay, students are allowed to independently design the text as a script, shoot a micro-movie for about 10 minutes, upload it to the learning platform, and everyone can discuss and learn about the shooting effect and content. Through this activity, students have a good understanding of the author's pride, sense of loss and sense of belonging in the text. They have made a qualitative leap in mastering Indian culture, especially the relationship between them and nature. At the same time, they have certain aesthetic, reflective and critical abilities.

3.2.3 Cooperative Learning

Team-Based cooperative learning is an important part of the flipped class. After the students finish learning the extracurricular teaching videos, the teachers can help the students to complete the meaning construction of knowledge in dialogue and negotiation (Fairclough, 2001). In fact, from the point of view of teaching practice, cooperative learning, an interactive and cooperative learning style, not only exists in the classroom, but can run through the whole teaching-learning process in and out of the class. In the course of *Advanced English*, students are required to prepare and discuss problems in class in groups. In this process, everyone brainstormed, exchanged ideas, and clarified their own positions and viewpoints. Students' subjective initiative was fully brought into play, which can not only make the projects complete collaboratively and efficiently, but also deepen the emotions among students. In the traditional *Advanced English* teaching mode, teachers mainly teach knowledge in class, who can completely control the teaching rhythm and teaching content. However, this teaching method does not consider the individual needs, which is difficult to arouse students' interest in learning, and easy to separate the teaching content from the actual reality. In the *Advanced English* teaching integrated with the flip class, the time allocation in the class and the depth of the discussion on the teaching content cannot be completely controlled by the teacher. Students learn the theoretical knowledge they need to master through the teaching courseware before class. The class time is mainly for students to participate in the discussion (Crouch, & Mazur, 2001). For example, in learning "No Signpost in the Sea", when discussing why the author appreciated albatross, the students had a heated discussion. Some students were responsible for searching for information, some for analyzing records, and some for sharing and presenting. Each student undertakes corresponding tasks in this process and completes the learning of knowledge through dialogue and negotiation.

4. Effects of the Flipped Classroom Effect

In the teaching reform of *Advanced English*, students actively participate in this mixed teaching, with high recognition and good teaching effect. The following are some students' feedback:

"Before class with the learning platform, the teacher sends the materials and videos that need to be previewed to the learning platform in advance, so that the students can be familiar with the relevant materials of the text in advance, thus greatly saving the time for previewing before class and improving the learning efficiency. "

"In class, the method of seizing questions is adopted to stimulate the enthusiasm of the students and enliven the classroom atmosphere. In class, we will be organized to have group discussions. Through mutual communication and supplement, everyone can actively participate in the class, which make it good in the class effect. At the same time, we should pay attention to analyzing problems in cooperation with students and fully stimulate the activeness of students' thinking. "

"In the aspect of after-class learning, the teacher also uses Learning APP to assign homework to us, and uploads the students' homework on the Learning APP after completing the homework. This method helps the teacher to check the homework faster and improves the efficiency. After learning different units, different tasks will be assigned, such as script performance, dubbing, and video recording. Let's finish it to deepen our understanding and impression of this text. "

A total of 42 students submitted feedback reports. The representative evaluation opinions presented in the report are shown in the following table (See Table2). It can be said that the teaching effect has basically reached the teaching goal set by the course of *Advanced English.*

Table 2
Representative Evaluation Comments in Students' Feedback Reports

Representative comments	Number of persons proposed	Proportion
The improvement of English knowledge&the understanding of society and life in the English-spoken countries	36	86%
Diversification of teaching forms	40	85%
High student participation	38	90%
The enhancement of team cooperation	40	95%
The improvement of the on-line learning	38	90%

5. The Problems Existing in the Flipped Classroom

5.1 Students Easily Distracted When Using Mobile Phones to Learn

The discussion in *Advanced English* class is mainly completed through the "learning APP" on the mobile phone, and the activities inside include discussion, answering questions, selecting candidates, etc. However, mobile phones can be used not only for mobile learning, but also for leisure and entertainment. When students use mobile phones to study in class, if their self-control is not strong, they are likely to pay more attention to information unrelated to learning, resulting in poor learning results.

5.2 The Task Not Be Completed of Autonomous Learning Stage

In the teaching mode of the reversed classroom , students' autonomous learning before class is the basis for carrying out classroom teaching activities. Only when students learn new knowledge before class can it be meaningful to carry out internalization activities of new knowledge in classroom teaching. If individual students do not complete autonomous learning of new knowledge due to various reasons, it will directly lead to their inability to keep up with the progress of classroom teaching and the learning effect is not satisfactory.

5.3 The Unclear Work in Groups Leading to Individual Students' Lazy

It is usually carried out in the form of group learning. In the process of group learning, students need to actively participate in learning activities in order to better realize the internalization of new knowledge. If the assignment of group tasks is not clear, and individual students are not active enough, which will lead to a big discount in the effect of internalizing their knowledge.

6. Summary

The flipped classroom mode takes students as the main body of teaching activities, and enables students to participate in the whole teaching process by means of various interactive classroom learning activities, thus greatly improving students' participation and enthusiasm in the curriculum and increasing the communication among students. In this process, teachers' effective management and guidance of the classroom become particularly important (Argyris, & Schon, 1974). Teachers should play the role of classroom organizers, good at mobilizing and inspiring students, guiding students to have meaningful discussions, and improving the utilization rate of classroom time. In addition, teachers should also be fully prepared before class and have a clear idea of the activities or discussion contents to be carried out, so as to provide targeted guidance and feedback in class, so that class discussions or activities will not become mere formality and students will really gain something.

References

Argyris, C. & Schon, D. A. (1974). *Theory in Practice: Increasing Professional Effectiveness*. San Francisco:Jossey-Bass.

Bergmann, J · & Sams, A. (2012). *Flip Your Classroom: Reach Every Student in Every Class Every Day*. Eugene, OR: International Society for Technology in Education.

Clandinin, D. J. & Connelly, F. M. (2000). *Narrative Inquiry: Experience and Story in Qualitative Research.* San Francisco: Jossey-Bass.

Connelly, M.& Clandinin, J. (1999). *Shaping a Professional Identity: Stories of Educational Practices.* New York: Teachers College Press.

Crouch, C. H. & Mazur, E. (2001). Peer instruction: Ten years of experience and results. *Am. J. Phys.*, *69*(9), 970-977 ·

Dewey, J. (1933). *How We Think?* New York:D. C. Heath.

Fairclough, M. (2001). *Language and Power*. Essex: Pearson Education Limited.

Fromm, E. (2005). *To Have or To Be? A New Blueprint for Mankind*. London: Bloomsbury Academic.

Guba, E. G. & Lincoln, Y. S. (1981). *Effective Evaluation: Improving the Usefulness of Evaluation Results through Responsive and Naturalistic Approaches*. San Francisco: Jossey-Bass.

Jarvis, W., Halvorson, W., Sadeque, S. & Johnston, S. (2014) A Large Class Engagement (LCE) model based on Service-Dominant Logic (SDL) and flipped classrooms. *Education Research and Perspective*, *38*(41), 1-24 ·

Muzyka, J. L. & Luker, C. S. (2016). *The Flipped Classroom Volume 1: Background and Challenges* American Chemical Society.

Shaffer, K. (2017-07-12). *6myths about the flipped classroom [EB/OL]*. https://www. Edutopia.org/ discussion/6-myths-about-flipped-classroom ·

Sternberg, R. J. (1985). *Beyond IQ: A Triarchic Theory of Human Intelligence*. New York: Cambridge University Press.

Tucker, B. (2012). The flipped classroom. *Education Next*, *(Winter)*, 82-83.

Exploring Chinese Rural Primary School Teachers' Application Competencies of Educational Technologies

Xiao-Rong YU[a], Di WU[a], Chun LU[a], Ting CAO[a], & Xi-Bei XIONG[b]*

[a]*National Engineering Research Center for E-Learning, Central China Normal University, China*
[b]*Faculty of Education, Guangxi Normal University, China*
*xbxiong@gxnu.edu.cn

Abstract: This study analyzes the Chinese rural primary school teachers' application competencies for educational technologies in Jilin Province, from perspectives of the application of digital teaching resources and digital teaching tools. According to the research results, this study provides practical suggestions from three perspectives: resource application, tool application and school-based training.

Keywords: Chinese rural areas; primary school teachers; application competencies; educational technologies

1. Introduction

Due to the relatively remote and backward economy in rural areas, Chinese rural primary school teachers, the main force of rural education, are faced with difficulties in their professional development (Zhu & Yan, 2015). The single teaching mode, disconnection between training content and real needs, insufficient training, or training being unsystematic and discontinuous have been noted by Chinese scholars (Yan, Li, & Ren, 2018). In order to promote the basic education curriculum reform, the China central government vigorously facilitates ICT applications in education by implementing a series of supporting policies and measures (Zhang, et al., 2010). In particular, rural primary school teachers' rational use of digital resources and tools has been the key criteria for the application of educational technologies (Mazalah, etc., 2016；Yusuf, 2005). Therefore, this study focuses on the application of digital teaching resources and tools to analyze the application competencies for educational technologies of Chinese rural primary school teachers.

2. Data Collection

2.1 Sampling

In this study, teachers from various disciplines in rural primary schools in Jilin province were sampled. Stratified sampling was conducted according to gender, age, discipline and other characteristics to make the samples representative. A total of 1840 valid questionnaires were collected in this study, with the valid rate of 91.2%. In terms of gender, male teachers accounted for 28.75% while female teachers 71.25%；In terms of subjects, teachers of Chinese accounted for 19.24%, mathematics 18.05%, English 11.12%, science 10.69%, arts 11.21%, music 11.73%, physical education (PE) 11.10%, information technology 5.44%, and moral education 0.85%.

2.2 Questionnaire

The questionnaire adopted in this study consists of two parts. The first part is the personal information of teachers, including teaching subjects, gender, age and educational background. The second part consists of teachers' application of teaching resources, teaching tools and their participation in ICTs trainings.

3. Data Analysis

3.1 Application of Teaching Resources

The application of digital resources in rural primary school is shown in Table 1. It revealed that rural teachers have gradually diversified in their access to digital resources. The professional resource supply platform, dominated by national and regional education has become the main source for rural teachers to develop their professional digital resources. It indicates that the digital education resources obtained by rural teachers are becoming more and more professional.

As shown in Table 2, the resource application frequency in rural areas is sufficient so that classroom teaching assisted by digital resources is basically realized. However, we cannot ignore that there is a great discrepancy between different subjects in the application of multimedia teaching resources. A careful comparison shows that the rural teachers who often use multimedia teaching resources for classroom teaching are teachers of English, music, information technology, and their using of school-based resource database is also relatively high.

In term of educational resources application, Table 3 reveals that the rural teachers have various multimedia teaching resources; however, PPT is still their favorite choice, accounting for more than 69%. To be specific, teachers of Chinese, English, mathematics use all kinds of teaching resources in a balanced way, especially for questions/test papers.

Table 1
Percentage of Digital Resources Application /%

	Overall	Chinese	Math	English	Science	Arts	Music	PE	ICT	Moral
National education resource platform	66.61	65.36	65.76	66.82	71.68	69.62	69.16	62.50	79.13	72.22
Regional education resource platform	48.06	45.95	46.40	50.93	49.56	49.37	47.14	42.19	49.57	33.33
Individual production	40.35	41.52	39.95	47.66	38.50	37.13	40.97	34.77	46.09	33.33
Sharing by teachers or research groups	40.02	38.08	37.72	41.59	37.17	37.55	40.97	39.06	41.74	33.33
Commercial search engine	37.70	36.36	34.24	37.38	36.28	38.82	34.80	36.72	41.74	27.78
School resource bank	30.26	26.54	25.31	34.58	36.28	28.27	31.72	28.91	31.30	16.67
Personal purchase	12.62	15.97	16.38	10.75	12.83	13.08	13.22	10.94	13.04	16.67

Table 2

Percentage of Resource Application Frequency /%

	Overall	Chinese	Math	English	Science	Arts	Music	PE	ICT	Moral
Always	22.38	28.67	28.88	25.81	20.69	21.67	22.08	13.95	29.57	11.11
Often	44.17	43.61	44.17	46.54	43.53	43.75	48.48	31.78	51.30	27.78
Sometimes	18.50	18.80	17.48	16.59	21.12	20.00	18.61	23.26	13.04	44.44
Rare	12.35	8.67	8.98	11.06	13.36	12.08	7.79	21.71	5.22	16.67
Never	2.60	0.24	0.49	0.00	1.29	2.50	3.03	9.30	0.87	0.00

Table 3

Percentage of Educational Resources Application /%

	Overall	Chinese	Math	English	Science	Arts	Music	PE	ICT	Moral
PPT	84.74	91.65	91.07	88.79	85.40	84.39	86.78	69.92	87.83	77.78
Micro lecture	36.08	36.61	37.22	40.19	38.94	38.82	40.09	32.42	40.87	44.44
Case	29.02	29.98	31.02	29.91	32.30	29.11	25.11	24.22	32.17	16.67
Online courses	22.60	24.57	24.32	22.43	26.11	22.36	21.15	21.48	31.30	38.89
Questions/test papers	19.53	26.78	27.30	21.50	21.68	16.46	14.54	12.89	13.04	11.11
Online video	17.96	18.92	18.11	17.29	19.91	21.52	17.62	17.58	19.13	11.11

3.2 Application of Digital Teaching Tools

Digital teaching tools, according to their function, can be divided into classroom teaching tools, resource making tools, test tools, teaching and research tools, etc. The application of digital teaching tools in rural primary school is shown in table 4. Compared with other disciplines, the teaching tools of English and music are more prominent in terms of teachers' self-exploration and students' individualized learning.

Meanwhile, the teaching materials of these two subjects are equipped with more special teaching tools. Special subject teaching software and network teaching platform are critical in solving the shortage of teaching resources in rural primary and secondary schools.

When coming to the application of resource making tools, rural primary school teachers have a good command of them, but rural primary schools have not established the mechanism of high-quality resources co-construction and sharing.

In the application of test tools, the application of marking tools and score analysis tools is poor. At present, rural primary school teachers are more accustomed to using electronic test question bank, but the traditional papers and manual marking still cannot go without.

The use of network teaching and research platform in rural area is not widely seen. The main reasons come from two aspects: on the one hand, rural teachers are weak in online teaching and research; on the other hand, rural primary schools have not yet formed online teaching and research support system.

Table 4

Application of Digital Teaching Tools in Rural Primary School %

	Classroom teaching tools		Resource making tools		Test tools		Teaching and research tools
	Teaching software	Online teaching platform	Multimedia courseware making tools	Digital resource sharing platform	Marking tools	Performance analysis tools	Online teaching and research platform
Overall	40.13	25.08	68.23	36.03	5.88	5.18	22.22
Chinese	38.82	25.55	73.22	41.28	6.39	4.67	22.36

Math	39.70	25.81	72.70	41.44	5.96	4.71	23.08
English	45.33	28.50	75.23	37.85	7.94	3.27	27.10
Science	38.94	28.76	71.24	37.17	7.52	5.31	28.32
Arts	39.66	29.11	71.31	33.76	4.64	4.64	23.21
Music	42.29	30.40	69.60	33.04	4.85	4.41	25.11
PE	33.20	23.05	58.98	30.47	3.91	4.69	20.70
ICT	49.57	34.78	67.83	37.39	6.96	4.35	24.35
Moral	27.78	38.89	77.78	22.22	5.56	5.56	27.78

3.3 School-based Training

School-based training plays an important role in improving teachers' application competencies of educational technologies (Yang, Wu, & Zheng, 2018). The specific situation of school-based training in rural primary school is shown in table 5. In terms of training content, the demand for teachers from various disciplines is diversified and consistent. Rural teachers have paid too more attention to the basic operation of ICTs and the improvement of personal resource production skills, instead of cognitive strategies and metacognitive knowledge. In ICT-supported teaching, rural teachers' demand for the training of ICT-based teaching design is higher than 62%. However, their demand for educational technology theory and TPACK is lower than 45%. Meanwhile, rural teachers tend to ignore the teaching and learning methods, so they not only need to constantly learn new teaching theories, pedagogies and information security knowledge, but they also need to improve their competencies of integration of ICT with teaching.

Table 5
The Rural Teachers' Requirements about School-based Training Contents/%

	Educational technology theory	ICT-based teaching design	Courseware making technology	Information technology application	Online resources application	Subject teaching tools	TPACK	Network security application
Overall	44.70	69.35	90.91	57.61	58.22	56.82	36.42	12.41
Chinese	39.85	69.31	90.84	56.93	57.92	53.96	33.66	8.17
Math	39.35	69.17	89.22	55.14	57.64	54.64	32.83	8.27
English	46.01	70.42	86.85	52.58	52.58	53.52	38.50	12.21
Science	42.48	66.81	85.84	54.42	48.67	52.65	29.20	11.95
Arts	44.68	63.83	86.81	50.64	54.47	59.15	34.89	8.94
Music	44.49	66.08	83.70	55.51	54.63	53.74	34.36	10.57
PE	41.57	62.75	76.08	52.94	46.27	45.88	30.59	12.94
ICT	43.48	70.43	87.83	58.26	57.39	69.57	46.09	23.48
Moral	38.89	72.22	88.89	27.78	61.11	61.11	33.33	5.56

4. Discussion and Conclusion

In terms of the educational resource application, it is necessary to develop school-based resources with local characteristics, and realize the co-construction and sharing of resources (Lin, 2008). Considering the fact that rural primary and secondary school teachers are poor at processing and reprocessing resources, it is urgent to encourage them to develop high quality curriculum-based resources that are suitable for rural area. Meanwhile, they should accumulate localized teaching resources in their teaching practice so as to meet the personalized and school-based needs.

In terms of teaching tools application, it is advisable to encourage rural teachers to apply teaching tools in classroom teaching with a wide range of practical applications. Because rural primary school teachers are not used to adopting teaching tools, they need to be guided to increase the frequency of application of teaching tools in classroom teaching, and experience the convenience and efficiency brought by teaching tools in classroom teaching, so as to improve the enthusiasm of rural teachers to apply teaching tools in classroom teaching.

In the aspect of school-based training, school-based training should be carried out with discipline as the unit, and rational incentive and evaluation mechanism should be formulated. There is a need to carry out "precision" training and carry out training based on the local conditions of rural areas. It is also important to promote typical ICT application cases in rural schools, and promote the in-depth integration of ICT with teaching under the weak condition of ICT equipment in rural areas.

Acknowledgment

References

Lin, Mei-Chuen. (2008). ICT education: To integrate or not to integrate? British Journal of Educational Technology, 39(6), 1121-1123.

Mazalah A., Jamaludin B., Ahmad Z. M., Aidah A. K., Fariza K., Mohd Y. D., Rosseni D., & Diana F. Z. (2016). The Application of 21st Century ICT Literacy Model among Teacher Trainees. TOJET: The Turkish Online Journal of Educational Technology, 15(3), 151-161.

Yusuf, M. O. (2005). Information and communication education: Analyzing the Nigerian national policy for information technology. International Education Journal, 6(3), 316-321.

Zhang, Jingtao., Fang, Yuanyuan., & Ma, Xiaoling. (2010). The latest progress report on ICT application in Chinese basic education. British Journal of Educational Technology, 41(4), 567–573.

Yan, Hanbing., Li, Xiaoying., & Ren, Youqun. (2018). The development and verification of the self-assessment tool for pre-service teachers' application ability of information technology. Research on Audio-visual Education. 1, 2018.

Zhu, Zhiting., & Yan, Hanbing. (2015). The Interpretation for Primary and Secondary School Teachers' Information Technology Application Ability Standard, trial. Research on Audio-visual Education. 9, 2015, 5–10.

Yang, Zongkai, Wu, Di., & Zheng, Xudong. (2018). The Key Historical Transition of Information Technology Reform Education in the New Era. Education Informatization 2.0. 39(4), 16-22.

Using Online Literature Circles to Engage EFL Students in Collaborative Learning and Its Effect on Student' Self-efficacy

You SU*, Chunping ZHENG
School of Humanities, Beijing University of Posts and Telecommunications, China
*suyou@bupt.edu.cn

Abstract: Online literature circles can be powerful and beneficial for promoting the learning of English as a foreign language (EFL). This study aims to investigate the influence of using online literature circles as an instructional method on EFL students' English self-efficacy. This study involves 228 second-year college students at a university in North China. A pretest-posttest quasi-experimental design was conducted to examine whether students' English self-efficacy would change after their participation in the online literature circles activities. The results indicated that the students' self-efficacy in English listening, speaking, reading, and writing has all improved after participating in online literature circles activities.

Keywords: Literature circles, collaborative learning, self-efficacy, wiki, EFL

1. Introduction

Literature circles are "small peer-led discussion groups, involved in reading the same piece of literature, and who come together on a regular programmed basis to share interpretations of what they have read" (Shelton-Strong, 2012, p. 214). Literatures circle have been considered as a sound instructional method that could provide a social space for students to engage in collaborative learning (Widodo, 2016). When participating in literature circles activities, students were assigned with different roles like discussion leader, culture collector, passage person, and word master. Through the fulfillment of each role and by interacting with other members in the literature circles, students become active learners rather than passive receivers. Previous research has documented the benefits of literature circles activities in facilitating peer communication, promoting language acquisition, and fostering learning autonomy (Daniels, 2006; Su, Li et al., 2019; Widodo, 2016).

With the increasing interest in using Web 2.0 tools (e.g., wiki, blog, chatroom) in language education, language teaching researchers and practitioners have called for moving traditional literature circles into online space so as to enhance collaboration and advance the pedagogy of literature circles (Larson, 2009). In particular, Hathaway (2011) points out that merging wiki technology with literature circles becomes especially powerful and beneficial for synthesizing the skills of collaboration, communication, critical thinking, and creativity with 21st century technology skills. Organizing online literature circles can also be a boon for learners who are shy and reluctant to share ideas in face-to-face literature circles. However, most of previous studies on online literature circles were carried out in the context of first or native language education. Few studies have been conducted on the design and implementation of online literature circles in the context of teaching English as a foreign language.

Self-efficacy refers to students' beliefs in their abilities to complete specific tasks and attain goals (Bandura, 1997). Although several studies have explored the positive influence of online collaborative learning on students' self-efficacy, most of them were situated in other domains like science and mathematics (e.g., Chen, Wang, & Lin, 2015). There is scarce literature examining the impact of instruction based on online collaborative learning on language learners' self-efficacy.

In the present study, online literature circles activities were designed and implemented as a way to promote collaborative learning in an EFL course at a key university in North China. This study aims to investigate whether the online literature circles activities can improve the students' English self-efficacy.

2. Procedure

2.1 Participants

This research involved 228 second-year undergraduate students (around 18~19 years old) enrolled at a university in North China. As most of the students were majoring in computer science, telecommunications, and electronic information science, more male students (159 males) were included in this research. Before taking part in the study, all the participants had more than six years of formal English language learning experience in schools. They also had one-year experience of blended English language learning at the university. The participants were representative of the EFL learners at the university in terms of their English ability. Like most college students in China, the participants lack opportunities to use English outside the classroom.

2.2 Design and implementation of online literature circles

In this study, the collaborative learning takes the form of Wiki-based literature circles. In the light of previous studies of literature circles (e.g., Widodo, 2016), students in this study are required to form groups of five members and finish literature circles on wikis where they share ideas, feelings, questions, connections, and judgments about the materials they read. Figure 1 illustrates the procedure of the collaborative learning activity and the task roles of the literature circles.
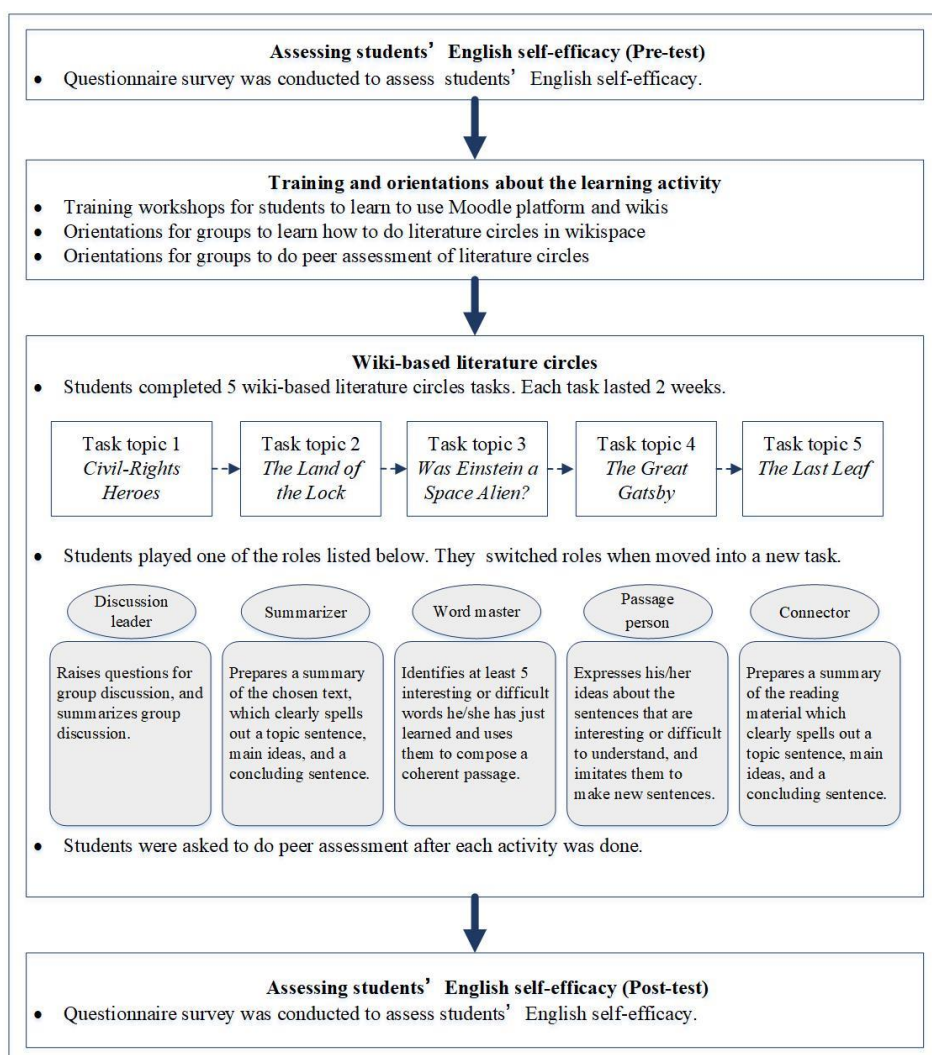
Figure 1. Procedure of the collaborative learning activity

Students carried out their literature circles in a self-paced manner and all the task-related communication took place via online messages and discussion boards. Students were also scheduled to meet the teachers once a week for a two-hour face-to-face discussion about their literature circles. Altogether, students conducted five different literature circles tasks based on five articles of different genres. Group members were required to switch the roles when starting a new task so that each of them could have a complete experience of doing literature circles. Figure 2 shows a snapshot of students' literature circles on the wikispace of the Moodle learning platform.

Figure 2. A snapshot of students' literature circles on Moodle

2.3 Data collection and analysis

This research adapted the English language self-efficacy (ELSE) questionnaire (Su et al., 2018) to assess students' English self-efficacy in four skills: listening, speaking, reading, and writing. The questionnaire consisted of 32 items concerning students' belief about how capable they were to complete specific tasks in English. Each factor of the ELSE questionnaire comprised of 9 to 13 items that were presented in the format of five-point Likert scale with values ranging from 1 (I cannot do it at all) to 5 (I can do it well). The sample questions of the four components are shown as follows:
- Listening self-efficacy: Can you understand English lectures of general topics?
- Speaking self-efficacy: Can you ask your English instructor questions in English?
- Reading self-efficacy: Can you read short English narratives?
- Writing self-efficacy: Can you use accurate grammar when you write English essays?

The participants' English self-efficacy was measured before they participated in the literature circles activities. A post-test of the participants' English self-efficacy was conducted at the end of the course. After deleting invalid questionnaire data, 228 students' responses remained for analyses. The present study first employed exploratory factor analysis to examine the factor structure and the construct validity of the ELSE questionnaire. The reliability coefficient was also collected to ensure the internal consistency of the measurements as a whole. Finally, paired sample t-test was conducted to examine whether students' English self-efficacy has improved after their participation in the online literature circles activities.

3. Results and Discussion

3.1 Principal component analysis of the English self-efficacy questionnaire

A principal component analysis was performed on the 32 items of the ELSE questionnaire. Four factors were recognized, and they accounted for 66.15% of total variance. Consequently, 30 items of the questionnaire remained in the finalized ELSE. As shown in Table 1, the four self-efficacy sub-scales

were listening (Mean = 3.22, S.D. = 0.82), speaking (Mean = 3.72, S.D. = 0.70), reading (Mean = 3.55, S.D. = 0.68), and writing (Mean = 3.84, S.D. = 0.66). The reliability coefficient for each scale in this study ranged from 0.88 to 0.94, with an overall reliability of 0.96. The results suggest the satisfactory reliability for measuring students' English self-efficacy.

Table 1

Rotated factor loadings and Cronbach's alpha values for the four sub-scales of the ELSE

	Factor 1 Listening	Factor 2 Speaking	Factor 3 Reading	Factor 4 Writing
Factor 1: Listening, α = 0.93 , Mean = 3.22, S.D. = 0.82				
Listening 1	0.72			
Listening 2	0.73			
Listening 3	0.76			
Listening 4	0.75			
Listening 5	0.66			
Listening 6	0.77			
Listening 7	0.82			
Listening 8	0.75			
Factor 2: Speaking, α = 0.94, Mean = 3.72, S.D. = 0.70				
Speaking 1		0.59		
Speaking 2		0.67		
Speaking 3		0.56		
Speaking 4		0.73		
Speaking 5		0.70		
Speaking 6		0.78		
Speaking 7		0.72		
Speaking 8		0.70		
Speaking 9		0.70		
Speaking 10		0.75		
Factor 3: Reading, α = 0.88, Mean = 3.55, S.D. = 0.68				
Reading 1			0.72	
Reading 2			0.72	
Reading 3			0.67	
Reading 4			0.58	
Reading 5			0.64	
Reading 6			0.56	
Factor 4: Writing, α = 0.88, Mean = 3.84, S.D. = 0.66				
Writing 1				0.73
Writing 2				0.78
Writing 3				0.70
Writing 4				0.65
Writing 5				0.71
Writing 6				0.49

Note: Overall reliability coefficient: 0.96; Total variance explained: 66.15%

3.2 Differences in English self-efficacy between the pre-test and the post-test results

Paired sample t-test analyses were conducted to examine whether the implementation of online literature circles activities had influence on the student's English self-efficacy. Results indicated that, compared with the pre-test results, the students scored higher in the post-test on the four dimensions of English self-efficacy and significant differences were observed on all dimensions (see Table 2). The

results clearly suggested that the students' English self-efficacy was improved after participating in online literature circles activities.

Table 2

Comparison of English self-efficacy between the pre-test and post-test

	Pre-test		Post-test		*t* value significance
	M	SD	M	SD	
Listening	2.87	0.77	3.21	0.82	7.06***
Speaking	3.40	0.75	3.72	0.70	6.52***
Reading	3.33	0.73	3.55	0.68	4.29***
Writing	3.59	0.70	3.84	0.66	5.40***

Note: ***p<.001

4. Conclusion

This paper reports on the design and implementation of online literature circles activities to engage EFL students in collaborative learning. It further examines whether students' English self-efficacy improves as a result of participating in online literature circles activities. The research results indicate that online literature circles activities have positive influence on EFL students' English self-efficacy. In other words, students' self-efficacy in English listening, speaking, reading, and writing has improved after participating in online literature circles activities.

Several limitations of this study should be noted. This research did not involve a control group to examine the impact of online literature circles on students' self-efficacy. it is encouraged that experimental studies be conducted to examine the influence of the treatment of online literature circles in students' English self-efficacy. It should be noted that the present study only employed quantitative measures. Future study could consider using more in-depth qualitative methods to examine the effectiveness of using online literature circles as an instructional method.

Acknowledgements

References

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York, NY: Freeman.

Chen, C. H., Wang, K. C., & Lin, Y. H. (2015). The comparison of solitary and collaborative modes of game-based learning on students' science learning and motivation. *Journal of Educational Technology & Society, 18*(2), 237–248.

Daniels, H. (2006). What's the next big thing with literature circles? *Voices from the Middle*, *13*(4), 10–15.

Hathaway, R. (2011). A powerful pairing: The literature circle and the wiki. *The ALAN Review, 38*(3), 14–22.

Larson, L. C. (2009). Reader response meets new literacies: Empowering readers in online learning communities. *The Reading Teacher, 62*(8), 638–648.

Shelton-Strong, S. J. (2012). Literature circles in ELT. *ELT Journal*, *66*, 214–223.

Su, Y., Li, Y., Liang, J. C., & Tsai, C. C. (2019). Moving literature circles into wiki-based environment: The role of online self-regulation in efl learners' attitude toward collaborative learning. *Computer Assisted Language Learning*, *32*(5-6), 556–586.

Widodo, H. P. (2016). Engaging students in literature circles: Vocational English reading programs. *Asia-Pacific Education Researcher, 25*(2), 347–359.

The Relations among Undergraduate Students' Sourcing, Anxiety, and Perceived Trustworthiness of Online Information

Tai-Hsien HOU[a], Kuan-Ming SHEN[b] & Min-Hsien LEE[ac*]
[a]*Program of Learning Sciences, National Taiwan Normal University, Taiwan*
[b]*Institute of Education, National Sun Yat-sen University, Taiwan*
[c]*Institute for Research Excellence in Learning Sciences, National Taiwan Normal University, Taiwan*
*leemh@ntnu.edu.tw

Abstract: The present study aimed to understand how undergraduates' sourcing of online information related to their anxiety and perceived trustworthiness of online information. A total of 378 undergraduates participated in the present study that adapted three questionnaires to explore their sourcing, anxiety, and perceived trustworthiness of online information. Exploratory factor analysis and confirmatory factor analysis were employed to ensure the reliability and validity of these three instruments. The Structural Equational Modelling analysis was conducted to investigate the relationships among undergraduate students' sourcing, anxiety, and perceived trustworthiness of online information. The research findings indicated that sourcing online information by personal and multiple evaluation relates to metacognitive online searching strategies, and sourcing online information by authority evaluation relates to behavioral online searching strategy that relates to less anxiety and more perceived trustworthiness of online information. Based on the research findings, theoretical and practical suggestions for future research are provided.

Keywords: Sourcing of online information, Anxiety of online information, Perceived Trustworthiness of online information

1. Introduction

Prior studies have invested a lot of efforts in investigation of students' sourcing of online information which includes evaluating and using available or accessible information about the sources on the Internet. As the Internet has become an important knowledge resource for learning activities, Tsai (2004) proposed that the use of the Internet could be referred as epistemic, metacognitive, and cognitive learning tools. However, few studies have examined students' sourcing of online information from the above three-level (i.e., epistemic, metacognitive, and cognitive) perspective, simultaneously. To fill this gap, the purpose of this study was to develop and validate a new questionnaire based on the three-level perspective to understand students' sourcing of online information. Besides, researchers suggested that how student' evaluate and search information may relate to their anxiety (e.g., Erfanmanesh, Abrizah, & Karim, 2014) and trustworthiness of online information. This study also intended to understand the relations among students' sourcing of online information and their perceived anxiety, and trustworthiness of online information.

2. Methods

2.1 Participants

378 undergraduates with average age of 19.93-year-old in Taiwan participated in the present study. All of the participants were unpaid volunteers, and they were invited to complete the three instruments, regarding the preference of students' sourcing, anxiety, and perceived trustworthiness of online information. These questionnaires addressed this study's aim and importance, and informed the students of their right to withdraw.

2.2 Instruments

The present study validated three questionnaires to explore undergraduates' sourcing, anxiety, and perceived trustworthiness of online information. All of these instruments were assessed by means of a 5-point Likert scale ranging from 1, *strongly disagree*, to 5, *strongly agree*.

Firstly, the sourcing of online information questionnaire adapted the Internet-Specific Epistemic Justification Inventory (Bråten, Brandmo, & Kammerer, 2018) which measured the epistemic justification of online information and the Online Information Searching Strategy Inventory (Tsai, 2009) which measures the metacognitive and cognitive level of sourcing of online information to explore undergraduates' preference of sourcing of online information. The sourcing of online information questionnaire consists of six constructs. The detailed definition and a sample item of the six constructs are presented below:

(1) Personal: measuring the participants' addressed the strategy to justify knowledge claims on the Internet through reasoning and the use of prior knowledge. A sample item is 'When I read about the science topic on the Internet, I evaluate whether this information is consistent with what I already know about this topic.'

(2) Multiple: measuring the participants' addressed the strategy to check knowledge claims on the Internet by cross-checking and corroborating across multiple sources. A sample item is 'To determine whether the information I find about the science topic on the Internet is trustworthy, I compare information from multiple sources.'

(3) Authority: measuring the participants' being concerned about the authoritativeness when using the Internet. A sample item is 'To check whether information I find about the science topic on the Internet is reliable, I try to determine whether it is written by a person with a high level of competence in the area.'

(4) Metacognitive: assessing the participants' skills involved in higher-order and content-related cognitive activities on the Internet, such as purposeful thinking, select main ideas and evaluation aspect strategies. A sample item is 'When searching for science-related information, I look through titles or hyperlinks in a web in order to catch major information.'

(5) Procedural: measuring the participants' content-general searching approaches on the Internet, included trial & error and problem-solving aspect strategies. A sample item is 'I try some possible entrance websites when I cannot find enough about science-related information.'

(6) Behavioral: measuring the participants' skills required for basic Internet manipulation and navigation. A sample item is 'I know how to use a web browser when I search for science-related information, like IE or Chrome.'

Moreover, the current study adapted five items of the Information Seeking Anxiety Scale by Erfanmanesh et al. (2014) to understand students' anxiety of online information (a sample item: I feel anxious when resources found during information seeking process are irrelevant).

Furthermore, the current study developed three items to explore students' perceived self-efficacy toward the trustworthiness of online information (sample item: I think the science-related web information that I use to solve the problem is trustworthy).

2.3 Data analysis and procedure

The purposes of the current study were to understand undergraduates' perception of sourcing, anxiety, and trustworthiness of online information and explore the relations among sourcing, anxiety, and trustworthiness of online information. Thus, three questionnaires were validated to achieve the research purposes.

In the current study, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were employed to ensure the reliability and validity of the instruments. Moreover, the Structural Equational Modelling analysis (SEM) was conducted to investigate the relations among undergraduate students' sourcing, anxiety, and perceived trustworthiness of online information.

3. Results and Discussion

3.1 Factor analysis of students' sourcing, anxiety and perceived trustworthiness of online information

This study utilized exploratory factor analysis to validate the factors of sourcing, anxiety and perceived trustworthiness of online information questionnaires. To validate the three questionnaires, this research adopted the principal component analysis and the oblimin rotation method to clarify the factors of the items. The result of EFA was presented in Table 1.

According to Table 1, the value of factor loading of sourcing of online information questionnaire ranged from .54-.88, and those of anxiety, and trustworthiness of online information ranged from .74-.88, and .80-.88, respectively. Moreover, the Cronbach's alpha coefficients of sourcing of online information ranged from .82-.88, and those of the Cronbach's alpha coefficients of anxiety, and trustworthiness were .85, and .79, respectively. Based on those descriptions above, the results of EFA revealed that these three questionnaires indicated satisfactory reliability.

Additionally, confirmatory factor analysis was conducted to ensure the validity. According to Table 2, the values of factor loading, and t- value were acceptable. Moreover, the fit indices (the ratio of chi-square to degrees of freedom = 2.22, CFI = .95, RMSEA = .062, NFI = .92, NNFI = .94, GFI=.80) showed that the measurement model provided a satisfactory fit to the data. Furthermore, average variance extracted (AVE), and composite reliability (CR) are suggested to evaluate the convergent *validity of the constructs (Hair, Black, Babin, Anderson, & Tatham, 2006; Pedhazur, 1997). The CFA results indicated that all of the loading values of the measured items were significant and higher than 0.5. Compared with the cut-off value of 0.60, the CR values of all factors ranging from 0.82 to 0.90 indicated acceptable reliability of the factors (Bagozzi & Yi, 1988). Moreover, the AVE values ranging from 0.47 to 0.70 revealed adequate convergent validity of the factors.*

Table 1

The EFA result for the sourcing, anxiety, and trustworthiness of online information questionnaires

Factor		Number of items	EFA factor loading	Reliability coefficients
Sourcing	*Personal*	*4*	*.54-.79*	*.86*
	Multiple	*4*	*.57-.68*	*.87*
	Authority	*4*	*.72-.85*	*.86*
	Metacognitive	*5*	*.62-.76*	*.82*
	Procedural	*4*	*.59-.66*	*.83*
	Behavioral	*4*	*.62-.85*	*.88*
Anxiety	*Anxiety*	*5*	*.74-.88*	*.85*
Trustworthiness	*Trustworthiness*	*3*	*.80-.88*	*.79*

Note: Sourcing of online information: Total variance explained: 66.88%, overall α = 0.93

Table 2

The CFA result for the sourcing of online information questionnaire

Scale	Number of items	Factor loading	*t*- value	AVE	CR	Subscale score	
						Mean	*SD*
Personal	4	0.68-0.76	9.83* – 11.40*	0.53	0.82	4.23	0.53
Multiple	4	0.70-0.85	10.25* – 13.47*	0.60	0.86	4.20	0.62
Authority	4	0.74-0.93	11.28* – 16.09*	0.70	0.90	3.53	0.86
Metacognitive	5	0.56-0.73	7.71* – 10.74*	0.47	0.81	4.02	0.57
Behavioral	4	0.63-0.88	9.09* – 14.55*	0.64	0.88	4.18	0.68
Procedural	4	0.72-0.88	10.69* – 13.11*	0.63	0.87	4.32	0.56

* $p < 0.05$, RMSEA= 0.062, CFI = 0.95, NFI = 0.92, NNFI = 0.94, GFI = 0.80

CR: Composite reliability

AVE: Average variance extracted

3.2 Structural Equation modelling analysis results

To explore the relations among sourcing, anxiety, and trustworthiness, structural equation modelling analysis was conducted. The path coefficients of the structural model that specified the relationships between the latent constructs (factors) are presented in Figure 1. The fit
indices of the structural model show that the model has an acceptable fit (the ratio of chi-square to degrees of freedom = 2.22, CFI = .95, RMSEA = .062, NFI = .92, NNFI = .94, GFI=.80).

According to Figure 2, 'Personal' had a positive relation with 'Metacognitive,' and 'Procedural' (γ = .47, and .32, p < .05). 'Multiple' also had a positive relation with 'Metacognitive.' In addition, 'Authority' positively related to 'Behavioral (γ = .16, p < .05),' which positively related to 'Trustworthiness (β = 0.27, p < .05),' and negatively 'Anxiety (β = -0.24, p < .05).'
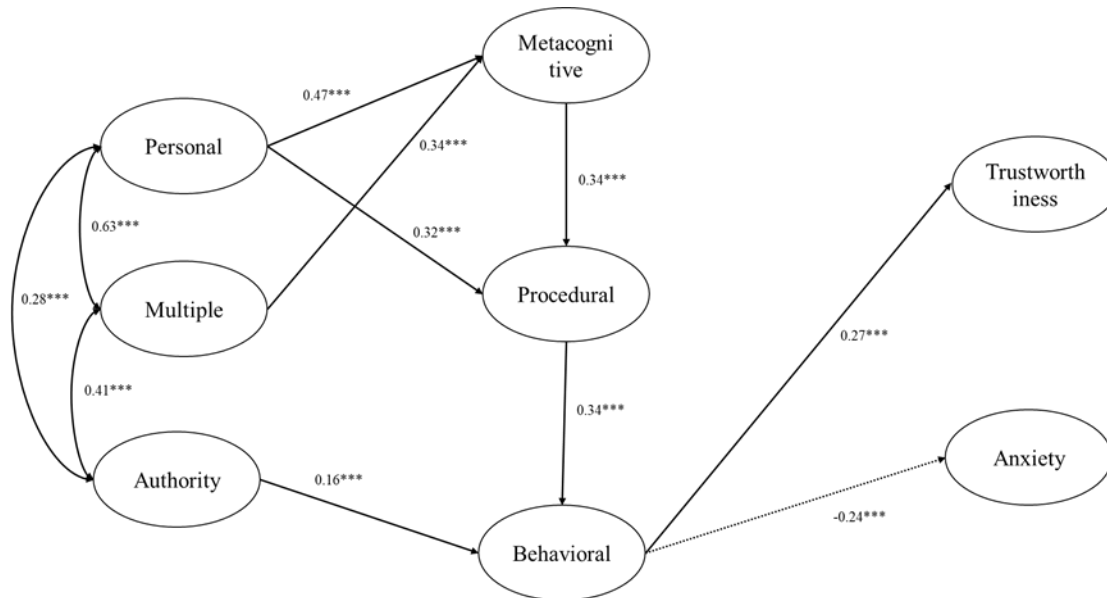
Figure 1. The Structural Equation modelling analysis results indicated that students' sourcing of online information related to their anxiety and perceived trustworthiness of online information

4. Conclusion

The purpose of the present study was to understand the relations among undergraduates' sourcing, anxiety, and trustworthiness. According to the result of SEM, students' sourcing of online information related to their anxiety and perceived trustworthiness of online information.

More specially, students who justified online information by their personal understanding tended to embrace metacognitive and procedural searching strategies. Besides, students who justified online information by multiple sources tended to draw on metacognitive searching strategy. Furthermore, students who justified online information by authority had a tendency toward behavioral searching strategy. In this way, students who justified the online sources by authority through the behavioral searching strategies seem to have less anxiety and much more perceived trustworthiness of online information.

In conclusion, the preliminary results obtained from the current study may provide feedback and future directions to educators and researchers to improve the quality of sourcing of online information.

Acknowledgements

References

Bagozzi, R. P., & Yi, Y. (1988). On the evaluation of structural equation models. Journal of the Academy of Marketing Science, 16(1), 74–94.

Bråten, I., Brandmo, C., & Kammerer, Y. (in press). A validation study of the internet-specific epistemic justification inventory with Norwegian preservice teachers. Journal of Educational Computing Research. https://doi.org/10.1177/0735633118769438

Erfanmanesh, M., Abrizah, A. & Karim, N. H. A. (2014). Information seeking anxiety: Concept, measurement and preliminary research. International Journal of Information Science & Management, 12, 47- 64.

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2006). Multivariate data analysis (6th ed.). New York, NY: Prentice Hall.

Pedhazur, E. J. (1997). Multiple regression in behavioral research (3rd ed.). Orlando, FL: Harcourt Brace.

Tsai, C.-C. (2004). Beyond cognitive and metacognitive tools: The use of the internet as an 'epistemological' tool for instruction. British Journal of Educational Technology, 35, 525-536.

Tsai, M. J. (2009). Online information searching strategy inventory (OISSI): A quick version and a complete version. Computers & Education, 53, 473-483.

Research on College Students' Practice Behavior Model after Class of Programming Course

Fang-Jing NING[a], Bao-Ping Li[a,b*]
[a] *Faculty of Education, Beijing Normal University, China*
[b] *Beijing Advanced Innovation Center for Future Education, Beijing Normal University, China,*
*libp@bnu.edu.cn

Abstract: In this paper, we develop the learning system-DQuiz used in the C language programming course of college students, which can support students to use the mobile terminal to carry out programming exercises at any time. The study selected 74 undergraduates from a university and used DQuiz to conduct a one-semester after-class study. During this period, this study collected the learning behaviors of students in the after-class exercises, including doing new questions, view answers, view explanation, collect question, review, comment and like. Through statistical analysis and lag sequence analysis, it is found that the high-score group students tend to comment more frequently, and the behavior probability of reviewing after collecting questions and viewing the answer after a review is higher, while the low-score group students tend to do new questions after reviewing. Based on this, the study suggested that in the after-class exercises:1. Students should be guided to participate in peer learning and mutual help behaviors. 2. Students should be guided to actively carry out knowledge review, and the teaching platform should push practice explanation to help students improve learn programming effects.

Keywords: Learning behavior, Programming learning

1. Introduction

With the development of smart-phones, tablets, and wireless mobile communication terminals, mobile learning has increasingly become a free and convenient way to learn. In traditional programming learning, debug is proved to be an effective way to improve students' programming skills (Hwang, Shadiev, Wang, & Huang, 2012). However, in the mobile learning environment, it is not suitable for students to debug on tables.

The data of learning behavior is the data generated by the learner during the learning process, such as the number of clicks, length of study, the progress of learning, and activity (Ji & Han, 2019), which can reflect the student's learning and learning characteristics (Zheng, Jiang, Yue, Pu, & Li, 2019). The method of analyzing these behavioral data is called learning behavior analysis that focuses on collecting traces that learners leave behind and using those traces to improve learning (Verbert & Duval, 2012). It can help teachers to understand students' learning situation and learning style, judge their enthusiasm for learning, position their roles, and provide important teaching intervention methods (Ji & Han, 2019). Studies have shown that in programming learning, learners' behavior in programming is often considered as a key factor for assessing how effective a methodology is for learning programming skills (Del Fatto, Dodero, & Gennari, 2016).

The mobile learning environment has a large amount of unstructured data that can store student learning behavior in the form of data records on the platform. Based on this, this study aims to collect college students' programming learning behaviors by using mobile practice Application, and to analyze college students' after-class practice strategies by analyzing the differences in behavior patterns of students with different learning levels, and to provide intervention strategies for teachers' after-class practice guidance.

2. Literature Review

2.1 Programming learning

At present, there are many learning platforms for assisting programming learning to enhance learning effects. Zingaro, Cherenkova, Karpova, and Petersen (2013) used the Python classroom response system, which teachers can use to give students questions during class. The types of questions include multiple-choice questions and code-writing questions. When the student submits the answer, the system will automatically provide immediate feedback on the type of error of the student according to a set of rules. The teacher can view the answers and feedback submitted by the student in real-time, so as to adjust his teaching plan in time. Students can gain the key skills of code writing through problem-solving skills and the ability to write code and debug code. Students and teachers can also communicate and discuss certain issues in the classroom. Hoffman, Lu, and Pelton (2011) used a web-based quiz system c-doku to provide students with a large number of code snippets, allowing students to fill in the input and output by reading the code. The system automatically checks the solution to provide feedback, which improves the student's code reading ability. The learning platform built by Basu, Biswas, and Kinnebrew (2017) provided students with programming blocks (e.g., conditions and loops) and hypertext resources (e.g., science books and programming guides). The platform let students practice conceptual concepts such as abstraction and decomposition by constructing conceptual models and computational models. The system also provides multiple-choice exercises, instructor guidance and suggested resource pages.

Most of these platforms provide students with questions, answers, communication, and other learning resources. At the same time, from the application scenarios of these teaching platforms, researchers pay more attention to learning or phased tests of the course, and rarely apply them in after-class exercises. In fact, after-class exercises are an important part of programming learning. After-class exercises can improve learning effects through test effects. Test effect means that taking the same time to test the learning materials that have already been learned, instead of repeating the learning, the learning effect of the material will be better.

In most universities in China, the programming course hours for non-computer majors are usually 2 to 4 hours per week. The first two hours are taught by the teachers, and the last two hours are programming exercises by students. However, it is not enough to practice only by the time of the class. Students not only have to practice new knowledge but also review and consolidate existing knowledge. This requires students to spend more time and practice a lot under the class. Therefore, the study of students' after-class programming practice strategies is of great value in improving students' programming ability.

2.2 Learning behavior analyze

learning behavior analysis focuses on collecting traces that learners leave behind and using those traces to improve learning (Verbert & Duval, 2012). The learning behavior analysis method has been initially applied to programming learning and has achieved some results. For example, by recording the information search behavior of the programming learners on the online discussion forum, it is found that the general programming learners indeed seek for information from discussion forums by actively searching and reading progressively according to course schedule topics. But compared to novices, advanced students consistently perform query refinements, examine search results and commit to reading (Lu & Hsiao, 2017). By recording the six types of learning behaviors in collaborative programming learning activities including completely independent, self-improving using, performing poor without, confident after, imitating, plagiarizing, it is found that learning behavior has a certain relationship with academic achievement(Hwang, Shadiev, Wang, & Huang, 2012).

A major obstacle to applying learning behavior analysis methods in the programming domain is the lack of meaningful observable actions for describing the students' learning process (Lazar, Sadikov, & Bratko, 2017). The learning behaviors associated with programming learning found in current research usually include the total amount of learners' exercises, the number of correct and wrong attempts, and the scores of exercises. For example, Spacco, Denny, Richards, Babcock, Hovemeyer, Moscola, and Duvall (2015) collected the number and percentage of students' try and practice, the

number and the percentage of submission exercises from the platform of the CloudCoder novice programming exercise. It was found that the more times students try to practice, the better the ability of students' programming. Norris, Barry, Fenwick, Reid, and Rountree (2008) used the ClockIT toolkit to collect the event of students' project open or close events, package open or close events, compilation success, compilation error, compilation warning, invocation, file change or delete. It was found that the percentage of compilation errors and the type of compilation errors appear to relate to the student s performance on the project. Edwards, Snyder, Pérez-Quiñones, Allevato, Kim, and Tretola (2009) used the web-CAT automated scoring programming exercise platform to collect students' number of Submissions, time of the first submission, time of last submission, total elapsed time, and amount of code written. It is found that the first and last submissions of the high score students are earlier than the low score students.

Combined with the common functions of the programming learning platform, it can be found that there are more researches in programming learning itself, but other factors such as feedback, monitoring, and socialization in the programming learning process will also have an impact on learning. Therefore, reviewing answer, viewing explanation and other helpful feedback behaviors, collecting, review and other self-monitoring behaviors and comments, likes, and other social behaviors in the process of doing the new questions, are worth further exploration. Analyzing these behaviors will help to improve the student's programming learning with the exercises, especially to determine the sequence relationship between these behaviors, and to provide appropriate support strategies at the right time.

3. Research design

3.1 Research Platform

The study selected the mobile application DQuiz (Daily Quiz) for programming learning (Zhang, Li, Zhou, & Chen, 2019). The application supports students to conduct multiple-choice exercises after class and collects various types of programming learning behaviors. The core functions of the system are daily exercises, viewing answers, viewing explanation, collecting question, comment and like. After the student submits the answer, the system will immediately give correct and incorrect feedback. Students can only continue to choose whether to view the correct answer or view the explanation after submitting an answer. Students can also collect the title, and the collected questions will be automatically generated into the collection area. Students can view the questions in the collection area at any time. The collection question is a way of marking the question, which is convenient for the student to view the question next time.

3.2 Research Data and Method

In order to gain a deeper understanding of how students learn, especially if there is a difference in learning patterns. This study used lag sequence analysis to analyze students' learning behavior. Lag sequence analysis was proposed by Sackett (1978) to explore human behavior patterns by analyzing the significance of a behavior occurring after another behavior. This study encodes students' behaviors during the practice process, including seven behaviors, namely, doing new questions, reviewing, reviewing answers, viewing answer analysis, collecting questions, comment and like. The specific behavioral descriptions are shown in Table 1.

Table 1

Post-class practice behavior description

Behavior	Encode	Description
New Questions	NP	Students click the <Submit> tab to practice a new question.
View Answers	VA	Students click the <View Answers> tab to view a question's answer.
View Explanation	VE	Students click the <View Answers> tab to view

Collect Question	CQ	Students click the <Collect Question> tab to collects a certain topic.
Review	RE	Students click the <Submit> tab to practice the question again.
Comment	CM	Students click the <Comment> tab to ask questions or comments on a topic.
Like	LK	Students click the <Like> tab to like a comment.

3.3 Teaching Experiment

The study selected 74 freshmen from a university participating in the C language programming course, including 27 boys and 47 girls. These students are non-computer majors, which have no experience in programming. All students receive the same teacher's teaching at the same time and complete the same required after-class assignments. All students complete their studies in a natural state.

4. Result

4.1 Basic Situation

According to the final grades, the study divided the first 27% and the latter 27% of the students into high-score group and low-score group to study the differences in the behavioral patterns of the two groups of students. There were no significant differences between the two groups in terms of the number of new questions, online learning time, and programming basics (5-point scale).

Table 2

Student basic situation table

| | M | | T |
	Low-score group	High-score group	
Pre-test (programming basics)	1.64	2.27	1.761
Number of new questions	223.25	224.70	1.237
Online learning time	10.71h	15.81h	1.640
Final exam score	59.05	94.51	14.018***
Number of exercises	22.15	30.06	1.646

4.2 Programming Learning Behavior Frequency

From the frequency of the behavior, high-score group students and low-score group students have no significant difference in the frequency of reviewing, viewing answers, viewing explanation and collection. According to the frequency of comments, the high-score group students were significantly higher than the low-score group students ($p > 0.05$). Therefore, simply commenting and liking in the multiple-choice questions can help improve the learning effect. The frequency of other learning behaviors is not obvious, even on viewing answers and viewing the analysis of answers, low-score group students are higher than high-score group students.

Table 3

Independent sample t-test analysis of learning behavior frequency by knowledge score

Behavior frequency	M		Final exam score
	Low-score group	High-score group	T
New Question	65.3	70	0.193
View Answer	12.05	26.15	2.187*
View Explanation	61.7	41.8	-1.632
Collect Question	78.25	56.1	-1.757
Review	20.6	28.3	1.394
Comment	65.3	70	0.193
Like	12.05	26.15	2.187*

4.3 Programming Learning Behavior Pattern

The study defines a behavioral transformation into another behavioral sequence. After analyzing and summarizing 49 pairs of behavioral sequences, GSEQ (Generalized Sequential Querier) is used to statistically predict the probability of occurrence of student behavioral sequences (Z-score). And the study select the significant behavior ($z > 1.96$) to draw the behavioral sequence conversion diagram of the two groups of students, more intuitively understand the difference in learning behavior patterns between the two groups of students as shown in Figure 1. The nodes in the graph represent behavior. The direction of the arrow indicates the direction of the behavior transition. And the number on the arrow indicates the Z-score of each behavior sequence.

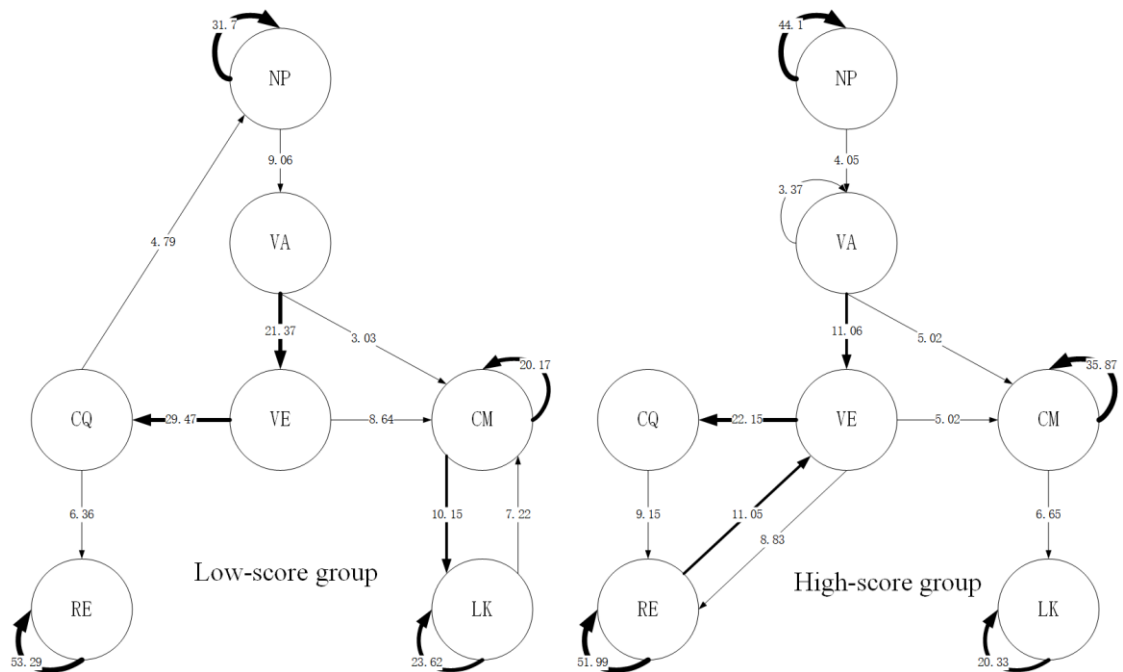*Figure 1.* Low-score group (left) and high-score group (right) learning behavior transition map

It can be seen from the figure that the high-score group and the low-score group are basically similar in the behavior sequence, and can be summarized into several main behavior patterns.
(1) Doing new questions in a row: Do new question (NP)-do new question (NP). It complete new problems in a row.

(2) Do new questions and understand them: There are two paths: do new question (NP) - view answer (VA) - view explanation (VE)- comments (CM) - like (LK) and do new question (NP) - view answer (VA) - view Explanation (VE) - collect question (CQ). The subjective efforts of the former are more obvious, and the latter relies more on the automatic solution of the system.

(3) Review Questions: There are two paths: a continuous review (RE-RE) and review (RE) - view explanation (VE) - collect question (CQ) - review (RE).

However, in the above three aspects of behavior patterns, high-score group and low-score group are slightly different:

(1) Doing new questions in a row. The probability of high-score group students' behavior is higher than that of low-score group. It can be inferred that the high-score group students' first-time correct rate is higher so that the behavior sequence of doing the new question is less interfered by the error feedback.

(2) Do new questions and understand them. High-score group and low-score group behave differently after collect question (CQ) and comment (CM). Low-score group students will do new question (NP) after collecting question (CQ), while high-group students are more likely to enter the review (RE) after collecting question (CQ). Because in daily teaching, students often collect the wrong topics and review them later. The learning behavior pattern of collecting question and then doing new questions reflect that the students in the low-score group are more likely to wait for the teacher to explain in the class. On the contrary, the high-score group students tend to review and deepen the impression. Low-score group are significantly more interactive between comments and likes than highs. Because the practice frequency of low-score group is less than the high-score group, it means that students are more inclined to do many exercises in one time. Relatively speaking, the high-score group is a kind of decentralized learning and more frequent practice questions, which is also in line with the testing effect.

(3) Review Questions: High-score group students are more inclined to review (RE)-view explanation (VE)-collection question (CQ)-review (RE). During the review, the high-score group will often view the explanation (VE), forming a closed-loop of review. Answer explanation often explains the error in more detail and describes the knowledge of other option designs. This behavior pattern also reflects the behavior of high-score group students deep understanding exercises.

5. Research Conclusions and Recommendation

This study analyzes the frequency and sequence of high-score group students and low-score group students' learning behavior in one-semester practice. From the frequency of learning behavior, the more comments and likes, the better the learning effect, but not in reviewing, viewing answers, viewing explanation and collecting question, even low-score group students view answers and view explanation more frequently than high-score group students. This shows that participation in social learning can effect positively, but complete personal learning has limited effect on programming learning even frequently viewing answers effect negatively. From the perspective of the learning behavior sequence, the high-score group students tend to review after collecting the questions compared to the low-score group. The collected question is generally a wrong question or a difficult problem. After the collection, more review has been carried out, reflecting the timely consolidation and exploration of the problem by the high-score group. It's also important to look at when students view the explanation. Although the low-score group tend more frequently view explanation than the high-score group, the high-score group is more significant in behavior from review to view explanation and from view an explanation to review, indicating the importance of view explanation when review. Answer explanation is a more deeply explanation and combing than the answer, which can prevent students from being guess question correctly or misunderstood. For procedural knowledge such as c language, the learners tended to review the explanation of the question and re-answer it.

Based on the above conclusions, this study proposes the following two suggestions for the after-class exercises of programming learning.

(1) When practicing after class, it is very important that teachers and students, students and students communicate around the exercises. With the development of smart systems, the general teaching platform provides diagnostic feedback to help students answer relevant exercises, but this is not a substitute for communication between people. In the discussion area of the question, students can express their doubts, and teachers and students can give targeted explanations. Some of the possible reasons for doing question wrong are that knowledge is not mastered or the other details are not careful.

This question cannot be resolved from viewing the answer or viewing answer explanation. Free speech around the question enables students to achieve a transition from passive acceptance to active learning. (2) When practicing after class, the teacher should grasp the timing of the presentation of the answer explanation, and students should be encouraged to view explanation when reviewing. In normal teaching, there always exits situation that the teacher thinks that the student is mastered and the student is embarrassed to say no, or that the student does not realize that he or she does not master. Therefore, on the one hand, when the students review the question in the teaching system, the teaching system can actively present explanation. This will not make the students lose the opportunity to answer again because of viewing explanation, but also allow the students to prove their ideas when they are right. On the other hand, if there is no teaching platform, the teachers can also analyze the detailed answers explanation to the students by mail, group, etc.

Acknowledgements

References

Basu, S., Biswas, G., & Kinnebrew, J. S. (2017). Learner modeling for adaptive scaffolding in a computational thinking-based science learning environment. User Modeling and User-Adapted Interaction, 27(1), 5-53.

Del Fatto, V., Dodero, G., & Gennari, R. (2016). How measuring student performances allows for measuring blended extreme apprenticeship for learning Bash programming. Computers in Human Behavior, 55, 1231-1240.

Edwards, S. H., Snyder, J., Pérez-Quiñones, M. A., Allevato, A., Kim, D., & Tretola, B. (2009). Comparing effective and ineffective behaviors of student programmers. In Proceedings of the fifth international workshop on Computing education research workshop (pp. 3-14). Berkeley, USA: ACM Press.

Hwang, W. Y., Shadiev, R., Wang, C. Y., & Huang, Z. H. (2012). A pilot study of cooperative programming learning behavior and its relationship with students' learning performance. Computers & education, 58(4), 1267-1281.

Hoffman, D. M., Lu, M., & Pelton, T. (2011). A web-based generation and delivery system for active code reading. In Proceedings of the 42nd ACM technical symposium on Computer science education (pp. 483-488). Dallas, USA: ACM Press.

Ji, Y., & Han, Y. (2019). Monitoring Indicators of the Flipped Classroom Learning Process based on Data Mining-Taking the Course of" Virtual Reality Technology" as an Example. International Journal of Emerging Technologies in Learning, 14(3), 166-176.

Lazar, T., Sadikov, A., & Bratko, I. (2017). Rewrite Rules for Debugging Student Programs in Programming Tutors. IEEE Transactions on Learning Technologies, 11(4), 429-440.

Lu, Y., & Hsiao, I. H. (2017). Personalized Information Seeking Assistant (PiSA): from programming information seeking to learning. Information Retrieval Journal, 20(5), 433-455.

Norris, C., Barry, F., Fenwick Jr, J. B., Reid, K., & Rountree, J. (2008). ClockIt: collecting quantitative data on how beginning software developers really work. In Proceedings of the 13th annual conference on Innovation and technology in computer science education (pp. 37-41). Madrid, Spain: ACM Press.

Sackett, G. P. (1978). Observing behavior: I. Theory and applications in mental retardation. Oxford, England: University Park.

Spacco, J., Denny, P., Richards, B., Babcock, D., Hovemeyer, D., Moscola, J., & Duvall, R. C. (2015). Analyzing Student Work Patterns Using Programming Exercise Data. In Proceedings of the 46th ACM Technical Symposium on Computer Science Education (pp. 18-23). Kansas City, USA: ACM Press.

Verbert, K., & Duval, E. (2012). Learning analytics. Learning and Education, 1(8).

Zheng, S. Y., Jiang, S. P., Yue, X. G., Pu, R., & Li, B. Q. (2019). Application Research of an Innovative Online Education Model in Big Data Environment. International Journal of Emerging Technologies in Learning, 14(8), 125-138.

Zhang L., Li B., Zhou Y., Chen L. (2019) Can Fragmentation Learning Promote Students' Deep Learning in C Programming?. In: Chang M. et al. (eds) Foundations and Trends in Smart Learning. Lecture Notes in Educational Technology. Springer, Singapore

Zingaro, D., Cherenkova, Y., Karpova, O., & Petersen, A. (2013). Facilitating code-writing in PI classes. In Proceeding of the 44th ACM technical symposium on Computer science education (pp. 585-590). Denver, USA: ACM Press.

A preliminary investigation of the features of the communication software assisted design thinking based learning

Guan-Chen LIU[ab*], **Chih-Hsiang KO**[a]

[a]*Department of Design, National Taiwan University of Science and Technology, Taiwan*
[b]*visual communication design, JinWen University of Science & Technology, Taiwan*

Abstract: The purpose of the present study is to preliminary understand the efficiency of implementing technology (communication software) to foster student's learning of visual identity and branding design in order to cultivate their design thinking implicitly. A total of thirty-six students who major in visual communication design participated in this study. Students who took a corporate identity design course were choose to be the participants. To probe their view of implementing communication software (Line and Facebook group), three open-ended questions about the assistance, advantage, and disadvantage of incorporating the two communication software were asked through an online questionnaire. Moreover, coding frameworks were derived based on students' responses in order to induct their replication and to help researcher grab a clearer picture of students' perspectives towards the application of communication software in the course. Results show that the convenience and the immediacy of communication software are the features that students mostly take advantages of. This is to some extent consistent to the viewpoint about information technology. Meanwhile, students reported most frequently of the disadvantages of the distraction, and provides various defects about incorporating communication software during learning.

1. Introduction

The rapid development of information technology today make the integration of information technology into instruction a very important part of current education. The so-called information technology integration teaching is to use information technology in courses, teaching or teaching materials, and to use information technology as an auxiliary tool to help teaching activities to be carried out more efficiently (Dexter, Anderson & Becker, 1999; Dias, 1999). Using the universality and convenience of information technology and mobile vehicles, students can use the Internet to assist in learning and learn more through the Internet at any time and any place, helping students to solve problems more efficiently. At the same time, teachers can also assist in teaching through the convenience of information technology and enhance the immediacy of communication between teachers and students through information technology (Ezziane, 2007). On the other hand, "design thinking" is a thinking skill that is good at planning and perfect for design, with creativity as the center and problem solving as the core goal. Design thinking consists of three parts of thinking skills - "brainstorming method", "level thinking method", and "vertical thinking method". Brainstorming (BS) method, which is a method to stimulate creativity, stimulate association, and strengthen thinking skills. Because it emphasizes the idea of "jumping out" from the subconscious, rather than consciously thinking of a plan, it is considered an effective creative thinking skill (Bowkett, 2005). Vertical Thinking is a traditional way of thinking logically, also known as convergent thinking or logical thinking. It starts with known theories, experience and knowledge. It is believed that through vertical thinking, people can explore in depth and explore the deepest answers. Lateral Thinking, which was proposed by Edward de Bono (1992), which focus on combining perception and logic to solve problems.

To understand student's opinion about the efficiency of technology (i.e. communication software) apply in a design course, two research questions was formed to fulfill the research purpose as follows:

Research question 1: How do communication software (Line and Facebook group) assisted students' learning?

Research question 2: What are the advantages and disadvantage of communication software (Line and Facebook group)?

2. Literature Review

2.1 Information Technology assisted instruction

The integration of information technology into instruction refers to implement technology tool into the course, teaching or learning materials in order to foster teaching efficiency. The focal point of incorporating information technology into instruction is to promote student-centered as well as autonomous learning, and to stimulate the innovation of teaching approaches ((Dexter, Anderson & Becker, 1999; Dias, 1999; Wang, 2010). Moreover, it is argued that the innovation and the diversification of teaching approaches could be nurtured through employing technology to cultivate students' thinking skills, critical ability, creative ability, and problem-solving ability (Wang & Huang, 2001). Wang (2001) further elaborated the superiority of using technology in the learning context could facilitate the diversity and interactivity of learning material, and thus contribute to a more down-to-earth and flexibility of teaching content. In summary, student' learning motivation could be activate through abundant learning content and the way of learning.

Taking the advantage of conveniences, information technology and mobile device allow students to learn from the Internet. Furthermore, the efficiency of solving problems could also be more enhanced since many works can be done without time and space limitation. Simultaneously, teaching could be assisted by technology to promote the immediacy of the communication in teacher-student interaction (Ezziane, 2007). However, the information technology still has its limitation. For example, Ou Yang, Yin & Chang(2007) advocate the information technology should be used appropriately, or the learning achievement can be reduced due to the unsuitable application. To evaluate the suitability of applying information technology into the learning context, Stosic (2015) raise five criterion: whether it quipped with educational significance, whether it allow students to participate the teaching activity, the usability is it easy to use? The degree of interaction between information technology and students, and the allowing to track students' learning progress.

2.2 Design Thinking

Design is a creative act, and planning is a way of doing things with systematic logic. The core goal of "Design thinking" is being able to master the design, and meanwhile focusing on creativity and solving problems (Han, 2012). The so-called thinking includes the application of the strategy, the way the problem is solved, the focus of the goal and the decision of the design (You Shiyi, 2013). There are three parts, namely, "brainstorming method", "lateral thinking method" and "vertical thinking method". The Brainstorming (BS) method is a method designed to stimulate creativity, motivate association, and strengthen thinking skills. It is considered an effective creative thinking skill because it emphasize on the idea of subliminal "jumping out" rather than consciously come up with a plan (Bowkett, 2005). Lateral Thinking, which was proposed by Edward de Bono (1992), he believes that there are many kinds of thinking in the world, which are the combination of perception and logic. Therefore, the perception and creativity developed through horizontal thinking are indispensable. Vertical Thinking is a traditional way of thinking logically, also known as aggregating thinking or logical thinking. It is based on known theories, experience and knowledge (Yu, 2013). Through vertical thinking, people can explore in depth and explore the deeper answers to questions. However, this way of thinking is easy to draw, and sometimes it ignores the possibility of another orientation. It may also hinder the development of new thinking, accept new ideas, and easily lead to inert thinking, that is, unwillingness. Discarding existing ideas and causing stagnation of thinking

3. Methodology

To fulfill the aims of the present study, a purposive sampling method was adopted. Students in a corporate identity design course were choose to be the participants. This course lasts for one semester, and the students filled out a questionnaire in the last class. The details of research design are elaborated in this section.

3.1 Participants

A total of thirty six college students involved in this study. Their major is visual communication design, which training students to visualize messages and ideas with graphic design, packaging design, corporate identity design, environmental visual design, typesetting and related applications.

3.2 Course

The objective of the course is to help students understand the principles and applications of visual identity and branding design. This course is oriented towards design and creation, and focuses on the combination of visual symbols and application media. The course lasts for 18 weeks, once a week for two hours. At the end of the period, there will be a grouping to participate in the competition. Through the classroom application of the Facebook community and the Line group discussion, timely feedback and interaction was realized.

3.3 Tools

For understanding student' view about using communication software in their learning, a questionnaire with three questions were distributed through online Google questionnaire. First, for the assistance of communication software, students were asked a question: "How did find the assistance of using communication software during your learning?" Second, for the advantage of communication software, students were asked a question: "How did find the advantage of using communication software during your learning?" Last, for the disadvantage of communication software, students were asked a question: "How did find the disadvantage of using communication software during your learning?"

On the other hand, two communication software- Facebook and Line group function were used simultaneously in the course. Both of these two communication software quipped with group forming function that allow related members to join in for specific discussion topic or intention. However, there are some different features between Facebook group and Line group. Facebook group provides a platform for users to share multiple representations (e.g. text, video, links, etc.) and allow other members to leave their comments under the post, whereas Line group is more like a message software that provide instant contact although it shares the above-mentioned similar functions with Facebook. Therefore, Facebook was choose to let the students upload their works and comment on each other's work or share ideas, while Line was used to solve problems in a timely manner, or follow students' work progress. The interface of the two communication software and the actual implementation are shown in *Figure1*.
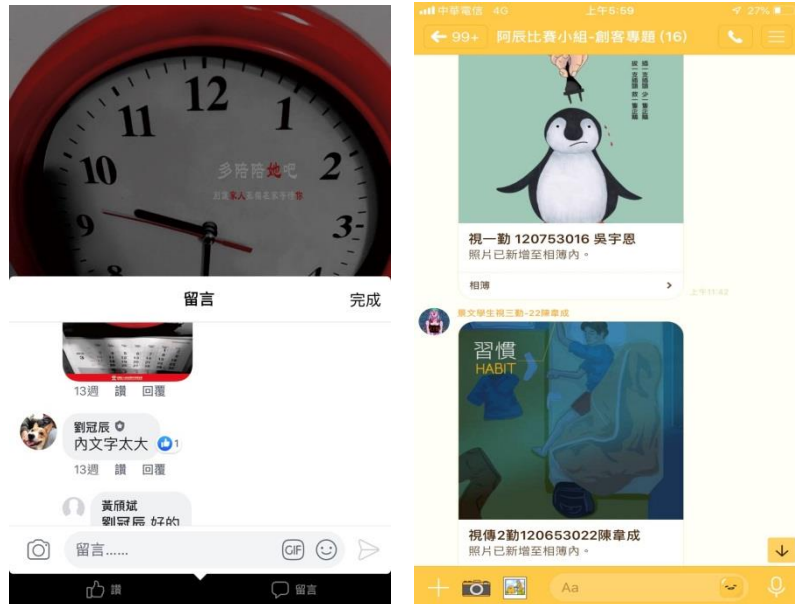
Figure 1. The screenshots of using communication software into instruction. Facebook group (left picture) function was primly adopted for students to post their works on, and leave comments on each other's work or share ideas. Line group (right picture) was used to instant contact to solve problems or track students' progress.

4. Data collection and analysis

4.1 Data Collection

An online Google questionnaire with three open-ended questions was distributed to students at the last class. The students responded to the questions according to their experience and feeling about using Facebook and Line software in the class during the whole semester. After answering each question, they have to click a button to send out their responses. It will not be able to send the questionnaire with missing any of the questions. As soon as they send out the questionnaires, the teacher will immediately receive the responses in an online form.

4.2 Data Coding

To code student's responses, three coding frameworks were formed based on the data. For the assistance of communication software, based on students' responses, four categories were identified: convenience (C), immediacy (I), peer learning (PL), and others (O). Table 1 shows the coding framework of the assistance of communication software.

Table 1

The Coding Framework of Students' Responses to the Assistance and Advantage of Communication Software

Main category	Code	Example
Convenience	C	Assistance: Easy to contact and receive the message. Advantage: It is convenient and clear to communicate clearly what the teacher's requirements are.
Immediacy	I	Assistance: I can know immediately what works should to be handed in and accomplish. Advantage: Get first-hand information quickly, and also prevent paper information from getting lost.

486

Peer Learning	PL	Assistance: Because you can discuss online. Advantage: I can know how others designs
Other	O	Assistance: Modern trend. Advantage: Could be integrate into daily life.

As for the advantage of communication software, students were asked a question: "How did find the advantage of using communication software during your learning?" In this part, students' response were similar to the previous question about the assistance of communication software. Thus, the coding work of student' responses to the advantage of communication software shared the same framework with the response to the assistance of communication software.

Regarding the disadvantage of communication software, also based on student' responses, four main categories were identified: Distraction (D), Inconsistency (I), None (N), and Other (O). Table 2 shows the coding framework of the disadvantage of communication software.

Table 2

The Coding Framework of Students' Responses to the Disadvantage of Communication Software

Category	Code	Example
Distraction	D	1. It is to be distracted.
None	N	1. None.
Other	O	1. It is not necessarily everyone is online at any time, it may take an hour or even a day to receive a reply. 2. When the signal is unstable and the website is down, the schedule of the progress is affected.
Inconsistency	IC	1. I don't know if I really communicated to each other. 2. If you discuss the work with the teacher, you will have no way to understand the meaning of the teacher.
Missing information	M	1. If I turn off the reminder and I will miss the new information.
Chaos	C	1. Sometimes it's not clear, which information is matched with that file, sometimes it's a bit confusing.

5. Results

To answer the research questions, students' responses were coded based on a framework which derived from the response data. The results of the two research questions are aggregated in Table3. For research question 1, students' report about the assistance of implementing communication software during the course were coding and count. Results show that the most frequently reported assistance of communication software in the class is convenience (count: 14, percentage: 39%), following by Immediacy (count: 14, percentage: 36%), Peer learning (count: 3, percentage: 8%), and other (count: 6, percentage: 17%). This result may indicate that students believe that the most direct help from the communication software is convenience and immediacy.

For research question 2, students responses to the question about the advantage of incorporating communication software are convenience (count: 19, percentage: 45%), following by Immediacy (count: 13, percentage: 31%), Peer learning (count: 6, percentage: 14%), and other (count: 4, percentage: 10%). The revealed result seems to be similar to the results of the previous question, that is, the rank of the code are in the same order. However, a slight difference could be found that the count and percentage are distributed vary from the responses of the first question. In other words, although the rank order are same, the distribution of percentage of each item between assistance and advantage is

distinct. This may attributed to that the provided responses from students can be classified into more than one category.

Table 3

The Results of Students' Responses to the Disadvantage of Communication Software

	Code	Count	Percentage
Assistance	C	14	39%
	I	13	36%
	PL	3	8%
	O	6	17%
Advantage	C	19	45%
	I	13	31%
	PL	6	14%
	O	4	10%
Disadvantage	D	2	5%
	N	11	31%
	O	15	42%
	IC	3	8%
	M	3	8%
	Ch	2	6%

As for the disadvantage of communication software applied in the class, students report the mostly reason is other (count: 15, percentage: 42%), following by none (count: 11, percentage: 31%), inconsistency (count: 3, percentage: 8%), m (count: 3, percentage: 8%), chaos (count: 2, percentage: 6%) and distraction (count: 2, percentage: 6%). These results may imply that students aware more various disadvantages of the communication software than the assistance and the advantages. Nevertheless, most of the students also sense that there is no disadvantage of using the communication software during their learning.

6. Discussion and conclusion

Through the preliminary collection and analysis of students' views on the integration of technology into communication technology (communication software), we can find that the most directly felt benefit is the generally recognized characteristics of information technology—convenience and immediacy. As Ezziane (2007) pointed out, students can break through the limitations of time and space for more efficient learning by using the universalization and convenience of information technology and mobile vehicles. Teachers can also use information technology to enhance the immediacy of communication between teachers and students. On the other hand, the mixed shortcomings of using the communication software also received from students. Future work could be devoted to a larger sample, and compare to different groups.

References

Bowkett, S. (2005). *100 ideas for teaching creativity*. New York: Continuum.

Cross, N. (1999). Natural intelligence in design. Design Studies, 20(1), 25-39.

de Bono, E. (1992). *Serious creativity: Using the power of lateral thinking to create new ideas*. Scranton, PA: HarperBusiness.

Dexter, S. L., Anderson, R. E., and Becker, H. J. (1999), Teachers' view of computers as catalysts for changes in their teaching practice, *Journal of Research on Computing in Education*, 31(3), 221-239.

Ezziane, Z. (2007). Information technology literacy: Implications on teaching and learning. *Educational Technology and Society*, 10(3), 175-191.

Han, P. T. (2012). *She Chi Shing Su Kao [Designing Type of Thinking]*. Taipei: Linking Publishing.

Ou Yang, Y., Yin, M. C., & Chang, C. C. (2007). From Theory to Practice-The Curriculum Design and Learning Effects of Integrating Information Technology into Instruction for Pre-service Teachers. *Ko Cheng Yu Chiao Hsueh*, *10*(1), 97-110.

Stošić, L. (2015). The importance of educational technology in teaching. International Journal of Cognitive Research in Science, Engineering and Education (IJCRSEE), 3(1), 111-114.

Torrance, E. P. (1965). Rewarding creative behavior. Englewood Cliffs, NJ: Prentice-Hall.

Wang, C. H. (2010). Narrative Research on the Implementation of Educational Policies for Technology Integration. *Chiao Yu Shih Chien Yu Yen Chiu*, *23*(1), 31-56.

Wang, Y. T., & Huang, C. C. (2001). The Investigation of Technology Integration into Teaching. *Sheng Huo Ko Chi Chiao Yu Yueh Kan*.

Yu, S. P. (2013). *Visual-Brainstorming Research-At the Industrial Design Sketch Concept Stage*. (Unpublished master's thesis, National Taiwan Normal University, Taipei, Taiwan). Retrieved from https://ndltd.ncl.edu.tw/cgi-bin/gs32/gsweb.cgi/login?o=dnclcdr&s=id=%22101NTNU5619016%22.&searchmode=basic

A Systematic Analysis of Chinese Reviews of Flipped Classroom

Meilun SHIH[a*] & Feng-Ru SHEU[b]
[a]*Center for General Education, National Taiwan University, Taiwan*
[b]*Universtiy Libraries, Kent University, USA*
*mshih@ntu.edu.tw

Abstract: Flipped classroom (FC) is a recognized and popular approach of teaching and learning in the field of education. However, the large body of studies make it difficult to access a comprehensive summary of available evidence to evaluate the impact and effective implementation of FC. The aim of this review of reviews is to explore two questions: 1) What are the trends of FC studies that were identified in reviews in the last decade? 2) What are the trends of Chinese FC reviews that were conducted in the last decade? Results of this review can be used to guide future interventions and implementation in the field.

Keywords: Flipped classroom, systematic review

1. Introduction

Flipped classroom (FC) is a new and popular way of teaching and learning that has attracted extensive scholarly attention in the field of education (Akcayir & Akcayir, 2018). Since 2010, a significant number of articles related to FCs have been published; not only in North America, but around the world. In China, the first FC study in Chinese academic journal database CNKI was published in 2012 and the number of related studies rocketed in next few year. For a field to continuously progress, it is important to be aware of its developmental patterns in the past to obtain insights for future implications (Dwivedi, Venkitachalam, Sharif, Al-Karaghouli, & Weerakkody, 2011). Given the promising potential of FC, systematic reviews are essential for revealing information about the trend and impact of flipped approaches in China. However, each review has its own scope and comprehensiveness (Law, Leung, & Cheung, 2012). For example, when a review focuses on providing a thorough background, it might miss more recent developments. Based on the different perspective of examination of each review, different set of studies might be selected and different analysis results would be generated at the end. This study identifies this gap in previous reviews and aims to provide a more comprehensive glimpse of FC development in China through the lens of a review of reviews. It also aims to mark the development of FC reviews conducted in the past decade in hope to classify the process of possible directions for future research.

More specifically, the purpose of current study is to systematically examine relevant Chinese reviews concerned with FC that were published during the last decade. This review is guided by two questions: 1) what are the trends of FC studies that were identified in reviews in the last decade? 2) what are the trends of FC reviews that were conducted in the last decade?

2. Method

2.1 Inclusion and Exclusion Criteria

The quality of the included reviews is an important consideration for review study. There are several criteria can be used to select articles. For example, use articles that are published in journals which are indexed in profound databases like SSCI, use articles published in one or several leading journals in a field, or use articles with highest citation rate. For this study, we select articles that were published in journals included Chinese Social Science Citation Index (CSSCI). CSSCI is an interdisciplinary citation index for Chinese journals. It was developed by Nanjing University in 2000. More than 500 journals of

humanities and social sciences are included in CSSCI. Because of the high quality of published papers, many leading universities in China use CSSCI as an evaluation indicator for faculties' academic performance or promotion. We use CNKI platform to access CSSCI database and search for papers.

2.2 Search Strategy and appraisal

The search took place in May 2019. Chinese reviews about FC were selected from journals in the CSSCI database. Key search titles and terms like "flipped classroom", "inverted classroom", "literature review", and "systematic review" in Chinese are used for paper selection. After the searching process, each article was examined by researchers to check abstract, or full article if necessary, for the suitableness for the purposes of this study. The final sample size retained for data analysis for this study was 18.
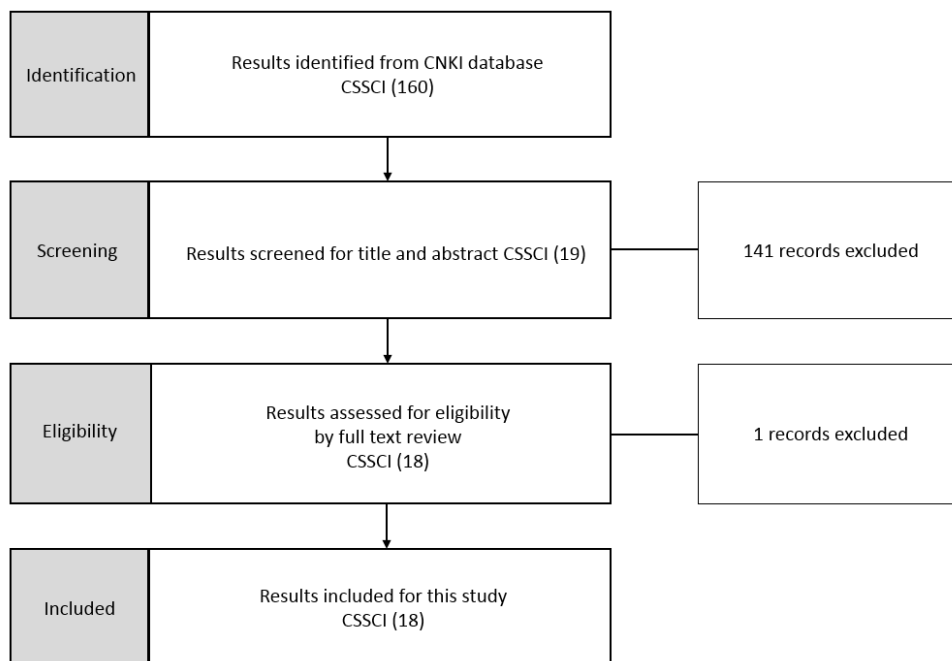
Figure 1. Flow chart of the selection of articles in the review process

Data was independently reviewed by researchers using a standardized form to extract information such as publication year, research method, and review results. See Appendix A for the whole list of reviews included in this study. Generated themes from the results of these reviews were categorized into more comprehensive groups based on their similarities. Different opinions between two researchers were further discussed until a consensus was reached.

3. Result

3.1 General characteristics of the FC studies

3.1.1 Keyword clustering

Thirteen out of the 18 FC reviews conducted keyword cluster analysis. Among the 13 reviews, eight focused on Chinese FC studies, three focused on English FC studies, and two performed analysis to both Chinese and English FC studies. Table 1 shows the top ten high-frequency keywords that were identified from Chinese and English FC studies. For Chinese FC studies, "active learning" (12), "massive online open course (MOOC)" (12), and "instructional design" (11) are the three keywords with highest frequency counts. For English FC studies, "active learning" (5), "blended learning" (5), and "education" (5) were the keywords with the highest-frequency.

Table 1

The top ten high-frequency keywords in Chinese and English FC studies

Chinese Keyword	Frequency	English Keyword	Frequency
Active learning	12	Active learning	5
MOOC	12	Blended learning	5
Instructional design	11	Education	5
Information technology	10	Problem-based learning	4
Teaching model	10	MOOC	4
Micro-courses	10	Engagement	3
Instructional videos	10	Team-based learning	3
Learning process	9	Collaborative learning	3
Classroom instruction	9	Higher education	3
Teaching innovation	9	Student-centered learning	3

3.1.2 Summary of findings in FC studies

Inductive analysis was conducted on the result, discussion and conclusion sections of the included FC reviews, and the results were showed in Table 2. Findings of FC studies that were identified in FC reviews can be categories into three sections: current situation, effectiveness of FC, and concerns of FC studies. For each main category, subcategory for more detailed findings were generated as well.

Table 2

Summary of findings of FC reviews

Main category	Subcategory	Source of review
Current situation of FC	Stable trend of FC studies	1, 7, 8
	Localization studies of FC	1, 6, 8
	Focus on empirical studies	1, 9
	Obvious core researchers and institutions	8, 9, 14
Effectiveness of FC	Positive impact on students' learning	2, 3, 13
	FC has different effect on different size of class	3
	FC is good for studying practical knowledge	4, 5
	FC has different effect on different subject learning	3
	FC has different effect on different grade level	4, 5
Concerns of FC studies	Unbalanced distribution of disciplines	1, 9, 10, 14, 17
	Insufficient empirical research and comparative research	1, 7, 11, 12, 15, 16
	Inadequate connection to theory	1, 9, 14
	Shortage of evaluation research	1, 7, 13, 16, 17
	Shortage of resource development	1, 7, 13, 16
	Small sample size	2
	Insufficient field sharing	10, 11, 17

3.2 General characteristics of FC reviews

3.2.1 Publication by year, language, and data source

Of the 18 reviews, there are 8 of them were published in 2016, 4 in 2018, and 2 in 2015, 2017, and 2019. This result corresponds to the development of FC researches in China. Ten out of 18 reviews only analyzed studies published in Chinese. Five reviews included both Chinese and English studies about FC. Three reviews published in 2015 and 2016 analyzed only English papers about FC. Chinese FC studies were usually extracted from journals that were indexed in CNKI, VIP and Wanfang databases. And English FC studies were extracted from journal that were indexed in databases like Web of Science, Education Resources Information Center (ERIC), and Google Scholar. Most reviews used academic studies as reviewed subjects, and only one review used proceeding papers from a FC conference as the analyzed subject.

Table 3

Descriptive information of Chinese FC reviews

	Publication year	Review method	Language of reviewed papers	Tool for analysis	Sample size	Chosen period
1	2019	Mix	Chinese		116	5 (2013-3017)
2	2019	Quantitative	Chinese/English	Review Manager	19	12 (2007-2018)
3	2018	Quantitative	Chinese/English	Review Manager	38	7 (2011-2017)
4	2018	Quantitative	Chinese		37	11 (2007-2017)
5	2018	Quantitative	Chinese/English		70	5 (2012-2016)
6	2018	Qualitative	Chinese	Content analysis	30+	2 (2016-2017)
7	2017	Mix	Chinese	CiteSpace	9,845	5 (2012-2016)
8	2017	Mix	Chinese	CiteSpace	356	16 (2000-2016)
9	2016	Mix	Chinese	CiteSpace	2,503	4 (2012-2015)
10	2016	Mix	Chinese/English	CiteSpace	128	4 (2012-2015)
11	2016	Mix	English	Bicomb	308	9 (2007-2015)
12	2016	Mix	English	CiteSpace	158	16 (2000-2015)
13	2016	Mix	Chinese	Bicomb	509	5 (2012-2016)
14	2016	Mix	Chinese/English	Bicomb	153	16 (2000-2015)
15	2016	Qualitative	Chinese	Bicomb	918	3 (2012-2014)
16	2016	Mix	Chinese	Bicomb	3,690	4 (2012-2015)
17	2015	Mix	Chinese	SATI Ucinet	201	4 (2012-2015)
18	2015	Mix	English	CiteSpace Bicomb	216	16 (2000-2015)

3.2.2 Research method

Research methods of FC reviews can be generally categorized into qualitative and quantitative. Qualitative methods focused on the content analysis to generate common themes among studies, and quantitative methods studies focused on numerical data. However, some qualitative studies might use quantitative data-analysis techniques such as frequency or percentage analysis to analyze data. Therefore, we broadly sorted FC reviews into three research methods: qualitative review, quantitative review, and mixed method review.

Bibliographic Items Co-occurrence Matrix Builder (Bicomb) and CiteSpace are the two main tools used in mix reviews. Half of reviews published before 2018 used BICOMB to extract and count information to generate the co-occurrence matrix and provide basic data for subsequent statistical

analysis. CiteSpace is another popular tool to visualize and analyze trends and patterns in FC studies. There are 5 reviews used it to identify topical areas, find citation hotspots, and support structural clustering of data. For reviews focused on quantitative data, two of them used Review Manager (RevMan) for data analysis. RevMan is a software that supports meta-analysis of quantitative data and presents results graphically.

3.2.3 Sample size and chosen period

The sample size of the 18 reviews varied from study to study, ranging from 19 to 9,845. Overall, quantitative reviews had sample sized less than 100 studies. This is probably because quantitative reviews required more strict criteria of selecting studies with specific data set for analysis. Mix and qualitative reviews used Bicomb or CiteSpace can directly extract bibliographic data from database, therefore, they usually included more analyzed subjects (ranged from 128 to 9.845). The majority reviews specified the chosen period in their review. The average timeframe for Chinese FC reviews are 8 years. In general, reviews focused on English or the ones included English FC studies usually had longer chosen period of reviewed subjects (with average 10.6 years).

4. Discussion

4.1 Trends of FC studies

The development of FC studies in China can be divided into four stages: introduction (2012-2013), bloom (2013-2014), growth (2015-2016), and maturity (after 2017) (Chen & Liu, 2017; Mei, 2019). Since the first FC CSSCI study was published in 2012, the number of FC study increased rapidly. The high interest of FC in China might be resulted from two reasons: 1) The 10-years educational policy of e-learning encouraged the integration of information technology in teaching, and 2) the MOOC movement in China in 2013 (Hu, Dong, & Yang, 2017). However, based on the analysis of author and institutions, the majority FC studies in China were conducted by a group of core researchers and published from Normal Universities (Bu & Kong, 2016; Zhao & Cui, 2016). This situation leads to one of the concerns that several researchers indicated in their reviews: the unbalanced distribution of discipline. As indicated Wu and Zhang's (2016) review, 86.86% of the subjects of Chinese FC studies are in related field of education. The highly centralized distribution of FC studies limits

Results of keyword analysis indicated that the number of keyword in Chinese FC studies gradually increased over the years. This means the scope and range of Chinese FC studies expend to discuss more issues of FC. The high-frequency keywords of FC studies can be categorized into four groups: learning theory (active learning and learning process), teaching theory (instructional model, teaching innovation, and classroom instruction), curriculum (instructional design), and resource (MOOC, micro-course, teaching video, and information technology). Compare to English FC studies, Chinese FC studies seem to pay more attention on the related resource and technology of delivering FC. In addition, Chinese FC studies focus more on exploring FC from the teaching perspective instead of learning perspective.

The four quantitative reviews took a thorough look at the impact of FC on teaching and learning. These reviews concluded that FC has positive impact on students' learning from many different perspectives. For example, FC has different influences on different class size, grade level, study stage, subject, and types of knowledge.

4.2 Trends of FC reviews

In respond to the rapidly arouse of FC studies in China since 2014, there was a need of systematically review FC studies to have a comprehensive understanding of trend and pattern of FC development. More than half of the FC reviews we gathered for this study were published in or after 2016. Based on the cross-tabulation analysis, FC reviews published before 2017 tended to take mix method approach. Bicomb and CiteSpace were the two most used tools to extract FC studies' bibliographic data from database. More recent reviews tended to focus on quantitative data in FC studies and used software like RevMan to statistically evaluate the impact of FC.

FC reviews in China tend to take an overall perspective to FC studies. Most of them didn't set specific criteria of paper selection. No review focused on FC studies in one certain discipline, and some of them did not specify chosen period of their reviewed subjects. The review included more than 9,000 thousand studies used only one keyword "flipped classroom" for searching. One of the possible reasons is that many Chinese FC reviews used tools like Bicomb and CiteSpace to directly extract large amount of bibliographic data from databases. These type of tools allowed FC reviews to easily perform cluster analysis and include more studies for reviews. In addition, the development of FC studies in China is less than ten years. Therefore, FC reviews tend to set no limit on searching period. However, this trend of including everything and anything leads to another concerns about FC reviews in China. While reviews which based on a large amount of studies provided an overall picture of the trend in the field, they rarely provided detailed analysis and explanation to the actual impact or implemental changes. Chinese FC reviews provided answers to who, when, where, and how questions about FC studies, but they did not provide enough information to evaluate the actual impact of FC approach on one specific area, subject, or context.

5. Conclusion

This review of reviews examined Chinese FC reviews that was published in last decade. While most reviews took mix method to analyze overall trends of FC studies, more recent reviews focused on quantitative data about the influence of FC on learning. All quantitative reviews concluded that FC has positive impact on students' learning. In addition, FC has different impact on different class size, grade level, study stage, subject, and types of knowledge. Based on the annual number of Chinese FC studies, the development of FC in China seems to reach to the stage of stable or into descended in recent two years. Although there are still concerns of unbalanced distribution of subject and insufficient empirical studies, keywords analysis revealed that the topic range in FC studies was expanded. The majority studies discussed FC from the teaching perspective instead of learning perspective. Because this review only focused on Chinese FC reviews, more comparative study about FC reviews in different language or region might provide information to further investigate whether the developmental trends of FC identified in this study are only particular findings from one context or common trends cross context.

References

Akçayır, G., & Akçayır, M. (2018). The flipped classroom: A review of its advantages and challenges. *Computers & Education*, *126*, 334-345

Chen, J., & Liu, Y. (2017). Knowledge map analysis on domestic flipped classroom research. *Digital Library Forum, 5*(9), 47-53.

Dwivedi, Y.K., Venkitachalam, K., Sharif, A.M., Al-Karaghouli, W., & Weerakkody, V. (2011). Research trends in knowledge management: analyzing the past and predicting the future. *Information System Manage, 28*(1), 43-56.

Hu, Y., Dong, Y.C., & Yang, N. (2017). Current status and trend of domestic flipped classroom research: based on CiteSpace analysis. *Higher Education Exploration, 11*, 50-57.

Jonassen, D. H., Peck, K. L., & Wilson, B. G. (1999). *Learning to Solve Problems with Technology: A Constructivist Perspective (2nd Edition)*. Columbus, OH: Prentice Hall.

Law, R., Leung, D., & Cheung, C. (2012). A systematic review, analysis and evaluation of research articles in the cornell hospitality quarterly. *Cornell Hospitality Quarterly, 53*(4), 365-381.

Mei, P.J. (2019). A meta-analysis of flipped classroom in higher education. *Higher Education of Science, 1*, 6-14.

A Systematic Literature Review of Language Learning Based on Social Media

Chang XU, Chunping ZHENG*
School of Humanities, Beijing University of Posts and Telecommunications, China
*zhengchunping@bupt.edu.cn

Abstract: Language learning based on social media has attracted increasing interest in recent years. Despite its popularity and utilization, a number of people have a skeptical attitude towards the impacts and outcomes of this emerging style of language learning. This paper provides a review of the literature on the use of social media in language learning from 2015 to 2018. A total of 17 articles were identified from 4 influential journals, *Computer Assisted Language Learning, System, Language Learning & Technology* and *ReCall.* A systematic content analysis method was employed to analyze the research directions, research purposes, theoretical foundations, research designs and learning outcomes of the selected studies. In terms of the research directions, foreign language learning and informal intercultural communication with social media are mostly discussed. With regard to the research purposes, they can be divided into two groups: from the teacher's perspective and concerning the students. Most articles explore students' language learning. As far as the theoretical foundations are concerned, among the 17 articles, 9 indicate the theoretical background clearly, and various theories are employed to support the main points. In terms of the research designs, compared with Facebook, WeChat, Twitter and other social media, language learning through blogs is the most studied. Taiwan has conducted the most research on social media-based language learning. The main outcome of these articles signifies the effects of knowledge acquisition, motivation, and intercultural communication. It is advisable that more research be done to explore the relationship between Chinese social media users such as Chinese WeChat users and their language learning.

Keywords: Social media, language learning, literature review, content analysis

1. Introduction

Unlike previous generations, today's learners are surrounded by interactive media-sharing technologies leading to different learning styles (McBride, 2009). The advent of Web 2.0 tools and various electronic devices has led to the emergence of hybrid or blended learning (Buzzetto-More & Sweat-Guy, 2006; Goertler, 2011; Graham, 2005).

Just as Dizon (2016) said, the rise of computer-mediated communication (CMC) and Web 2.0 technologies such as blogs and social-networking sites (SNSs) has had a tremendous impact on how we consume information, communicate with others, and go about our daily lives. SNSs in particular seem to have great potential to impact language learning as these technologies have become an integral part of the lives of young people (Blattner & Fiori, 2009; Godwin-Jones, 2010).

Recent studies by Jin (2015) and Yen, Hou, and Chang (2015) for instance have illustrated how SNSs can promote L2 skills. Nevertheless, there has been resistance to their incorporation in the classroom, particularly at the tertiary level. Roblyer, McDaniel, Webb, Herman, and Witty (2010) found that while university students are much more open to the use of Facebook to support classroom work, faculty members are inclined to believe that the site is solely for personal or social purposes. This is in line with others who believe that Web 2.0 technologies may not be suitable in the context of formal L2 teaching (Lohnes & Kinzer, 2007; Waycott, Bennett, Kennedy, Dalgarno, & Gray, 2010). Despite these reservations, there is a need to examine the pedagogical value of SNSs in the context of L2 learning and teaching. In this literature review, five main questions are used to guide the analysis:

1) What are the research purposes of language learning based on social media?
2) What are the research directions of language learning based on social media?

3) What are the theoretical foundations of language learning based on social media?
4) How have researchers designed to promote language learning with the help of social media?
5) What are the learning outcomes of language learning based on social media?

2. Methodology

In this study the content analysis method was adopted. The collected data were classified according to the coding framework and then presented with frequencies along with detailed descriptions.

In this literature review, four journals, *Computer Assisted Language Learning*, *System*, *Language Learning & Technology* and *ReCall*, were selected to search for research articles on language learning based on social media. First, research papers were chosen for review by reading the titles, keywords and abstracts of every article in the four journals from 2015 to 2018. After searching, 22 articles related to social media were selected. As a few articles were not so appropriate for language learning based on social media, the 22 articles were re-examined carefully. Finally, five unrelated articles were removed and 17 articles were identified for further analysis.

3. Analysis of Results

3.1 Analysis of research directions

It is often observed that the globalization of social media has opened up new opportunities for informal intercultural communication and foreign language learning.

Social communication should be taken into account because social networking applications (apps) are widely used for communication on mobile phones every day (Khaddage, Muller, & Flintoff, 2016). It has been acknowledged that social media have changed the way of learning a foreign language; however, there are still some issues that researchers need to consider when carrying out experiments.

First, the use of social communication apps on mobile devices which are related to classroom teaching should be developed to match the specific class to reinforce teaching and learning, while integration into the class content should be taken into account in a MALL (Mobile-Assisted Language Learning) context (Zou, Li, & Li, 2018). Second, while communication effectiveness and information exchange are prioritized in the digital era (Warschauer, 2007), an alternative research direction reflecting the affordance of task-based discussions is called for to evaluate blog-mediated activities (Chen, Shih, & Liu, 2015). Third, as Levak and Son (2017) recommended, the selection of tools should be carefully considered in alignment with task aims and the affordances of the online tools.

3.2 Analysis of research purposes

With regard to the research purposes of language learning based on social media, they can be divided into two groups. One is from the teacher's perspective, and the other concerns the students.

As can be seen in Figure 1, most articles based on social media explored student language learning, with only two of 17 addressing teacher learning, which includes transformative learning and integration of language learning and teaching.

In terms of student learning, some practitioners have aimed to explore social media in language acquisition such as listening comprehension (Levak & Son, 2017), pronunciation (Fouz-Gonzalez, 2017; Mompean & Fouz-Gonzalez, 2016), and vocabulary acquisition (Arndt & Woore, 2018). Improving students' writing is the objective of many researchers. Benson (2015), Özdemir (2017) and Jin (2018), who had a similar research purpose, aimed to clarify the relationship between language and culture and the cultural effects on students' language learning in a social networking environment.
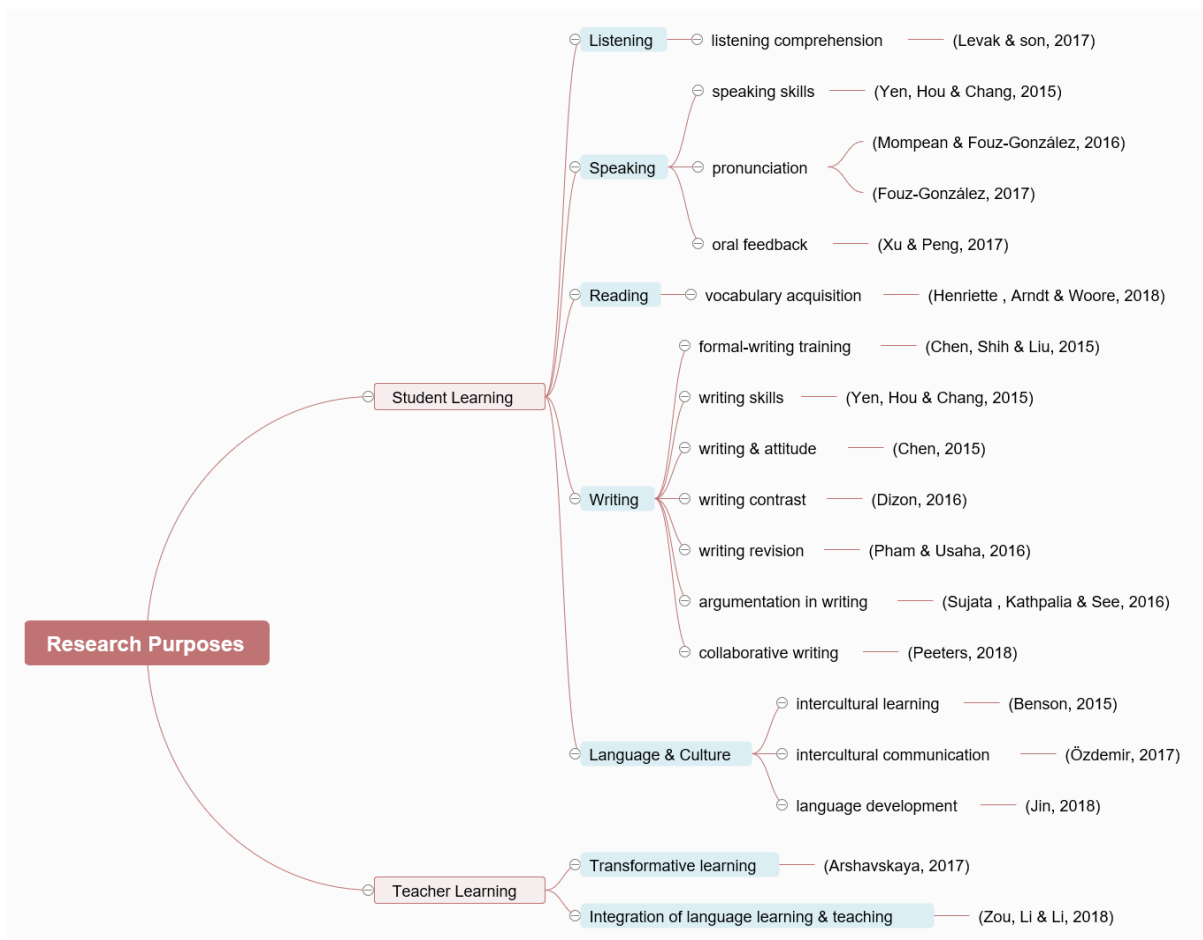
Figure 1. Research purposes of the studies.

3.3 Analysis of the theoretical foundations

Theory is the foundation of research. In the language learning based on social media experiments, various theories are employed to support the main points. In Figure 2, among the 17 articles, nine indicated the theoretical background clearly. Then each theory connects to one or more articles.

Chen (2015) used Specialization codes of legitimation to support his research. Specialization codes of legitimation is one dimension of Maton's Legitimation Code Theory (LCT), which emerged in the late 1990s by building upon Basil Bernstein's (2000) sociological theories, and has been applied across a burgeoning array of social fields and educational practices, including linguistics (Hood, 2011; Matruglio, Maton, & Martin, 2013), educational technology (Chen, Maton, & Bennett, 2011; Howard & Maton, 2011), school courses (Lamont & Maton, 2010; Macken-Horarik, 2011), higher education (Shay, 2011; Wolff & Luckett, 2013), and design studies (Carvalho, Dong, & Maton, 2009). LCT describes education as comprising fields of struggle where actors' beliefs and practices represent competing claims to legitimacy; that is, actors within a field are constantly "striving to attain more of that which defines achievement and to shape what is defined as achievement to match their own practices" (Maton, 2014).

Socio-cultural theory received increasing attention in the collected articles. The ecological and sociocultural perspective in SLA was developed out of sociocultural theory (Lantolf & Thorne, 2006; van Lier, 2004). Through the lens of sociocultural theory, all human activities are mediated by physical and psychological tools such as language and other symbolic signs. Language learning is a significant human activity mediated by various semiotic resources in the environment (Zou, 2018).
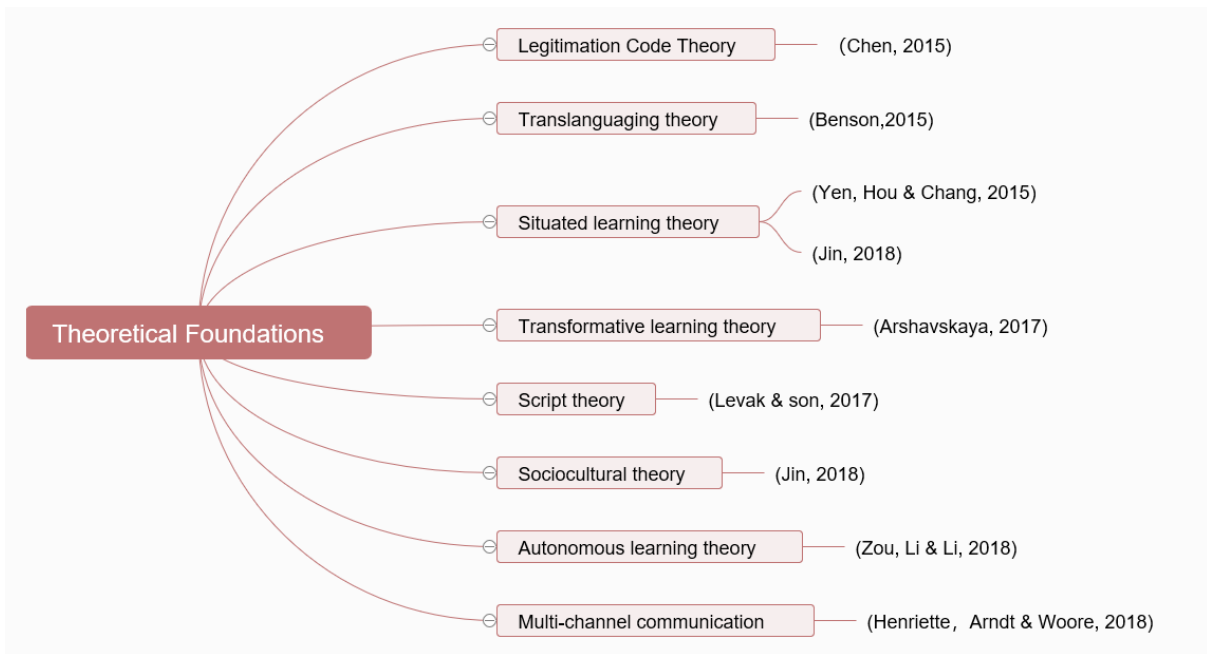
Figure 2. Theoretical foundations of the studies.

3.4 *Analysis of the research designs*

As shown in Figure 3, the designs of these studies are mainly mixed studies. According to Figure 4, practitioners mostly used blogs to carry out their research, and WeChat was adopted in three of the 17 studies.

As a matter of fact, there are more than 700 million active Chinese social media users on several major Chinese social networking sites (SNSs). Research shows that over 90% of Internet users in China are using SNSs (China Internet Network Information Center, 2016), making SNS use a must in daily life (Jin, 2018). Therefore, more research can be done to explore the relationship between so many Chinese social media users such as WeChat users and their language learning.

In the experiments, college students are the most likely research participants. Figure 5 reveals where the participants come from and which country has conducted the most experiments in language learning based on social media. Taiwan, China published three papers about this topic in 2015. With so many people learning English in China, there should be more experiments exploring social networks and the language learning of Chinese people.
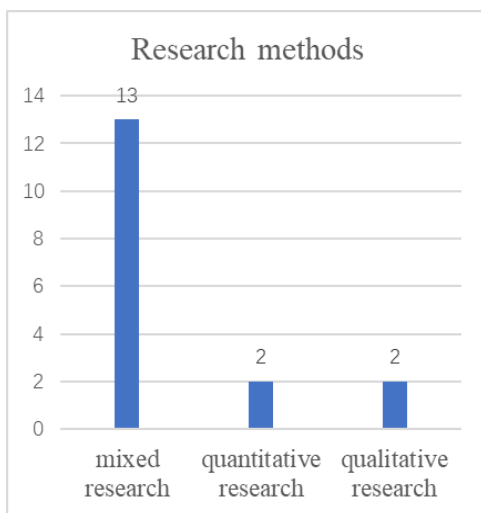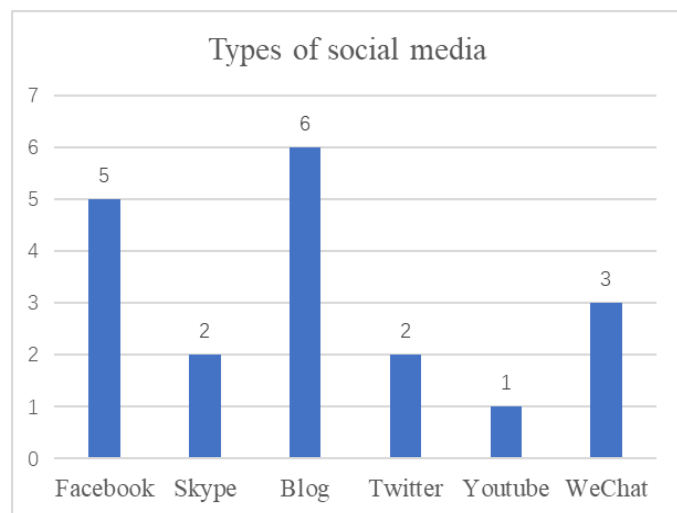

Figure 3. Research methods adopted.

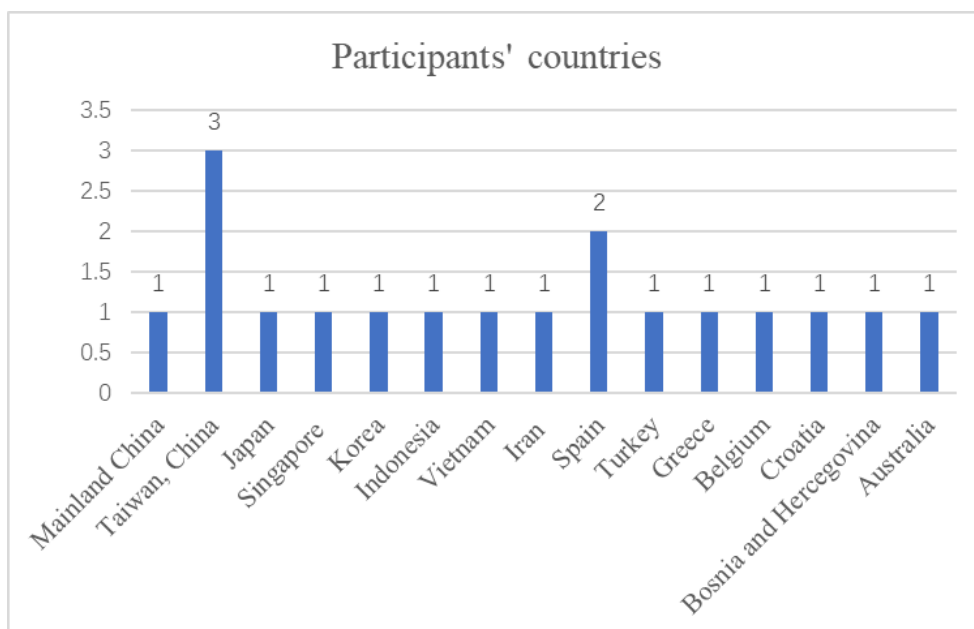*Figure 4.* Types of social media adopted.

Figure 5. Participants' countries.

3.5 Analysis of learning outcomes

A wealth of experimental studies have been carried out to ascertain the suitability of social media for language learning (Jin, 2018; Arndt & Woore, 2018). The main outcome of the studies signifies the effects of knowledge acquisition (Benson, 2015), motivation (Zou et al., 2018), and intercultural communication (Ozdemir, 2017). Meanwhile, the reviewed studies also reported their research limitations for explaining learning outcomes. For instance, several studies stated the limitations of small sample size (Arndt & Woore, 2018; Zou, Li, & Li, 2018) and the short duration of the teaching experiment (Fouz-Gonzalez, 2017; Xu & Peng, 2017). Internet services are sometimes an issue on campus resulting in slow Internet speed hindering audio-based communication. Besides, it is difficult to assess how much knowledge the students have obtained from social media. In order to improve educational significance of social media for language learning, teachers should integrate their curriculum design, task design with technology use. They should teach the students in accordance with their needs and take full advantage of social media.

4. Conclusion

This study reviewed 17 studies on the application of social media to language learning from 2015 to 2018. From the five aspects of the research directions, research purposes, theoretical foundations, research designs and learning outcomes, a coding and analysis framework was constructed for a systematic literature review. It would be conducive to follow-up studies to use the content analysis method to conduct a systematic literature review of the relevant literature on the application of emerging technology education.

Through this review and analysis, a number of studies were carried out to ascertain the suitability of social media in language learning. More research can be done to explore the relationship between Chinese WeChat users and their language learning. As the grounds for future research, literature reviews have the capacity to engender new ideas and directions for language learning based on social media.

Acknowledgements

References

Arndt, H. L., & Woore, R. (2018). Vocabulary learning from watching YouTube videos and reading blog posts. *Language Learning & Technology, 22*(3), 124-142.

Arshavskaya, E. (2017). Becoming a language teacher: Exploring the transformative potential of blogs. *System, 69*, 15-25.

Benson, P. (2015). Commenting to learn: Evidence of language and intercultural learning in comments on youtube videos. *Language Learning & Technology, 19*(3), 88-105.

Chen, W. C., Shih, Y. C. D., & Liu, G. Z. (2015). Task design and its induced learning effects in a cross-institutional blog-mediated telecollaboration. *Computer Assisted Language Learning, 28*(4), 285-305.

Dewey, D. P. (2017). Measuring social interaction during study abroad: Quantitative methods and challenges. *System, 71*, 49-59.

Dizon, G. (2016). A comparative study of Facebook vs. paper-and-pencil writing to improve L2 writing skills. *Computer Assisted Language Learning, 29*(8), 1249-1258.

Fouz-Gonzalez, J. (2017). Pronunciation instruction through Twitter: the case of commonly mispronounced words. *Computer Assisted Language Learning, 30*(7), 631-663.

Jin, L. (2018). Digital affordances on WeChat: learning Chinese as a second language. *Computer Assisted Language Learning, 31*(1-2), 27-52.

Kathpalia, S. S., & See, E. K. (2016). Improving argumentation through student blogs. *System, 58*, 25-36.

Khaddage, F., Muller, W., & Flintoff, K. (2016). Advancing Mobile Learning in Formal And Informal Settings via Mobile App Technology: Where to From Here, and How? *Educational Technology & Society, 19*(3), 16-26.

Levak, N., & Son, J. B. (2017). Facilitating second language learners' listening comprehension with Second Life and Skype. *Recall, 29*(2), 200-218.

Mompean, J. A., & Fouz-Gonzalez, J. (2016). TWITTER-BASED EFL PRONUNCIATION INSTRUCTION. *Language Learning & Technology, 20*(1), 166-190.

Ozdemir, E. (2017). Promoting EFL learners' intercultural communication effectiveness: a focus on Facebook. *Computer Assisted Language Learning, 30*(6), 510-528.

Peeters, W. (2018). Applying the networking power of Web 2.0 to the foreign language classroom: a taxonomy of the online peer interaction process. *Computer Assisted Language Learning, 31*(8), 905-931.

Pham, V. P. H., & Usaha, S. (2016). Blog-based peer response for L2 writing revision. *Computer Assisted Language Learning, 29*(4), 724-748.

Xu, Q., & Peng, H. Y. (2017). Investigating mobile-assisted oral feedback in teaching Chinese as a second language. *Computer Assisted Language Learning, 30*(3-4), 173-182.

Yen, Y. C., Hou, H. T., & Chang, K. E. (2015). Applying role-playing strategy to enhance learners' writing and speaking skills in EFL courses using Facebook and Skype as learning tools: a case study in Taiwan. *Computer Assisted Language Learning, 28*(5), 383-406.

Zheng, C. P., Liang, J. C., Yang, Y. F., & Tsai, C. C. (2016). The relationship between Chinese university students' conceptions of language learning and their online self-regulation. *System, 57*, 66-78.

Zou, B., Li, H., & Li, J. Y. (2018). Exploring a curriculum app and a social communication app for EFL learning. *Computer Assisted Language Learning, 31*(7), 694-713.

A Comparison of Chinese EFL Learners' Listening Comprehension in Dictation and Dicto-comp

Hongxia CAO[a, b*]
[a]*Nanjing University, China*
[b]*Nanjing Normal University, China*
[*]carolchx@126.com

Abstract: Dictation and dicto-comp are two task types which are often used in Chinese EFL listening class. When the effects of task type have been found in some types of listening tasks, little has been known about its effects in the case of dictation and dicto-comp. This study aims to investigate whether Chinese EFL learners achieve a similar level of comprehension of the audio input in dictation and dicto-comp. Sixty-eight students were divided into two experimental groups. The participants first completed a questionnaire on their perception of dictation and dicto-comp, and then each group received the dictation task and the dicto-comp task respectively and had two post-tests: a free written recall and a set of multiple-choice questions. The analysis of the post-test results and the students' response to the questionnaire showed that Chinese EFL learners achieved a similar level of comprehension of the audio input in the aspects of global comprehension, local comprehension, literal comprehension and inferential comprehension. Drawing on the Cognition Hypothesis, the paper discussed the role of task complexity in affecting learners' listening comprehension and it was found that the synergetic effects of the resource-dispersing dimensions and the resource-directing dimensions of task complexity led to the similar level of listening comprehension in these two tasks.

Keywords: dictation, dicto-comp, listening comprehension, task complexity

1. Introduction

In the English as a Foreign Language (EFL) setting, dictation and dicto-comp are among the task types which are often employed in listening class. Both task types require whole reconstruction of the audio input but they differ in task complexity. Although task type effects on listening comprehension have been found among certain types of listening tasks (e.g., Brindley & Slatyer, 2002; Cao, 2017; Cheng, 2004), little has been known about how learners comprehend the audio input in dictation and dicto-comp. Drawing on the Cognition Hypothesis (Robinson, 2003, 2005, 2007; Robinson & Gilabert, 2007), this paper aims to find out whether Chinese EFL learners achieve a different level of comprehension of the audio input in dictation and dicto-comp. It is hoped that this study could give more information on task type effects on listening comprehension.

2. Literature Review

2.1 Dictation and Dicto-comp

Used primarily as a form-based testing device, dictation was criticized and abandoned by communicative methodology (Lado, 1961; Oller, 1971). However, since the late 1980s, it has gained popularity again as a means of promoting necessary accuracy while integrating skills (Johnson & Johnson, 2001). Studies (e.g., Lee, 2010) have shown that students achieved significant gains in listening comprehension through doing dictation practices over a period. The term "dictation" in this paper refers to the traditional format of dictation. The text is read to the participants for three times. For

the first time and the last time, the text is read at normal speed and during the second time, the text is read sentence by sentence or segment by segment.

Dicto-comp is very similar to dictogloss, a popular interactive activity in the language classroom. They differ in that dicto-comp does not involve group work. For some scholars, these two terms can be used interchangeably (Thornbury, 1997; Wajnryb, 1990).

In a dicto-comp task, learners listen as the teacher reads a text to them. The teacher may read it several times. Then, learners reproduce the text in the words of the original or in their own. Dicto-comp is a task of dual-nature.

> To the extent that they reproduce the original passage, the students are writing a dictation. To the extent that they must use their own words to fill in memory gaps, they are writing something akin to a composition. (Riley, 1972, p. 238)

Although originally developed to draw learners' attention to grammatical points, dictogloss or dicto-comp can be used as a listening comprehension activity which helps to improve students' listening comprehension and note taking skills (Prince, 2013; Vandergrift & Goh, 2012).

2.2 Theoretical Framework

Considering the fact that none of the existing models could explain how tasks with varied task complexity affect learners' listening comprehension, this paper situated itself upon the Cognition Hypothesis (Robinson, 2003, 2005, 2007; Robinson & Gilabert, 2007).

The Cognition Hypothesis predicts that increasing task complexity in resource-directing dimensions of tasks benefit accuracy and complexity of production while increasing task complexity in resource-dispersing dimensions of tasks divides learners' attention and decreases accuracy and complexity of production. When both resource-directing and resource-dispersing dimensions are increased, synergetic effects are likely to take place.

Although the Cognition Hypothesis does not relate directly to listening tasks, it can be assumed that listening tasks, just like tasks of speaking and writing, also vary in task complexity. As can be seen in Table 1, both dictation and dicto-comp have high task complexity. Both involve multiple tasks of listening such as note taking and reconstruction. Both tasks take several steps in task completion. Despite the similarities, dictation and dicto-comp do display differences in task complexity, although the detailed differences might be unknown. For instance, on the [+/- single task] variable, although both dictation and dicto-comp involve multiple tasks, they might differ in the number of tasks involved. In addition, dicto-comp involves causal reasoning, but it is not clear whether dictation involves causal reasoning. More details of how different task types differ in task complexity are needed. More importantly, it is necessary to find out how task complexity manipulates the listening comprehension of EFL learners.

Table 1

How Dictation and Dicto-comp Differ in Task Complexity

Task type	Dictation	Dicto-comp
-/+ causal reasoning	+/-	+
+/- single task	-	-
+/- few steps	-	-

Note: Here, "+/-" indicates that task complexity on the [-/+ casual reasoning] variable in this task type is not clear according to the researcher's observation.

2.3 Studies on Task Type Effects on Listening Comprehension

Most studies on task type effects on listening comprehension focused on test method effects, i.e., how different test formats influence test scores or task difficulty (e.g., Brindley & Slatyer, 2002; Cheng, 2004; In'nami & Koizumi, 2009). These studies showed that listeners did better in certain task types and some listening tasks were more difficult than the other. Only a few studies looked into task type effects from the perspective of task demands or task complexity. Among them, Wang and Zhen (2014)

investigated the effects of listening tasks with different involvement loads (oral composition, fill-in and multiple-choice questions) on incidental vocabulary acquisition. It was found that tasks with higher involvement load resulted in better incidental vocabulary acquisition. However, the study only explored into task type effects on incidental vocabulary acquisition and did not examine its effects on learners' listening comprehension. Cao (2017) found that task type affected Chinese EFL learners' comprehension of the audio input in the aspects of global comprehension, local comprehension and literal comprehension, but no effect was found with that of inferential comprehension. Cao (2017) only investigated four types of listening tasks (multiple-choice questions, short answer questions, partial dictation and table-format gap-filling). To what extent and how task type affects learners' comprehension of the audio input in other types of listening tasks has remained unknown.

Therefore, the present investigation will examine the listening comprehension of Chinese EFL learners in dictation and dicto-comp so as to provide more information on task type effects on listening comprehension and examine the role of task complexity in affecting learners' comprehension of the audio input.

3. Methodology

3.1 Research Question

Do Chinese EFL learners achieve a different level of comprehension of the audio input in dictation and dicto-comp? If they do, to what extent?

3.2 Research Design

3.2.1 Participants

The participants in the study were 68 freshmen in School of Foreign Languages and Cultures of Nanjing Normal University. Before the experiment was conducted, a pretest was given to the two classes to see whether there were any differences in their listening comprehension ability. The test papers were scored and t test results showed that there were no significant differences in the pretest scores among the two classes ($t(66) = .215$, $p = .831$).

3.2.2 Instruments

The instruments of the study included one short listening passage, two treatment tasks, two post-tests and one questionnaire.

The listening material used in the study was one short passage in the listening section of a CET 6 session conducted in December, 2008. The audio material was edited with Adobe Audition and adapted into two audio recordings to fit into the requirements of dictation and dicto-comp.

For the dictation task, the participants listened to the recording three times. At the first reading, the whole passage was read at normal speed. At the second reading, the recording was played with intervals of 20 seconds each between sentences or phrases. Finally, the whole passage was read again at normal speed. The recording lasted for 14 minutes and 50 seconds. After the recording had been played for three times, three minutes was given for the participants to check their work. In all, the dictation task took 17 minutes and 50 seconds.

The dicto-comp group was asked to listen to the recording for three times and was then given 12 minutes and 30 seconds for reconstruction and checking. In all, 17 minutes and 51 seconds was used for this task. Thus, the dictation group and the dicto-comp group had almost the same amount of time in completing their respective listening task.

There were two post-tests: a free written recall and a set of multiple-choice questions. The free written recall aimed to test the participants' attention to details and the seven multiple-choice question items were designed to test the participants on their comprehension of the passage. The seven questions could be categorized following two dimensions: global vs. local and literal vs. inferential. There were 4 global questions and 3 local questions, while there were 3 literal questions and 4 inferential questions.

The questionnaire was designed by the researcher and aimed to examine how the participants perceived the two listening tasks. It involved three aspects: 1) the difficulty level of the two listening tasks; 2) the characteristics of the two tasks; and 3) the specific skills required in completing the two tasks. The questions in the questionnaire took two formats: multiple-choice questions and open-ended questions. Most of them were open-ended questions.

3.2.3 Data Collection

There were three steps in collecting the data.

(1) Pretest and Questionnaire

Two weeks before the experiment, a pretest was delivered to see whether the participants were of the same level of listening comprehension. After that, the participants were asked to complete the questionnaire concerning their perception of dictation and dicto-comp.

(2) Conditioning

The experiment was conducted in the language lab, the naturalistic class setting. The two experimental groups were conditioned to the task they would receive in the experiment. One week before the experiment, at the end of the listening class, each experimental group received two practice tasks. The dictation group practiced the dictation task and the dicto-comp group practiced the dicto-comp task. Each practice task took around 15 minutes.

On the day the experiment was conducted, the participants in each group had a second round of conditioning. Each of them had one practice task (about 20 minutes). The purpose was to secure that in the formal experiment, the participants could keep using the same types of strategies employed in the most recent listening task (Nix, 2016).

(3) Collection of the data

When the second round of conditioning was over, each group received their own task. First the participants in the two groups listened to the recording for three times and completed the dictation task and the dicto-comp task. After that, all the materials including the notes were collected and the participants had two post-tests. They first did a free written recall. Then the recall was collected and all of them were asked to complete Post-test 2, i.e., the seven multiple-choice questions.

3.2.4 Data analysis

The participants' overall scores in Post-test 2 were calculated and compared and their scores in the two dimensions of questions were scored and compared. Then, the scoring rubrics of the written recall in Post-test 1 were designed and the participants' scores in the recall were calculated and compared. Finally, the participants' questionnaires were coded according to the key terms which emerged in the answers. Students' answers in the questionnaires served as a supplement to the quantitative data.

4. Results and Discussion

4.1 Task Type Effects on Listening Comprehension

In order to examine whether learners achieved a different level of listening comprehension in dictation and dicto-comp, we first examined the two groups in terms of overall comprehension. "Overall comprehension" refers to the participants' scores in the seven multiple-choice questions in Post-test 2. An independent samples t test was run and it was found that the two groups did not differ significantly in the aspect of overall comprehension ($t(66) = -.191, p = .849$), which indicates that learners achieved a similar level of overall comprehension in dictation and dicto-comp.

In addition, independent samples *t* tests were also run to find out whether there existed differences between dictation and dicto-comp along two dimensions of listening comprehension: (1) global comprehension vs. local comprehension and (2) literal comprehension vs. inferential comprehension. In order to examine this, we further compared the scores of the six groups in these four aspects. Local comprehension had two indicators, marked as "local comprehension 1 (LC1)" and "local comprehension 2 (LC2)" respectively. LC1 refers to the participants' scores in answering the local questions in Post-test 2 and LC2 refers to the participants' scores in the written recall in Post-test 1.

The independent samples *t* tests results (See Table 2) showed that dictation and dicto-comp did not differ significantly in any aspect of comprehension. Therefore, when doing dictation and dicto-comp, learners had similar levels of comprehension concerning the gist and details of the text, the literal meaning and the inferential meaning, showing that dictation is just as an effective listening task as dicto-comp.

Table 2

Independent Samples t Test Results of Dictation and Dicto-comp

DV	*t*	*p*
GC	.720	.474
LC1	-1.019	.312
LC2	-.978	.332
LC	-.814	.419
IC	.407	.685

Note: GC=global comprehension, LC1=local comprehension 1, LC2=local comprehension 2, LC=literal comprehension, IC=inferential comprehension

The above results were consistent with the participants' answers to the questionnaire. Generally speaking, in both the dictation task and the dicto-comp task, the students paid attention to the main idea of the text, especially during the first listening, so they did not differ significantly in global comprehension. As for local comprehension, students doing dictation had to write down every word in the passage and the second reading allowed them to attend to the details. Students doing dicto-comp reported that this task type required them to reconstruct the whole text, so they had to note down as many details as possible. That is why the participants achieved a similar level of local comprehension. In the aspect of literal comprehension, according to the student reports, they only had to take down what they had heard and sometimes the comprehension did not take place until they read back what they had written down. The dicto-comp task was more challenging since they had to figure out the causal relationships between different parts of the text. This was very pressing, which led to their failure to comprehend some parts of the text. In terms of inferential comprehension, the participants of this study were EFL learners in the same university and their ability to make inferences might be stable. They had the similar level of ability to make inferences and this ability was not susceptible to task type.

These results provide more information for task type effects on listening comprehension. In Cao (2017), although it was found that task type effects did exist, but no significant differences were found between the multiple-choice question task and the table-format gap-filling task in any aspect of listening comprehension. Here, again, no significant differences were found between dictation and dicto-comp in the four aspects of listening comprehension concerned.

Besides, the results indicate that dictation, just like dictogloss (dicto-comp), focuses on both form and meaning, quite opposite to Prince's (2013) belief that in dictation, learners focus only on form while dictogloss ensures that learners "focus not just on form but on meaning" (p. 488).

4.2 The Role of Task Complexity in Listening Comprehension

The results of the study lend support to the Cognition Hypothesis, showing that this hypothesis might not only apply to oral tasks and writing tasks, but also to listening tasks.

Based on the learners' response in the questionnaire and their listening comprehension in dictation and dicto-comp, it can be predicted that increasing task demands on the [+/- single task] variable impedes learners' listening comprehension. Both dictation and dicto-comp consist of several

sub-tasks. The participants' answers in the questionnaire revealed that dicto-comp involves more sub-tasks than dictation. It includes the following subtasks: word spelling, note taking, reconstructing meaning from notes taken and organizing answers. Dictation also involves word spelling, note taking, reconstructing meaning from notes taken, but task takers do not have to organize the answers. Similarly, dicto-comp has higher demands on the [+/- few steps] variable and this also impedes their comprehension of the audio input.

In addition, it can also be predicted that increasing task demands on the [-/+ causal reasoning] variable in the resource-directing dimensions might improve learners' listening comprehension. Dictation does not seem to have very high requirements on clarifying the logical relationships in the text. Dicto-comp, instead, does have very high demands on the [-/+ causal reasoning] variable. Many students regarded understanding the causal relationship between different parts of the text as essential in completing the dicto-comp task. The higher task demands on the [-/+ causal reasoning] variable help improve learners' listening comprehension.

According to the Cognition Hypothesis, increased complexity in both resource-dispersing and resource-directing dimensions of task complexity leads to synergetic effects. The result that dictation and dicto-comp did not differ significantly in any aspect of listening comprehension well demonstrates such synergetic effects. Dicto-comp has higher task complexity in the resource-dispersing dimensions of [+/- single task] and [+/- few steps] and the resource-directing dimension of [-/+ causal reasoning] and this results in a similar level of listening comprehension in the two listening tasks.

5. Conclusion

The results of this study show that Chinese EFL learners achieve a similar level of comprehension of the audio input in dictation and dicto-comp.

The findings of this study lend support to the Cognition Hypothesis. They show that increasing task demands on the resource-dispersing dimensions might impede learners' listening comprehension and increasing task demands on the resource-directing dimensions might improve their listening comprehension. Increased task demands in both resource-dispersing and resource-directing dimensions of task complexity lead to synergetic effects. The findings also have pedagogical implications. They show that both dictation and dicto-comp are effective listening tasks but dicto-comp is more challenging and might be suitable for junior and senior college students.

References

Brindley, G., & Slatyer, H. (2002). Exploring task difficulty in ESL listening assessment. *Language Testing, 19*(4), 369-394.

Cao, H. (2017). Task type effects on the listening comprehension performance of Chinese EFL learners. *Modern Foreign Languages, 40*(2), 265-274.

Cheng, H. (2004). A comparison of multiple-choice and open-ended response formats for the assessment of listening proficiency in English. *Foreign Language Annals, 37*(4), 544-553.

In'nami, Y., & Koizumi, R. (2009). A meta-analysis of test format effects on reading and listening test performance: Focus on multiple-choice and open-ended formats. *Language Testing, 26*(2), 219-244.

Johnson, K., & Johnson, H. (2001). *Encyclopedic dictionary of applied linguistics: A handbook for language teaching* (2nd Edition). Beijing: Foreign Language Teaching and Research Press.

Lado, R. (1961). *Language testing: The construction and use of tests*. New York: McGraw-Hill.

Lee, S. C. (2010). Developing intensive listening skills: A case study of the long-term dictation tasks using rapid speech. *The English Teacher, 39*, 94-120.

Nix, J. L. (2016). Measuring latent listening strategies: Development and validation of the EFL listening strategy inventory. *System, 57*, 79-97.

Oller, J. W. Jr. (1971). Dictation as a device for testing foreign language proficiency. *English Language Teaching, 15*, 254–259.

Prince, P. (2013). Listening, remembering, writing: Exploring the dictogloss task. *Language Teaching Research, 17*(4), 486-500.

Riley, P. M. (1972). The dicto-comp: Reflections from the field. *English Teaching Forum, 10*(1), 21-23.

Robinson, P. (2003). Attention and memory during SLA. In C. Doughty, & M. Long, (Eds.), *Handbook of second language acquisition* (pp. 631–678). Oxford: Blackwell.

Robinson, P. (2005). Cognitive complexity and task sequencing: A review of studies in a componential framework for second language task design. *International Review of Applied Linguistics in Language Teaching, 43,* 1-32.

Robinson, P. (2007). Criteria for classifying and sequencing pedagogic tasks. In M. P. Garcia-Mayo (Ed.), *Investigating tasks in formal language learning* (pp. 7-27). Clevedon, UK: Multilingual Matters.

Robinson, P., & Gilabert, R. (2007). Task complexity, the Cognition Hypothesis and second language learning and performance. *International Review of Applied Linguistics in Language Teaching, 45*, 161-176.

Thornbury, S. (1997). Reformulation and reconstruction: Tasks that promote "noticing". *ELT Journal, 4*, 326-335.

Vandergrift, L., & Goh, C. M. (2002). *Teaching and learning second language listening: Metacognition in action.* New York: Routledge.

Wajnryb, R. (1991). *Grammar dictation*. Cambridge: Oxford University Press.

Wang, H., & Zhen, W. (2014). Task type on vocabulary incidental acquisition, *Foreign Language Education*,5, 63-67.

Exploring the relationships among teaching Chinese as a second language teachers' teaching beliefs, perceptions of Technological Pedagogical Content Knowledge (TPACK) and teaching self-efficacy

Ching-Fang Juan[a]*, Kuo-En Chang[b], Jyh-Chong Liang[cd]
[ab]Graduate Institute of Information and Computer Education, National Taiwan Normal University
[c]*Program of Learning Science,* National Taiwan Normal University
[d]Institute for Research Excellence in Learning Sciences, National Taiwan Normal University
*chingfang@ntnu.edu.tw

Abstract: The main purpose of this study was to explore teachers' teaching beliefs, perceptions of Technological Pedagogical Content Knowledge (TPACK) and their teaching self-efficacy. A total of 200 teaching Chinese as a second language teachers (TCSL) of Taiwan were participants in this study for the data collection. In this study, three questionnaires were used, including teacher's teaching beliefs, the teachers' perceptions of Technology-related Pedagogical Content Knowledge (TPK/TCK/TPCK) and teachers' teaching self-efficacy. As a result, the confirmatory factor analysis showed that the three questionnaires used in this study were valid and reliable. Besides, according to path analysis, the result indicated that the teachers with constructivism belief tended to have more perceptions of all the Technology-related Pedagogical Content Knowledge; on the contrary, the teachers with traditional belief showed that they tended to have fewer perceptions toward TPCK. Furthermore, it was found that teachers' TPK could positively predict all of their teaching self-efficacy; their TPCK could positively predict their subject content self-efficacy and their TCK can positively predict their Teaching outcome expectancy. All in all, there was a positive relationship between TCSL teachers' constructivism belief and their Technology-related Pedagogical Content Knowledge. Cultivating TCSL teachers' constructivism belief was suggested in TCSL teacher development for enhancing their perceptions of TPACK and their teaching self-efficacy.

Keywords: TCSL teacher, Teaching belief, TPACK, Teaching self-efficacy

1. Introduction

With growing enthusiasm for learning the Chinese language, Chinese learners and teachers of Teaching Chinese as a Second Language (TCSL) were increasing. When we mentioned the integration of technology into teaching, we would associate the concept with TPACK. Following TPACK structural model, it emphasized teachers' ability of using technology and related to Pedagogical Content Knowledge. Teachers would integrate technology into their teaching to improve the quality of teaching and enhance students' learning outcomes. However, in this study, the main purpose was to explore the relationships among teaching Chinese as a second language teachers' teaching beliefs, perceptions of Technological Pedagogical Content Knowledge (TPACK) and teaching self-efficacy. Thus, the aim of this study was to verify a proposed structural model including the three constructs by Structural Equation Modelling (SEM).

2. Literature Review

2.1 Teaching Beliefs

In terms of "teacher belief" was a complex cognitive process in education (Summers et al., 2017). Teachers' beliefs guided teachers' teaching behaviors, while teaching beliefs and teaching behaviors

were closely related and inseparable.   Teacher beliefs could be divided into two types (Lim & Chai, 2008). One was teacher-centered. We called it traditional teaching beliefs. It was characterized by knowledge dissemination and teacher decided how to conduct the class. The other was Student-centered constructivist teaching beliefs in which students were responsible for their own learning, constructing knowledge and learning together. Therefore, the role of teachers had changed from primary to guiding in the classroom (Meirink, Meijer, Verloop, & Bergan, 2009; Norton et al., 2005).

Teachers' teaching beliefs would change with the teaching methods and teaching objectives. Teachers' beliefs formed a subjective reality in the classroom; what they believed was a real experience and their teaching beliefs guided their decision-making, behavior and interaction with students. They were achieving teaching goals together (Summers et al., 2017).

Therefore, when teachers were expressing their teaching beliefs, teachers should understand their teaching objectives. Teachers could achieve consistency between teachers' beliefs and teaching objectives through their reflection in the classroom, especially to language teachers' beliefs (Farrell & Ives, 2015).

2.2 Technological Pedagogical Content Knowledge (TPACK)

TPACK was based on the PCK model (Shulman, 1987), Technological related pedagogical content knowledge abbreviated as TPACK, including Content Knowledge [CK], Pedagogical Knowledge [PK] and Pedagogical Content Knowledge [PCK] and Technological Knowledge [TK], Technological Pedagogical Knowledge [TPK], Technological Content Knowledge [TCK] and Technological Pedagogical And Content Knowledge [TPCK] (Mishra & Koehler, 2006).

First, teachers determined how they taught subject content knowledge (PCK) and then considered what technology to use; Second, the integration of technology into the subject content, it was integrated to help teachers transfer the content of teaching to students, so students could understand the subject content. In the classroom, teacher could effectively combine technology with PCK (Technological related pedagogical content knowledge) and solve the complexities that may face in teaching activity. Many studies had shown that TPACK was widely used in various fields and could achieve teaching goals and teaching results. This showed that TPACK was an important concept in the teaching process.

2.3 Teaching self-efficacy

The teacher self-efficacy (TES) was Rotter's (1966) attribution-based control theory. Rotter conceptualized control as a general expectation of controlling an individual's reinforcement relative to its environment development (eg, Rotter, 1966). There were many studies on teacher self-efficacy (Klassen, Tze, Betts, & Gordon, 2011), and these studies showed that teachers were with self-efficacy could enhance students' learning through teaching plan (Zee & Koomen, 2016).

TSE included the expectation of self-efficacy and general outcomes. The former referred to the belief that an action leaded to the desired result; the latter referred to the belief that the individual had the skill to obtain results. Therefore, the TSE divided into two types: high and low performance. Teachers were with high performance were positive for students' performance and learning. Teachers and students would participate in classroom activities, achieve goals, and have a sense of self-fulfillment with positive; on the contrary, teachers were with lower performance were negative to students' learning and behavior. Teachers' goal was inconsistent with students. Teachers decided by themselves, students were frustrated with teaching (Ashton 1984).

We posed the following research questions:

1.What is the validity of the questionnaires for measuring the three constructs (i.e.

teaching beliefs, perceptions of Technological Pedagogical Content Knowledge (TPACK) and teaching self-efficacy)?

2.What are the relationship between the three constructs?

3. Methodology

3.1 Participants

There were totally 200 participants, male were 32 and female were 168. They were presently in-service teachers of teaching Chinese as a second language (TCSL) in Taiwan. Their average age were 35 years old. Their educational backgrounds of the participants were 66 Bachelor's degrees, 118 Master's degrees, and 16 Doctoral degrees. Totally, 153 majored in Teaching Chinese as a Second Language Department, 14 majored in Chinese Department, and 33 in different major, including English, Education, Foreign Languages Department and so on.

3.2 Instrument

In this study, three questionnaires, including Teacher's Teaching beliefs (TTB), Teachers' perceptions of Technology-related Pedagogical Content Knowledge (TPACK) and Teachers' Teaching Self-Efficacy (TTSE). The three questionnaires were filled out at the same time.

The first questionnaire was the Teacher's Teaching Beliefs (TTB). It was divided into two dimensions which were the traditional and constructivism beliefs. There were two examples of Traditional Beliefs (TB) and Constructivist Beliefs (CB). The two dimensions were sample as follows:

Traditional Beliefs (TB): Teacher decided how to conduct the class, it is a teacher-centered class. Sample item: 'Teaching is to explain, demonstrate and guide students to learn'

Constructivist Beliefs (CB): Students were responsible for their own learning, constructing knowledge and learning with teacher, it is a student-centered class. Sample item: 'Teaching should be sufficiently varied and adjusted to match individual differences. '

The second questionnaire had three dimensions, mainly to understand the teachers' perceptions of Technology-related Pedagogical Content Knowledge (TPK/TCK/TPCK). The following were three examples of technology related Pedagogical Knowledge (PK), Content Knowledge (CK) and Pedagogical Content Knowledge (PCK). The two dimensions were defined as follows:

Technological Pedagogical Knowledge (TPK): Teacher integrated technology into teaching. Sample item : ' I can use technology to support Chinese language teaching, such as Application (APP), computer, visual aids and so on';

Technological Content Knowledge (TCK): Teacher knows how to search for multimedia resources. Sample item : ' I was able to search for multimedia materials related to learning Chinese language, for example, the films or movies from YouTube Channels or web resources to learning Chinese'

Technological Pedagogical Content Knowledge (TPCK): Teacher can combine pedagogical content knowledge with technology. Sample item: 'I know how to combine pedagogical content, teaching methods with technology. '

The third questionnaire was about teachers' teaching self-efficacy which includes Teaching self-efficacy (TSE), Subject content self-efficacy (SCE) and Teaching outcome expectancy (TOE). The three dimensions were defined as follows:

Teaching self-efficacy: Teachers have skills to help students learn Chinese. Sample item: 'I can help students reflect on learning outcomes by themselves.'

Subject content self-efficacy: Teachers can affirm their teaching professional ability. Sample item: 'I have full confidence with the Chinese language course that I taught.'

Teaching outcome expectancy: Teachers can improve the students' learning effectiveness. Sample item: 'Teachers always play an important role for the success of Chinese language learning.'

3.3 Data analysis

In this study, the Confirmatory Factor Analysis (CFA) with all of the items and dimensions of the three questionnaires (teacher's teaching beliefs, teachers' perceptions of TPACK and teachers' teaching self-efficacy) included in one model was performed to clarify the reliability and validity of all of the questionnaires. Moreover, to further understand the relationships among the dimensions of these three questionnaires, correlation analysis and SEM were performed.

4. Result

4.1 Verification of the validity of the three questionnaires

A total of 38 items were retained in the version (i.e. 10 items for Teachers' Belief, 14 items for TPACK, and 14 items for TSE). It shows the results of the confirmatory factor analysis for the three questionnaires in one model as well as the descriptive statistics for each variable. Each dimension has four to five questions. The goodness of fit of the structure, Chi-square = 628.887, P < .001, degree of freedom = 283, GFI = .80, IFI = .88, TLI = .86, CFI = .87, RMSEA = .078, and RMR = .069 were obtained, thus confirming the convergent and construct validity of this model for these three questionnaires.

4.2 The structural relationships among teachers' teaching beliefs, perceptions of Technological Pedagogical Content Knowledge (TPACK) and teaching self-efficacy

Figure 1 shows the structural relationships among the three questionnaires: TTB, TPACK, and TTSE. The goodness of fit of the structure, Chi-square = 628.887, P < .001, degree of freedom = 283, GFI = .80, IFI = .88, TLI = .86, CFI = .87, RMSEA = .078, and RMR = .069 were obtained, thus confirming the convergent and construct validity of this model for these three questionnaires.
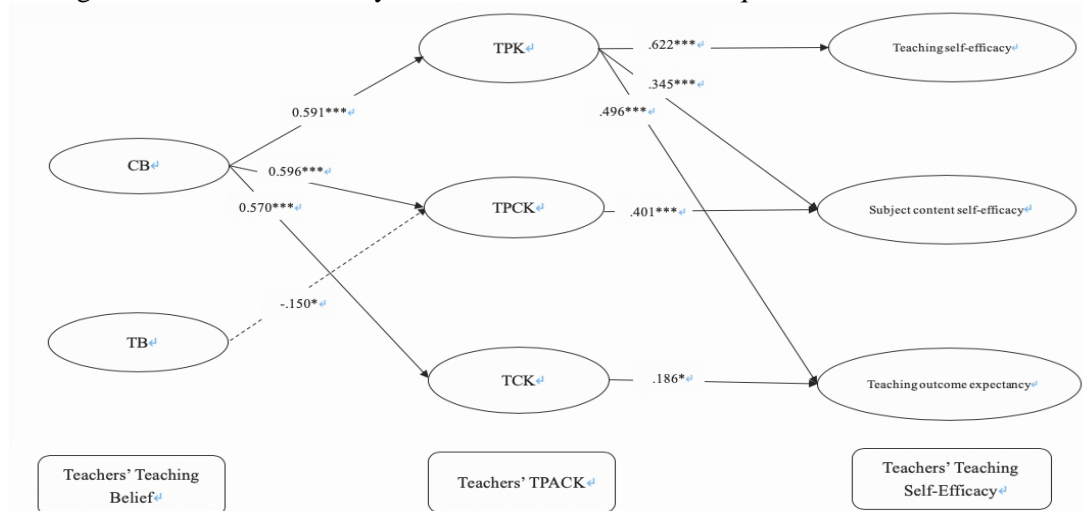

Figure 1. The structural equation model of the relationships among TB, TPACK and TSE.

According to Figure 1, 'TB' is the significantly negative dimension for explaining the variation in reproductive all Teachers' TPACK (path coefficient =−.150, P < .05), whereas 'CB' is the significantly positive dimension explaining the variation in all Teachers' TPACK (TPK's path coefficient = .59, P < .001; TPCK's path coefficient = .60, P < .001; TCK's path coefficient = .57, P < .001). In addition, "TPK" is the is the significantly positive dimension explaining the variation in all Teachers' Teaching Self-Efficacy (Teaching self-efficacy's path coefficient = .62, P < .001; Subject content self-efficacy's path coefficient = .35, P < .001; Teaching outcome expectancy' s path coefficient = .50, P < .001); On the other hand, 'TPCK' is the significantly positive dimension only can predict the Subject content self-efficacy(path coefficient = .40, P < .001) and 'TCK' is the significantly positive dimension only can predict the Teaching outcome expectancy (path coefficient = .19, P < .05).

5. Discussion

All in all, the result indicated that the teachers with constructivism belief tended to have more perceptions of all the Teachers' TPACK; on the contrary, the teachers with traditional belief showed that they tended to have fewer perceptions toward TPCK. Furthermore, it was found that teachers' TPK could positively predict all of their teaching self-efficacy; their TPCK could positively predict their subject content self-efficacy and their TCK can positively predict their Teaching outcome expectancy. There was a positive relationship between TCSL teachers' constructivism belief and their

Technology-related Pedagogical Content Knowledge. Cultivating TCSL teachers' constructivism belief was suggested in TCSL teacher development for enhancing their perceptions of TPACK and their teaching self-efficacy.

References

Ashton, P. (1984). Teacher efficacy: A motivational paradigm for effective teacher education. *Journal of teacher education*, *35*(5), 28-32.

Farrell, T. S., & Ives, J. (2015). Exploring teacher beliefs and classroom practices through reflective practice: A case study. *Language Teaching Research*, *19*(5), 594-610.

Klassen, R. M., Tze, V. M., Betts, S. M., & Gordon, K. A. (2011). Teacher efficacy research 1998–2009: Signs of progress or unfulfilled promise? *Educational Psychological Review*, *23*, 21–43.

Lim, C. P., & Chai, C. S. (2008). Teachers' pedagogical beliefs and their planning and conduct of computer-mediated classroom lessons. *British Journal of Educational Technology*, *39*(5), 807-828.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers college record*, *108*(6), 1017-1054.

Meirink, J. A., Meijer, P. C., Verloop, N., & Bergen, T. C. (2009). Understanding teacher learning in secondary education: The relations of teacher activities to changed beliefs about teaching and learning. *Teaching and teacher education*, *25*(1), 89-100.

Norton, L., Richardson, T. E., Hartley, J., Newstead, S., & Mayes, J. (2005). Teachers' beliefs and intentions concerning teaching in higher education. *Higher education*, *50*(4), 537-571.

Rotter, J. B. (1966). Generalized expectancies for internal versus external control of reinforcement. *Psychological Monographs*, *80*, 1–28.

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard educational review*, *57*(1), 1-23.

Summers, J. J., Davis, H. A., & Hoy, A. W. (2017). The effects of teachers' efficacy beliefs on students' perceptions of teacher relationship quality. *Learning and Individual Differences*, *53*, 17-25.

Zee, M., & Koomen, H. M. (2016). Teacher self-efficacy and its effects on classroom processes, student academic adjustment, and teacher well-being: A synthesis of 40 years of research. *Review of Educational research*, *86*(4), 981-1015.

Construction and Innovation Practice of "Internet +" Professional Development Mechanism for Urban and Rural Teachers

Bei-Bei Ye[a], Lei HE[b] , Jian HE[c] Su-Ying DUAN[d] & Xi-Bei, XIONG*

Faculty of Education, Guangxi Normal University, China

[a]14769956@qq.com
[b]4667089@qq.com
[c] hechejian@163.com
[d]2285229501@qq.com
*xbxiong@gxnu.edu.cn

Abstract: In the era of "Internet + education", Guangxi is confronted with significant regional imbalance in the construction of network interactive resource platform and the construction of regional and rural teacher professional development support service system. The pilot project of "Internet + Double-teacher Teaching", taking such imbalance into consideration, and making an analysis of the current problems faced by its urban and rural teachers' professional development, explores to set up a corresponding mechanism and an interactive resources platform. At the same time, it also tries to build a self-organizing operation mode between the local radiation pattern and urban and rural teachers' professional development community, and build a learning community carried forward by the special-class teacher workshops, so as to resolve such prominent problems like the common endogenous development, broaden the urban and rural teachers' professional development path, and ensure a coordinated development of urban and rural teachers' professional benefited by a local resources radiation mechanism. At present, the operation mode of this project has been promoted in 14 cities in this region.

Keywords: "Internet +", urban and rural teachers, double-teacher teaching, teacher professional development

1. Introduction

The construction of interactive resource platform is designed based on Jean Maisonneuve's group dynamics principle (Meisonoff, 1997), which believes that a cohesion force formed by elements within a group structure will promote the development and change of the group. In the guidance of group dynamics theory, we try to build an interactive resources platform, and set up a "face to face" communication group based on internet technology for both the urban and rural teachers to foster their common development elements so that a cohesion force is formed. A resource platform jointly built by urban and rural teachers will promote the development of the interactive innovation resources platform, the spread of high quality resources and information between groups (Fig. 1).
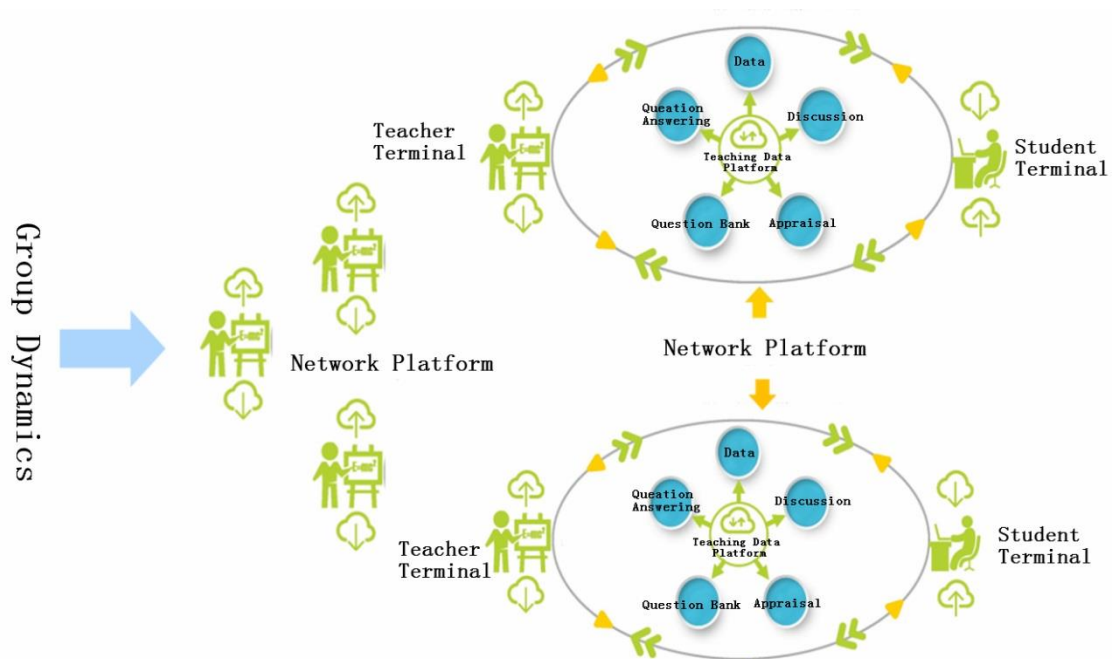
Figure 1: Schematic Diagram of Interactive Resource Platform

2. Data analysis

The "core advantage" of creating Guangxi interactive resource platform lies in connecting the relationship between experts and teachers, teachers and students, platform construction and resource generation, and the online and offline communication, and discussion between experts and teachers. Teaching management platform is a bridge connecting teachers and students, realizing resource dissemination, discussion and Q & A interaction, real-time monitoring and evaluation of tests (Gu, 2013). The platform resources not only include demonstration classes of experts and teachers, but also enable online discussions and expert comments; that is to say, a database of multiple subjects and multi-dimensional fields is formed to meet the diverse needs for its users (Song, 2014). For example, the mobile APP interactive resource platforms in Wuzhou and Cenxi of Guangxi, relying on the local powerful resources in their teachers' schools, and other schools, extensively covers the regional resources to ensure effective group communication.

The interactive resources platform in Guangxi is designed to solve the problems in practice to efficiently use the high quality resources, bridge the gap between urban and rural education, and improve the respective teachers teaching self-efficacy (Yang & Yang, 2013). Meanwhile, the improvement of the urban and rural teaching information and technology may help to higher their teachers training frequency and promote training quality (Wu, 2015), so that the urban and rural teachers are highly motivated to ease their job burnout, optimize their professional development path, richer rural teachers structure, and finally realize the teachers' balanced development between urban and rural areas in Guangxi by a promotion of the rural teachers comprehensive quality.

In constructing the mode of local resources' local radiation, we have experienced three times of mode innovation, each of which is an in-depth exploration of the problems found in the operation to form a unique mode of local resources' local radiation in Guangxi. When constructing the local radiation mode of local resources, we initially adopted the linear radiation mode of "university-city-experimental school"(Fig. 2). This model relies on the resources of colleges and universities, which radiate to prefecture-level cities that act as the medium to organize teachers of various experimental schools to study and train in colleges and universities, so as to improve the teaching level of various experimental schools (Xu, 2017). The biggest advantage of this model is its high efficiency and low cost. It gives full play to the local resource and is a favorable means for the common growth and progress of colleges and local experimental schools. But the disadvantage is that

the flow of resources is limited and unitary, and high-quality resources cannot effectively cover the rural area.

In view of the shortcomings of the first model, we make a second innovation: on the basis of the original three-level linear radiation, we add county-level excellent schools to lead rural experimental schools, forming a model of coordinated development of urban and rural teachers: "university-city-county-school", a four-level linkage model (Fig. 3). The hierarchy in this model is relatively clear, with city and county schools, experiment schools as three main motivations for the double-teacher teaching project, colleges and universities as resources for a collaborative development of city, county and school. The resources of colleges and universities are used to help county level schools to improve teaching quality, which will in turn help rural schools. Therefore, a good resource of conveyor belt is formed, so that teaching quality is improved ultimately.
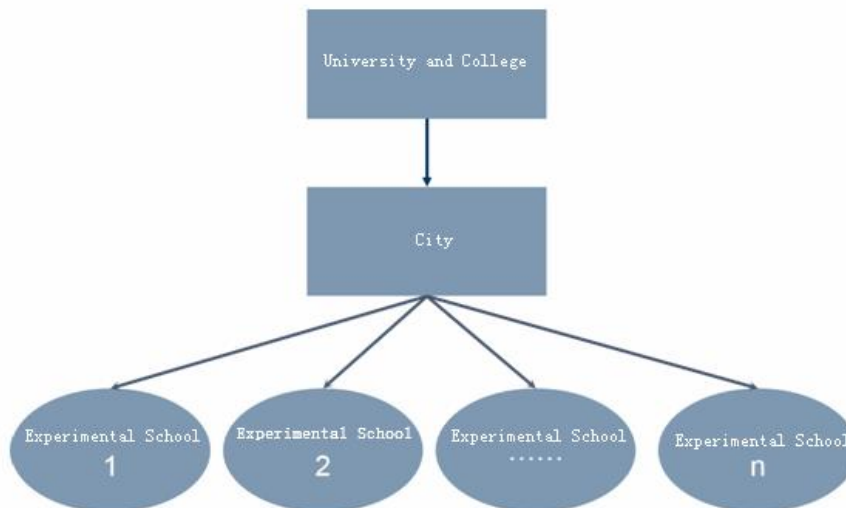

Figure 2: Collaborative Model 1: linear model of "university-city-experimental school"
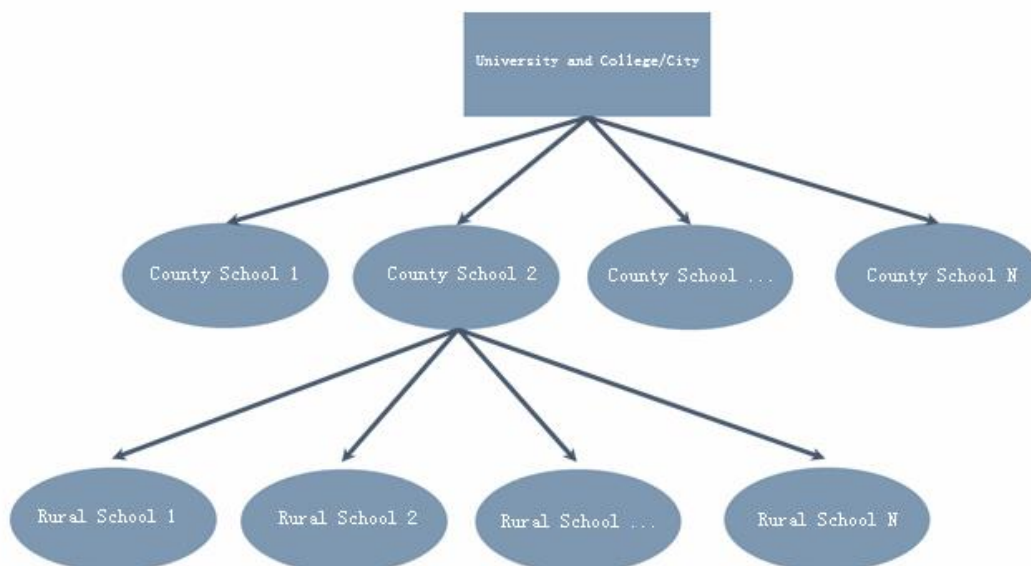

Figure 3: Collaborative Mode 2: "university-city-county-school" four-level linkage mode

Though Collaborative Model 2 enjoys a wide coverage and each party concerned is entitled with clear responsibility, still, under it, resources cannot be allocated and utilized fully. Therefore, Collaorative Model 3, a multi-level radiation mode of "college-city-county-central school-rural school/teaching site" comes into being (Fig. 4). The model, featuring itself with the advantages of the previous two models, not only gives full play to the intellectual resources in colleges and universities,

but cozies up to the resources of cities and counties and central school to form a complex resources flowing network, thus solving the problem of single resources flowing path (Zhang, 2017). In this mode, the schools have a variety of accesses to high quality information, not restricted by colleges or schools at the county level, but all parties concerned, and counterparts, or superior or subordinate, can communicate and learn from each other. It can be said that, Collaborative Mode 3 gives full play to local teaching resources. Forming a broader professional development community for teachers, this model can meet the diverse needs of urban and rural schools, teachers and students in terms of resource generation fields, types and amount. At the same time, under this mode, teachers can communicate face-to-face with experts and excellent teachers. As a result, they are more motivated and soberer in their professional development, stimulating their sense of teaching efficacy. Teachers, having more paths for professional development, knowing better their own appropriate paths, can improve themselves in an all-round manner.
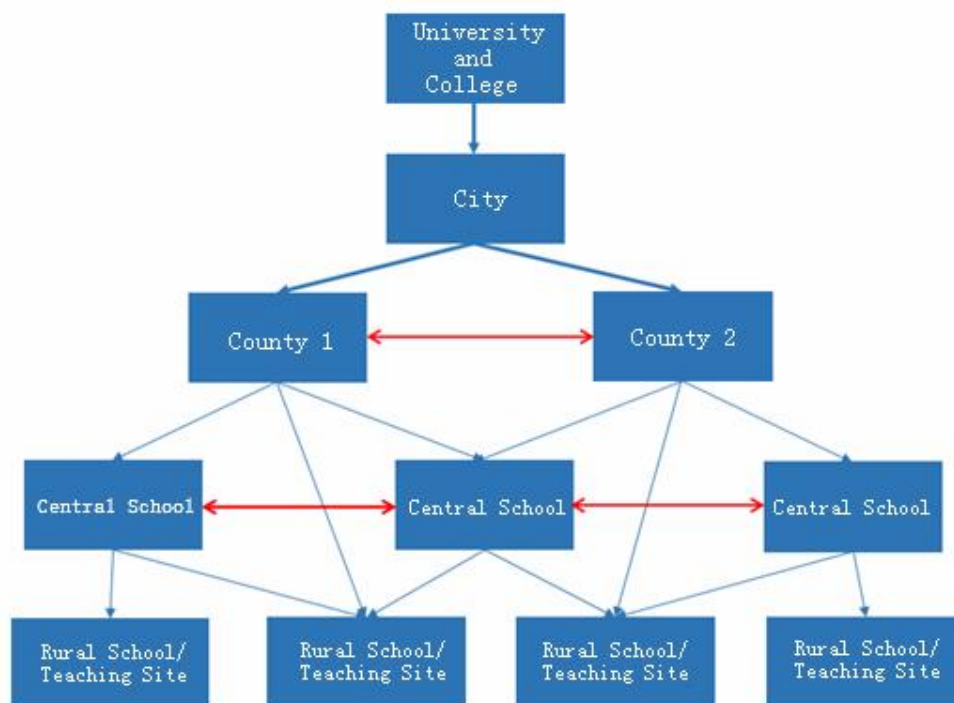

Figure 4: Collaborative Mode 3: "college - city - county - central school - rural school/teaching site": multi-level radiation mode

3. Discussion

Since its launching in 2010, the special-class teacher workshop project in Guangxi has been setting up over 200 special-class teacher workshops, covering one-third of special-class teacher in this region. In this project, a high-end research team has been gradually formed, with experts from Guangxi Normal University as its guide, the special-class teachers as the initiators, the backbone teachers as the main participants. This team, having the special-class teachers play leading role in its radiation, forms a benign teachers interactive mechanism, and motivates teachers to cooperate with each other, thus promoting the common development of teachers in different levels in the region.

The "Internet + Double-teacher Teaching" project, based on the "Guangxi Special-grade Teacher Workshop", builds a network platform to realize open and diversified interaction and radiation by establishing its teaching reform theme by means of factor analysis and role definition, and task division among instructors, hosts, helpers and participants.

The construction of the community quickly activates the development momentum of special-level teachers and their work enthusiasm of "spreading, helping and guiding", reshapes the teaching reform mechanism with teachers' subjectivity as the mainstream, and sets off a wave of teaching reform in the disciplines in question of the school. In the meantime, the community structure, function and reform is reflected by means of dynamic tracking and process evaluation in view of the

practice process and effect of the "Internet + Double-teacher Teaching" backbone teacher workshop. At the same time, hybrid research and studies of the urban and rural teacher should be promoted; workshop owners and research teams should be encouraged to work in the rural schools, and organize more face to face offline communications; support to the poverty-stricken areas, rural areas and minority areas should be strengthened, and hence the whole structure of urban and rural teachers is optimized and regional education development is balanced.

4. Conclusion

First of all, topic researches with local characteristics are vigorously supported by teachers' professional development institutions such as the city bureau of education and teacher training centers. Teachers are required to pair up to understand and study their jobs and disciplines to foster great enthusiasm to their own field. It is universally acknowledged that a topic research is to discover and then cultivate one's interests, and make it guide one's lifelong learning; at the same time, it is also an effective path for teachers to develop their professional, and improve their innovation practice capacity. The teachers should work in a down-to-earth manner to make up for their capacity for innovation.

Secondly, teaching competitions based on the "Internet+ Double-teacher Teaching" model are carried out, whose results are included into the measurement of teaching achievements, thus arousing teachers to take the initiative to reform teaching methods, and promote high-quality teaching. Meanwhile, the winning works of the teaching competition are a kind of teaching achievements, which will be transformed into rich resources for training teachers and teaching preparation resources, forming a local radiation resource pool of local resources and greatly enhancing the richness and relevance of regional teaching resources.

Finally, abundant independent training has initially realized the sustainable collaborative and innovative development of urban and rural teachers' specialty. Schools organize training, and invite other famed or experienced teachers to give online or offline classes according to their own needs. Targeted suggestions are put forward in line with the local resources and cases, bottlenecks of teachers' professional development diagnosed and development needs met. As a result, the urban and rural teachers' professional quality has been effectively improved.

References

Gu, Y. (2013). *Research on the Construction of Teacher Professional community---- on the Model of Special Class Teacher Workshop (in Chinese).* Guilin: Guangxi Normal University.

Meisonoff, J. (1997).Yin Shicai, Sun Zhaotong trans. *Group Dynamics.* Beijing: Commercial Press, 1997:16.

Song, X. M . (2014). A Class with the High School Affiliated to Renmin University of China --Research on the "MOOC1+1" or "Double-Teacher Teaching" Project (in Chinese). *Guangming Daily, 2014-6-17 (15 edition).*

Wu, K. N. (2015). Teachers Should Be Masters of Their Own Professional Development (in Chinese). *Journal of Nanjing Normal University (Social Science Edition), 5, 80-86.*

Xu, W. W. (2017). Innovation Engine: Non-profit Organization in Education Fair Governance--Taking "double-teacher teaching" Public Welfare Project as an Example (in Chinese). *Modern Management Science,1,118-120.*

Yang, Z., & Yang, R. Y. (2013). Self-organization: an Important Mechanism of Teacher Professional Development (in Chinese). *Education Research, 10, 95-102.*

Zhang, Q. W. (2017). Double-teacher Teaching Based on "Internet +" in Rural Teacher Training (in Chinese). *Journal of Primary and Secondary School Teachers Training, 5, 20-24.*

The Influence of English Language Learning APPs on the IELTS Exam Preparation Among Adult Learners

Wei CAO[a], Wei NING[b]
1434797137@qq.com

Abstract: As a language proficiency test widely used for overseas study and immigration purposes, IELTS is being accepted by more and more universities and immigration authorities.The number of candidates for IELTS in China is also rising year by year.In recent years, with the rise of online learning, more and more candidates attend classes while using various online English learning apps.However, not much of the study has been conducted about the relationship between the mobile English learning apps and the IELTS test preparation, and the focus on the working adult learners is even less.

This paper first introduces the IELTS test, the theoretical basis of the IELTS test, the characteristics of adult language learners and the classification of the current online apps. Then, the author combines the questionnaire survey and interviews with two adult IELTS students taught in the past year. The result shows that the online English learning app directly contributes to the improvement of IELTS listening and speaking study.At the same time, the degree of help depends to a large extent on the motivation and attitudes of the students themselves.

Keywords: IELTS, English language learning app, communicative language teaching, constructivism, student-centred learning , adult learners

1. Background

1.1 IELTS Exam

IELTS, the International English Language Test System, a language competency exam, is designed to assess the language ability of candidates who need to study or work where English is the language of communication.

In terms of the different purposes, candidates should choose Academic or General Training Module, which, as the name indicates, prepares them for their future study and for migration respectively.

Four skills are tested, Listening, Reading, Writing and Speaking.

IELTS results are designed and reported as band scores on a scale from 1 (the lowest) to 9 (the highest). At the moment, most of the universities and some immigration language requirements accept an overall score ranged from 6 to 7.5 with sub-skills no less than 5.5 or 6.

According to the IELTS taker perfromance 2017, candidates from Mainland China achieved an average score of 5.76 (Academic) and 5.93 (General Training) which was only slightly highers than a few Mid-East and Asian countries and was ranked at the bottom of the 40 most frequent countries or regions.

The above results show that Chinese IELTS takers' English level is much lower than their target. They need to spend longer time and find better ways to help them improve their performance in the exam.
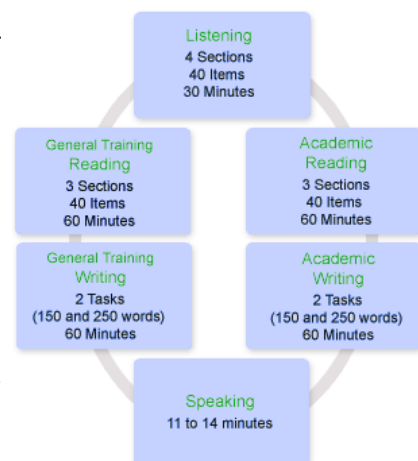
1.2 Learning and Teaching Strategies

1.CLT (Communicative Language Teaching)

  CLT was first introduced in the 1970s and it has been widely used in Second Language Teaching since then. This approach to language teaching is characterized by the following features: 1. an emphasis on learning to communicate through interaction in the target language; 2. the introduction of authentic texts into the learning situation; 3. an attempt to link classroom language learning with language activation outside the classroom. (Nunan. D. 1991) IELTS is a language competency examination which is based on the CLT theory -- the core of language teaching is ' communicative competence' which refers to a language user's grammatical knowledge of syntax, morphology, phonology and the like, as well as social knowledge about how and when to use utterances appropriately. (Canale, M. and Swain, M. 1980)

2.Constructivism
Constructivism believes learning is an active process, involving combining learners' prior knowledge and experiences with new knowledge. Learning is therefore done by learners' 'constructing' knowledge out of their experience. (Bo Li and Yanlong Chen, 2014)

1.3 Adult Learners

Adult learners generally include college students and professionals. Because of the limitations of this article, the adult learners referred to in this article are working people with bachelor degree or above. According to the June 2018 Adult English Study Group Research report, the proportion of professionals in the 749 effective questionnaire is 35.1%, of which 7.7% are non-occupational academic needs, but there is no way to subdivide it to see the exact percentage of IELTS exams required.

According to another 2018 Adult Online Foreign Language Education Analysis Report (a total of 3006 valid samples, of which 1421 are working people.) 26.7% of those who are preparing to take the IELTS or TOEFL test abroad.

According to the statistics of the 2018 IELTS White Paper in Mainland China, about 30% of the 9908 valid samples from June 1, 2017 to May 31, 2018 are adult candidates.

Based on the above three data, although the sample is not large enough, it can be seen that among the adult English learners, the learners who take the test for IELTS or similar overseas exams account for about 30% of all language learners.

1.3.1 Characteristics of adult language learning

First of all, adult students have rich social experience, strong autonomy and self-control ability, mature thinking mode and good logic ability.(Lijia. Xie, 2014) Such students can combine their personal experiences with what they study and learn effectively. In this respect, it is possible to promote language learning to a certain extent.However, there will be certain drawbacks, that is, the inherent passive or 'duck-feeding' learning habit will be transferred to language learning. For the IELTS preparation which requires a lot of output practices, it may have a negative impact.

Second, their learning motivation is strong.In terms of motivation, foreign language learners have two basic types of motivation: instrumental and integrative motivation.The vast majority of adult students are of instrumental motivation. The most direct purpose of learning English is to continue their studies, earn a diploma, degree or pass the exam, paving the way for personal career development (Nenghui. Guo 2016)

Third, adults have limited time to study, but they are more engaged.According to the 2018 Adult Online Foreign Language Education Analysis Report, the majority of adult learners' study time is concentrated from 6 pm to 24.00 pm, and about 82.5% of adult learners spend more than half an hour each time.

1.4 Mobile Learning

By 2017, online language learning users in China had reached 2,600 million, and this number is still rising every year.

According to an English Learning Product Market Research Report, mobile learning has become the mainstream, and the number of students studying for exams has accounted for 20.52% of the total number.In mobile learning preferences, 45.6% of users chose to use mobile phones to learn.
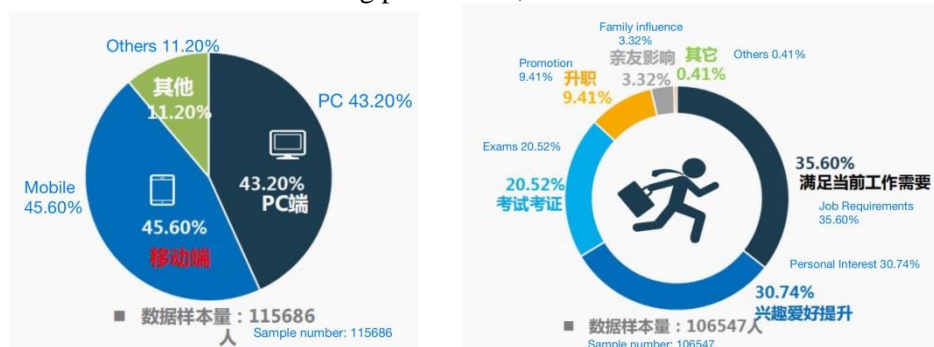
As far as the product type is concerned, we can divide it into roughly three categories. First, the online courses. For example, Hujiang Net School, New Oriental Online, Netease Cloud Classroom, etc. Such products provide a platform for students to have online classes. Second, language learning apps. For example, Liulishuo (speaking practice app), Baicizhan (learning vocabulary app), and Oxford Dictionary of English. Third, learning communities.This type of website provides an information sharing platform, and people can upload and download learning files.For example, TopSage.com.

In summary, the existing research focuses more on the effectiveness of online education, especially online courses. Secondly, because of the proportion of the audience, the existing research focuses more on the mobile learning of students, while less attention has been paid to adult learners, especially the effect of language learning apps on adults for exam purposes. In addition, in my own classes, there are often adult learners who can invest less time than school or university students, many of them do not have much chance to use the language in their work, and they sometimes require higher IELTS test scores than others to fulfill their target. They turn to me to look for solutions. Based on these reasons, this study focuses on the function of the language learning apps for adult IELTS learners, and demonstrates the effectiveness through questionnaires and interviews.

2. Research design

2.1 Research object

The survey received 50 valid questionnaires.Most of the participants were adult students who attended in IELTS training classes during the past year. The interviewees are between the age of 23 and 35, all of whom have at least undergraduate degree. Each person spent different lengths of time studying in their offline courses depending on the initial English level.Because this survey does not consider the variables mentioned above, there is no specific analysis based on age, initial level and the length of studying time at our training centre.

The two interviewees who participated in the interview were two of the participants in the questionnaire.The first interviewee has finished training, passed the exam, and is currently studying in Canada. She studied for about a year with an initial language proficiency of IELTS 6.0 and a final exam score of 7.0.The other one is currently studying, he has been studying for about three months and has not yet taken the test. His initial english level is much lower than the first interviewee. With the entrance mock exam, his initial English level was roughly equivalent to IELTS 3.5 to 4.

2.2 Research methods

According to the research objectives and research characteristics, this study selects a combination of questionnaires and interviews.Among them, the questionnaire collects basic data, such as the type of the language learning APPs used, the frequency of usage and the length of each learning period.The second purpose of the questionnaire is to understand the subjective response of users to the effectiveness of APPs.

The interviews are conducted to analyze specific information that is difficult to quantify from the basic data.In particular, the user's subjective response is reconfirmed in order to obtain the closest real-life experience.

3. Analysis of the research results

90 percent of the participants said that they would use the app to assist IELTS learning, and only 10 percent of them would not use it at all. About 80 percent of the participants use language learning apps rather than IELTS preparation app which only target at providing past exam information. Almost everyone who uses language learning apps has an app for speaking and listening and 50 percent of the participants use an extra vocabulary or reading app at the same time.

3.1 The impact of online language learning app on IELTS learning

After interviewing the two students, the online language learning app played an active role in assisting their IELTS preparation, especially in speaking and listening.For students with weak language foundation, learning through app will help their oral pronunciation and fluency. For students with better language foundation, learning through app provides them more speaking ideas and helps to reform their way of thinking.As for the listening aspect, both students agree the apps have a great influence on the cultivation of the sense of listening, and the answers can be quickly and accurately located when doing ielts listening exercises.

In addition to the positive effects of speaking and listening, both students believe that language learning apps have a positive impact on their learning attitudes.This point is not mentioned in the questionnaire.For student with weak language foundation, it takes him longer and longer to complete the tasks on the app as the level increases. Although he feels exhausted sometimes, it will be very satisfying and fulfilling after the goal is achieved. This sense of accomplishment plays a positive role in the classroom performance.As the current teacher of the student, I have profoundly realized the self-confidence that he shows in the classroom in the past month. The fluency and accuracy in oral communication have made great progress as well.For the student with a good language foundation, completing the language learning app every day works as a mental support for her IELTS learning to keep her having a more positive attitude towards preparing for the exam; and the degree of completion of the daily learning task on the app does not have any affect on her IELTS preparation.

Through the analysis of questionnaires and interviews, the usage consistency of the language learning apps by learners has also played a considerable impact on the final results and attitudes of students.The two interviewees learn on the app for at least 40-50 minutes per day throughout the learning process.

4. Conclusion

As a language proficiency test, IELTS preparation can benefit a lot from the usage of language learning apps.According to the questionnaire and interview results, whether the app is focused on listening or speaking or reading, IELTS listening and speaking are the two parts where the greatest improvement can be found.

Considering their limited classroom study time, language learning apps provide a perfect effective supplement to their exam preparation. Compared with younger IELTS exam takers, adult learners have a clearer target and more motivated. To a certain extent, this also reflects the

student-centered learning theory proposed by the constructivism. When students realize the personal value of learning, they will learn as an investment and willing to invest all wisdom and energy.This enthusiasm not only directly affects their learning attitude, but also affects their academic performance (Harel & Papert, 1991).At the same time, it is more important for one to believe in what we can do than what actually we can do. (Ning Wang et al. 2014).

In this way, we can encourage students to use such apps while teaching, and guide students of different language abilities in different directions and actively build students' self-learning ability which in turn could promote student's learning performance.

The survey used fewer samples and there was no purposeful test linguistic app for IELTS writing and reading.At the same time, the survey did not consider other factors that may affect students' IELTS learning, such as the age of the students, social background, length of study and target scores.

References

Bo, Li & Yanlong, Chen. Study on the Teaching Strategies of IELTS Courses Based on 'Skyclass' Network Platform. *Journal of Hebei Radio& TV University.* 2014.

Canale, M. and M. Swain. Theoretical Bases of Communicative Approaches to Second Language Teaching and Testing. *Applied Linguistics, 1980,1* (1), 1-47

Harel, I.E., & Papert, S.E. *Constructionism.* New York: Ablex Publishing. 1991.

Lijia, Xie. The Construction of Dual-Direction Model of Internet-Based Adult English Teaching. *The Chinese Journal of ICT in Education.* 2014

Nenghui, Guo. The Research on the Application of Mobile APP in Adult English Teaching. *Journal of the College of Northwest Adult Education.* 2016.

Ning, Wang. et al. Factors which Influence the Study Satisfaction on Open Education Online Courses [J]. *Education Research,(6),* 111-118.

Nunan, D. Language Teaching Methodology: *A textbook for Teachers* [M], New York: Prentice Hall Inc. 1991.

WORKSHOP 15 - The 4th Computer-supported Personalized and Collaborative Learning

Design and Construction of the Learner-centered E-learning System for Facilitating Dermoscopy Image Analysis and Diagnosis in Medical Education

Tzu-Shin LIN & Shelley Shwu-Ching YOUNG*
Institute of Learning Sciences and Technologies, National Tsing Hua University, Taiwan (R.O.C.)
*scy@mx.nthu.edu.tw

Abstract: Dermoscopy is a noninvasive imaging technology that allows visualization of deeper skin structures by reducing surface reflectance, also supports more accurate diagnosis in early stage in melanoma. Compared to clinical training, learning diagnosis and related knowledge via e-learning system could be more convenient and efficient because learning materials can be collected organized based on pedagogical rationale, and users can learn personally anytime and anywhere. Thus, in this study we aim to focus on designing and implementing an e-learning system that provides well-designed images, interactive and intuitive learning environment for medical students to actively learn melanoma dermatopathology more effectively. The development of the system focuses on learning content design and instructional design. In the learning contents, the primary image resources intend to be the numerous learning materials in two steps: to reduce noise in images, and to add noise in images. After new resources are synthesized, its type can be confirmed by deep learning system. The final AUC of classifying diseases is over 0.85 with our system. In order to get the system improved, we conducted the formative evaluation to the 10 target learners. Overall, the participants are positive to the self-directed e-learning system. Moreover, some useful comments were provided for enhancing the system. The four instructional design features applied to this system include: (1) intuitive correspondence between lesion and diagnosis; (2) segmented components with structural organization; (3) terminology with link and clear tracing document; and (4) personalized system. According to the above rational and strategies, this e-learning system is expected to be a better self-directed learning platform that can afford the target users to learn flexibly, with massive resources and intuitive instructions and learn the technique of accurate diagnosis more effectively; the formative evaluation also showed that learners may have higher learning efficiency and motivation with this self-directed e-learning system. Currently the system is still undergoing, final result will be presented in the future.

Keywords: Medical education, Self-directed learning, E-learning system, Dermoscopy image

1. Introduction

In medical education field, faculty, administrators, and learners find that multimedia e-learning enhances both teaching and learning. Chumley-Jones et al. (2002) cited several studies assessed learners' preference for web-based learning. Most learners in medical, dentist and nursing background preferred web-based learning to continuing medical education conferences, lectures, video, audiotapes, journals, or textbooks. Compare to other learning methods, the accessibility, navigation, and attractiveness predict learners' satisfaction in web-based learning (Bouhnik & Marcus, 2006).

Early diagnosis of melanoma is of critical importance for patient prognosis. With pigmented lesions occurring on the surface of the skin, melanoma is amenable to early detection by expert visual inspection. Although skin lesions are visible to the naked eyes, early-stage melanomas may be difficult to distinguish from benign skin lesions with similar appearances. This has led to many missed melanomas despite an epidemic of skin biopsies.

Dermoscopy is a vivo imaging technique that can clearly identify the criteria of pigment network, which may not see by naked-eye. ISIC, the international skin imaging collaboration, has released over 10000 lesion images captured by dermoscopy to the public, provided people to utilize for noncommercial purpose. Based on these images, it is more likely to observe the early stage of

melanomas by visual inspection. Its use increases diagnostic accuracy between 5% and 30% over clinical visual inspection, depending on the type of skin lesion and experience of the physician.

To assist the training for medical students in visual diagnosis, author aim to design and develop an e-learning system for medical students. The goal for this system includes: to help students observe and learn the method to utilize dermoscopy images in diagnosis, learning contents and examinations will take place in this learning system.

2. Literature Review

Mayer et al. (2014) had listed three important instructional goals which enhance the effectiveness on learning: to reduce extraneous overload, to manage essential processing, and to foster generative processing during learning. Knowles (1975) had listed three immediate reasons why self-directed learning is important: (1) active learners learn more and better than passive learners, and active learners have more purposefully and with greater motivation in learning; (2) self-directed learning is more in tune with our natural process in psychological development, similar to the progress we became independent and responsible to ourselves; and (3) new developments in education put heavy responsibility on the learners. Rapid change becomes the only stable characteristic in this new world, thus self-directed learning is important when knowledge updates in short period of time.

Continuing technological advances are inevitably impacting the study and practice in dermatopathology. Shahriari et al. (2017) had reviewed the recent flow of growth and change in dermatopathology learning. In the online learning section, the authors mentioned that most of the online information for dermatopathology is limit to biopsy resources, less of them focus on dermoscopy images. For e-learning platforms that provide dermoscopy image analysis training, the great majority of these platforms are type of distance learning videos, ppts or image database, which are lack of interactive and autonomous learning methods, and way to practices. However, with these online resources, users are no longer limited to communicating only within their own institutions, but the establishment of online communities allow the public to reach dermatopathology knowledge easily.

3. Methods

3.1 Learning Content Design

The main purpose of this e-learning platform is for learners to gain clinical experiences with dermoscopy image online. Because the design of contents focuses on the image of skin diseases, large database of dermoscopy images is important for this system. Besides collecting dermoscopy images from open databases, simulated images based on real dermoscopy images can enhance the amount of learning resources. There are three steps to auto stimulate numerous lesion images which are highly realistic:

Hair is the most significant noise in dermoscopy images, the difference in color and shape can become the characteristic for detecting. Generally, hair is relatively darker than skin color, which can be separated by adaptive thresholding. Next, hair usually presents in slender shape, which can be picked out by selecting the geometric shape. It is important not to pick out scars from image, scars have similar color but different geometric characteristic to hair. After selecting all noise in image, the noise areas are filled in by Telea's FMM inpaint method (Telea, 2004).

With the same method of noise detecting in the above section, noises can be drawn and added in noise-reduced dermoscopy images.

After new images are synthesized, the type of disease can be confirmed by deep learning system. In 2018, we have done a disease classifier with the mean AUC (area under curve) of lesion diagnosis reached 0.85; in the ISIC challenge 2018, the best classifier has a mean AUC of lesion diagnosis reached 0.983.

3.2 Instructional Design

3.2.1 Intuitive Correspondence Between Lesion and Diagnosis

For learners who are learning to diagnosis diseases via dermoscopy images, the discernment in trifling pigment network makes it hard to get started. To provide clear classification and correct location of pigments and other disease characteristics, corresponding information is placed in the side window which shows when cursor reached the lesion attribute.

3.2.2 Segmented Components with Structural Organization

Focusing on learning dermoscopy imaging analysis, the construction and structure of the large scale of learning contents become an important issue. With appropriate segmented components and structural organization, it is possible to reduce extraneous overload and essential overload in learning process.

3.2.3 Terminology with Link and Clear Tracing Document

The relation and explanation of professional terminologies are complicated and confused. We added hyperlink to specific terms to emphasize the relationship between every links. Clear flow in connections reduces essential overflow in learning process and gives learners logical organization within whole content.

3.2.4 Personalized System

Highlighting unfamiliar contents and bookmarking important parts help learners to enhance the efficiency of learning, without reviewing known knowledge repeatedly. Based on the personalized information, the examination is designed to choose questions those learners are unfamiliar with.

4. Formative Evaluation and Result

The system is still in prototype stage, the formative evaluation was conducted to collect responses for the system improvement. In the evaluation questionnaire, questions include five-point Linkert scale and open-ended questions from 5-point 'strongly agree' (SA), 'agree' (A), 'nether agree or disagree' (N), 'disagree' (DA), to 'strongly disagree' (SDA) with 1-point. In the formative evaluation, we intended to collect the target users' responses to the structural design, function design, visual design and others in text. Ten voluntaries participated in this evaluation from National Tsing Hua University, Taiwan.

Based on the instructional design issues in the method, there are some representative views of this learner-centered e-learning system listed as below.

Table 1

The consistence of evaluators (n = 10)
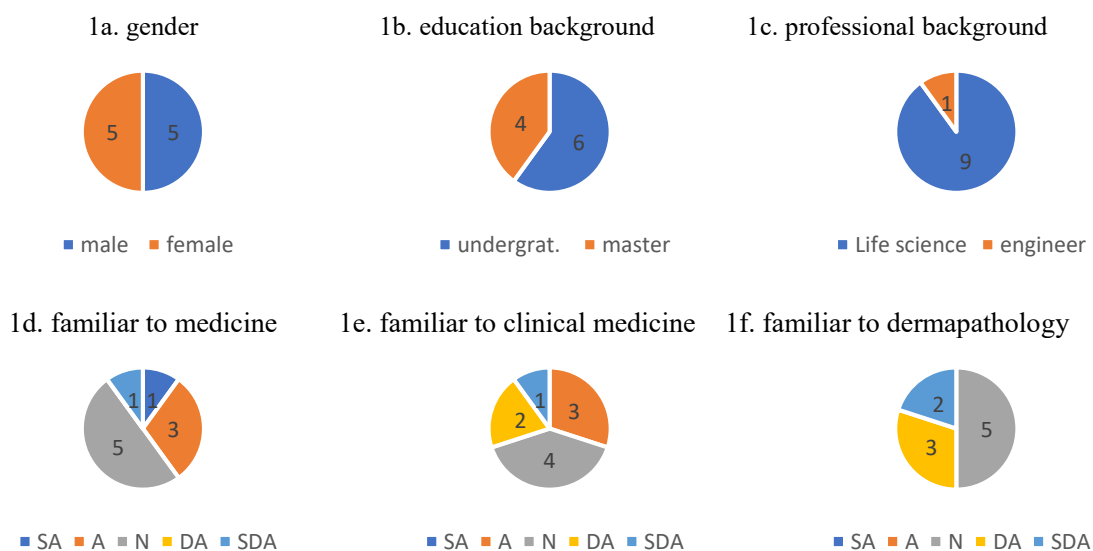
4.1 Intuitive Correspondence Between Lesion and Diagnosis

Figure 1. System screenshot – image diagnosis learning sample page

Figure 1 presents the function of intuitive correspondence between lesion and diagnosis. This page is designed with: clicking the lesion or characteristic area in the image, the similar area will be emphasized with different color, which provided learners to distinguish the different specialized area intuitively.

Table 2

Intuitive correspondence between lesion and diagnosis (n = 10)

	SA	A	N	DA	SDA	Avg	SD.
Learners could gain wanted information of images in this page.	30%	40%	30%	0%	0%	4.0	0.8
The function of changing color of clicked specialized characteristic is useful.	50%	40%	10%	0%	0%	4.4	0.7
The function of changing color of clicked specialized characteristic is better comparing to traditional teaching method, pointing out characteristic by arrow-pointing and circling.	70%	10%	20%	0%	0%	4.5	0.8
The design of this image diagnosis webpage is an ideal self-directed e-learning system.	30%	50%	20%	0%	0%	4.1	0.7

According to the result of formative evaluation, all of the questions related to intuitive correspondence between lesion and diagnosis got the average score over 4 (out of 5). Especially comparing to traditional teaching method, this intuitive presentation provides better learning efficiency with the average score 4.5-out-of-5. In the open question, one evaluator had suggested that adding the highlighting function to image characteristic. The results supported that the design is intuitive and can reduce extraneous overload in learning process.

4.2 Segmented Components with Structural Organization
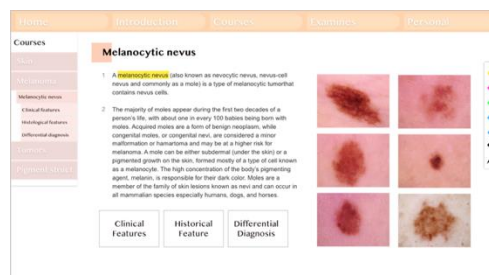
Figure 2. System screenshot – course page sample.

Figure 2 is a screenshot of the course page that related to segmented components with structural organization. In this sample, the index on the left side is listed in stair structure with different color style; in the center of this page, contexts are separated with number at the start of the paragraph; related images are placed on the right of this page, learners can link to the page of image diagnosis learning by

clicking images; on the side of the page, highlighter bar provides learners to emphasize important message delivered in the text content.

Table 3
Intuitive correspondence between lesion and diagnosis (n = 10)

	SA	A	N	DA	SDA	Avg	SD.
The design of the page is simplified.	50%	40%	10%	0%	0%	4.4	0.7
The structure of this website is easy to understand.	20%	60%	20%	0%	0%	4.0	0.7
The index could guide them to needed pages rapidly.	10%	70%	20%	0%	0%	3.9	0.6
The level relationship of the sidebar is clear.	50%	30%	20%	0%	0%	4.3	0.8
The display of text content and image content is consistent.	10%	80%	10%	0%	0%	4.0	0.5

According to formative evaluation, most of the questions related to segmented components with structural organization got the average score of 4. The question with relatively lower score is about process of gaining contents from the website, while the questions about structure got higher scores. It is surmised that the indicator written in text is not that clear comparing to visual structure; improvement in text designing should be considered in the system. In the opening question, one evaluator suggested that the design of sidebar in course section should remain the options even not selecting them; the original design of the sidebar is remaining the directed parent items of current page and the items in first level.

4.3 Terminology with Link and Clear Tracing Document
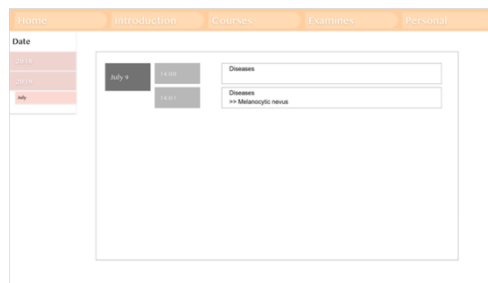
Figure 3. System screenshot– linking list sample page.

In figure 4, it showed the history of their personal browse record. Classified by time, this page recorded the page and section learners had clicked before; linking to related course page is also available.

Table 4
Terminology with link and clear document

	SA	A	N	DA	SDA	Avg	SD.
The design of linking list could assist learners to sort out their thread of thought.	30%	40%	30%	0%	0%	4.0	0.8
The design of linking list can enhance the efficiency of learning.	30%	30%	40%	0%	0%	3.9	0.9

According to the result of formative evaluation, the design in terminology with link and clear document is slightly useful. In the opening question, evaluators had suggested that related website link can also add in this system. Concluding both parts of the evaluation, this function supports learning process, although it might not be one of the most important issue in self-directed e-learning system.

4.4 Personalized System

Figure 4. System screenshot – Personal page & My notes.

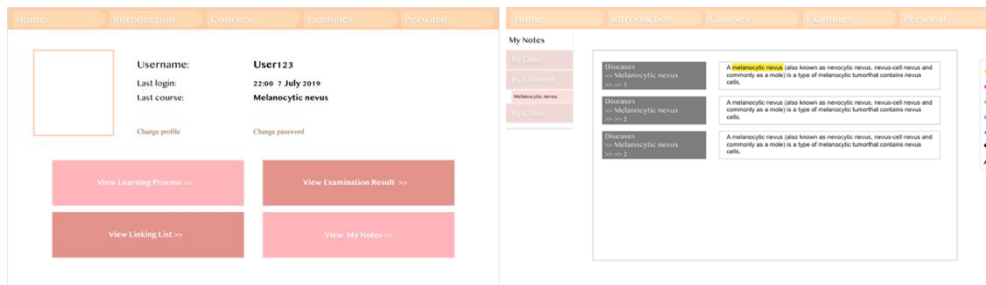The design of personalized system covers several topics: in the course pages (figure 1, 2), the right-side sidebar listed highlighting tools with 4 colors, eraser, backward and forward function button. These tools were desgined for marking text contents, and these emphasized paragraph will also occur in 'my notes' page arranged by course, highlighter's color, or date. In the 'my notes' page (figure 4), the marked contents were placed in paragraph, and by clicking the gray blocks in page, learners can link to the content in course page.

Table 5
Personalized System

	SA	A	N	DA	SDA	Avg	SD.
It is useful to highlight keynotes in text context.	50%	30%	20%	0%	0%	4.3	0.8
The design of multi-color highlighters is efficient for learning.	40%	40%	20%	0%	0%	4.2	0.8
Classification in 'my notes' is useful for searching needed notes.	20%	60%	20%	0%	0%	4.0	0.7
The presentation method of notes makes evaluators clear to get notes.	30%	50%	20%	0%	0%	4.1	0.7
The link between 'my notes' and the related course makes clear thread of thoughts.	40%	40%	20%	0%	0%	4.2	0.8
The design of personalized page supports deeper learning in self-directed e-learning system.	40%	40%	20%	0%	0%	4.2	0.8

The results of the personalized system are all positive with a scores above 4.0. In the open question, evaluators had suggested that it will be useful if there is function for texting learners' own note or adding a discussing forum for learners to communicate with.

Some evaluators had suggested that the theme color of the website is corresponded to the topic (skin and skin diseases), but the light background and white texts let their eyes feel tired after long time of usage; some contents are too small to look at, adding function for zoom in/zoom out may enhance the efficiency of learning. Other opinions such as gray blocks looked unexpected, or excepting video contents are mentioned.

5. Conclusion and Future Work

From the feedback of the formative evaluation, it could be understood that participants were positive to this system, some useful and constructive opinions or suggestions were also presented. The instructional design, concepts of visualization, interaction, autonomy and assessment presented in this system support medical student to learn dermoscopy image analysis. The suggestions in the formative evaluation will be integrated into our design for improving the self-directed system. Furthermore, we hope to conduct the environment after the system is ready for use in the authentic setting in the future.

References

Chumley-Jones, H. S., Dobbie, A., & Alford, C. L. (2002). Web-based learning: sound educational method or hype? A review of the evaluation literature. *Academic medicine*, *77*(10), S86-S93.
Giddings, Sharron. (2015). Self-Directed Learning (SDL) in Higher Education: A Necessity for 21st Century Teaching and Learning. 10.13140/RG.2.1.2446.7365.

Gureckis, T. M., & Markant, D. B. (2012). Self-directed learning: A cognitive and computational perspective. *Perspectives on Psychological Science*, *7*(5), 464-481.

International Skin Image Collaboration
https://www.isic-archive.com/#!/topWithHeader/tightContentTop/about/isicArchive

Mayer, R. E., & Fiorella, L. (2014). 12 Principles for Reducing Extraneous Processing in Multimedia Learning: Coherence, Signaling, Redundancy, Spatial Contiguity, and Temporal Contiguity Principles. *The Cambridge Handbook of Multimedia Learning*, 279.

Shahriari, N., Grant-Kels, J., & Murphy, M. J. (2017). Dermatopathology education in the era of modern technology. *Journal of cutaneous pathology*, *44*(9), 763-771.

Telea, A. (2004). An image inpainting technique based on the fast marching method. *Journal of graphics tools*, *9*(1), 23-34.

Vestergaard, M. E., Macaskill, P. H. P. M., Holt, P. E., & Menzies, S. W. (2008). Dermoscopy compared with naked eye examination for the diagnosis of primary melanoma: a meta-analysis of studies performed in a clinical setting. *British Journal of Dermatology*, *159*(3), 669-676.

Social Factors in the Usage Continuance of Instant Messaging for Group Collaboration

Ryan EBARDO[a*], **Laiza LIMPIN**[b]

[a]*Jose Rizal University, Philippines*
[b]*Mindanao State University – General Santos City, Philippines*
*ryan.ebardo@jru.edu

Abstract: The ubiquity and mobility of mobile technologies have led to the proliferation of instant messaging apps, which have become a primary choice of communication mode among students. This trajectory gives birth to various affordances which presents opportunities for research on how these tools can support learning beyond the walls of traditional classrooms by facilitating group collaboration. While prior studies focused on examining the technological factors in the use of collaboration tools, other researches revealed that social factors are equally important. In this paper, we contribute to the dearth of research in exploring social dimensions as antecedents of usage continuance of collaboration tools. A total of 168 students participated in an empirical study which revealed social influence and social presence as predictors of positive attitude towards instant messaging tools for collaboration. Further analysis of data establishes social influence as the strongest indicator of usage continuance. However, contrary to prior research, social influence does not predict social presence. Future research, implications for the academe and limitations of the study are also discussed.

Keywords: Instant messaging, collaboration, social influence, social presence, theory of reasoned action

1. Introduction

In today's work environment, technology tools that foster collaboration and effective communication has become a necessity to accomplish tasks from teams composed of members from varied backgrounds (Orta-Castañon, Urbina-Coronado, Ahuett-Garza, Hernández-de-Menéndez, & Morales-Menendez, 2018). In response, higher educational institutions have incorporated computer-mediated collaboration software within their technology infrastructure to ensure that the future workforce will be adept to these technologies (Yadegaridehkordi, Shuib, Nilashi, & Asadi, 2019). Recent observations indicate that the mobile phone ownership is on the rise and that majority of users belong to the younger generation. In addition, access to the Internet is more affordable which renders the use of mobile apps as an integral part of the daily activities of today's digital natives (Bere & Rambe, 2019; Graham & Jones, 2019).

The numerous benefits acquired from mobile phone ownership and the affordances in the use of instant messaging apps attract students from higher education (Graham & Jones, 2019). As a result, they are considered the most active users of these technologies through activities related to learning such as knowledge sharing, collaboration and communication (Bere & Rambe, 2019). Aside from students, faculty members have also realized the value of the use instant messaging apps in cascading valuable knowledge outside the physical boundaries of the classroom. The work by Murire and Cilliers (2017) reveal that frequent communication and interaction between the faculty and students through digital communication tools can improve the learning experience resulting to better academic performance. An important feature of these communication apps is the ability to create groups which promotes collaboration among learners in the context of education (Bere & Rambe, 2016).

Despite the numerous benefits of collaboration technologies in education, detriments exist in its adoption and continued usage (Ifinedo, 2018). This paper contributes to the scholarship in several avenues. First, prior literature on the use of instant messaging tools are focused on the adoption phase and conducted primarily on developed economies resulting to a limited research investigating its usage continuance from the perspective of a developing economy (Mouakket, 2019). Second, prior research have highlighted the critical role of social factors in the use of collaboration technologies in groups

(Graham & Jones, 2019) and rather than using technology dimensions in the post-adoption of instant messaging tools, this study tests the influence of social dimensions in the continued use of this technology.

Students enrolled in a university course that requires them to work in groups to design and develop an information system for an existing organization were invited to participate in an online survey. Capturing the social aspects such as social influence and social presence of the continued use of collaboration for group work among learners is imperative to the successful integration of these technologies in the modern work environment (Huang, 2016). A total of one hundred sixty eight students (168) enrolled in the course participated in the study and the results were analyzed using Partial Least Squares (Hair, Hult, Ringle, & Sarstedt, 2014; Wong, 2013). In the next sections, discussions of related literature on the use of instant messaging tools in higher education, the theoretical guidance adopted and hypothesis development are presented. Implications and limitations are acknowledged after the discussion of the results.

2. Related Studies and Theoretical Framework

In higher education, collaboration technologies were found to be effective in accomplishing academic requirements involving group tasks. The study of Gronseth and Hebert (2019) reveal that mobile instant messaging tools are preferred by students over other collaboration technologies embedded in learning management systems due to its ease of use and accessibility. Widely available mobile instant messaging tools appear to be popular among students as a collaboration tool. For example, a study on the use of WeChat among graduate students found that there is a strong sense of collaboration among peers. The group features in this popular app allows participants to express themselves freely, establish new relationships and continue to collaborate beyond the course (Tang & Hew, 2018). The interactivity among users in a group represents one of the primary motivators in the use of instant messaging tools. For example, in a study investigating the use of WhatsApp by undergraduate students, online discussions and sharing of resources were some of the advantages identified as activities that support academic learning (Gon & Rawekar, 2017). These findings are consistent with a prior study by Bouhnik and Deshen (2014) in their investigation of the use of WhatsApp by students and teachers in high school. While interest from the scholarship on the use of instant messaging as a collaboration tool has increased in recent years, studies that investigate the social behavioral dimensions of its usage is scant. Majority of the studies have taken the technological and academic perspectives in its use, neglecting the importance of social factors in online collaboration through these technologies.

Continued use of technology is a body of discipline within information systems research that puts emphasis on investigating individual behaviors use of technology after its initial adoption. According to the Theory of Reasoned Action or TRA, external determinants can predict the behavioral intention of an individual to perform an action such as attitude and subjective norms (Ajzen, 1975). Attitudes are behavioral beliefs that refer to the result of a person's evaluation of the consequences of performing a specific act. Subjective norms can take a form of a person's perception on what people around him thinks about performing a specific act (Yousafzai, Foxall, & Pallister, 2010). While these determinants represent the two salient dimensions of behavioral intention to commit an act in TRA, scholars have suggested operationalizing external variables to improve the theoretical precision of TRA (Mishra, Akman, & Mishra, 2014; Ortiz De Guinea & Markus, 2009). In the context of this study, instant messaging tools offer features that cultivate digital interaction among users that can invoke social presence (Bere & Rambe, 2016). It is defined as the perceived degree of salience of an individual in computer mediated collaboration (Graham & Jones, 2019). Prior studies have argued that social presence is an important determinant which influence the attitude of students in the usage continuance of collaboration technologies among students (Huang, 2016). This construct is operationalized to influence attitude which along with social influence determines the behavioral intention of students to use instant messaging for group collaboration as shown in Figure 1 – Theoretical Framework.
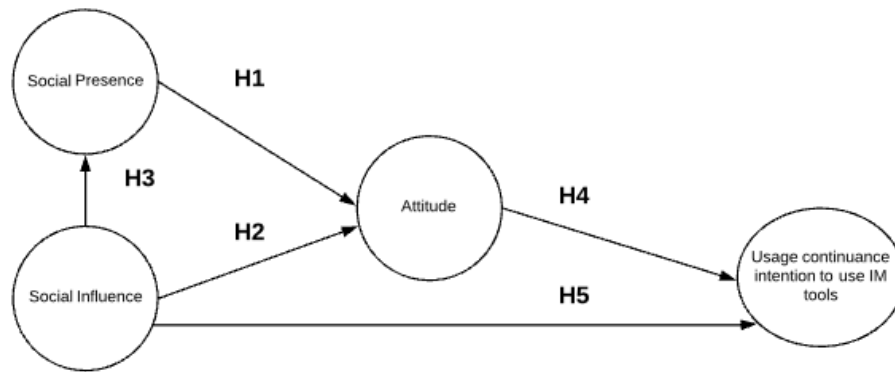
Figure 9. Theoretical Framework

In the domain of education, prior research has explored factors that positively influence the usage continuance of collaboration technologies. Social presence (SP) was found to positively influence the attitude of learners towards the continued use of collaboration technologies (Huang, 2016). Likewise, social influence (SI) is also a strong determinant of attitude in the continued use of tools that support teamwork (Huang, 2016; Olschewski, Renken, Bullinger, & Möslein, 2013). In a virtual environment, individuals who are considered important by users may have a direct effect on their perceived social presence (Huang, 2016). Lastly, attitude (ATT) and social influence (SI) were found to have strong positive influence in the behavioral intention to use or continually use technologies as originally argued by TRA (Lu, Zhou, & Wang, 2009; Mishra et al., 2014). Given the findings of prior research, we offer the following set of hypotheses:

H1 – Social Presence (SP) has a positive influence on Attitude (ATT).
H2 – Social Influence (SI) has a positive influence on Attitude (ATT).
H3 – Social Influence (SI) has a positive influence in Social Presence (SP).
H4 – Attitude (ATT) has a positive influence on the Usage Continuance (UC) intention to use instant messaging tools for collaboration.
H5 – Social Influence (SI) has a positive influence on the Usage Continuance (UC) intention to use instant messaging tools for collaboration.

3. Methodology

Due to its fit with the research objectives of this investigation and the presence of constructs operationalized in this study, a scaled-down questionnaire was adopted from the study of Huang (2016) to test the hypotheses.   Students enrolled in a university located in the Philippines were invited to participate in the study by answering an online survey and informed consent was solicited. The students are enrolled in a course that relies heavily on group work. They were invited to create instant messaging groups using WhatsApp throughout the duration of the course. Questions were modified to match the use of instant messaging for collaboration and six (6) students were invited to answer a paper-based survey. A group discussion was conducted to get the feedback of the students. Questions that were difficult to understand were modified and incorporated in an online survey that was deployed to eighteen (18) students to test the validity and reliability of the instrument. A Partial Least Squares algorithm was applied, and the results are shown in Table 1.

Table 6

Instrument Validity and Reliability

	Chronbach's Alpha	Composite reliability	Average Extracted Variance
Social Presence (SP)	0.863	0.848	0.737
Social Influence (SI)	0.834	0.880	0.711
Attitude (ATT)	0.733	0.845	0.731
Usage Continuance (UC)	0.821	0.840	0.725

534

To establish validity and reliability, constructs in the structural model should have values that are higher than 0.70 for both Cronbach's Alpha and Composite Reliability. On the other hand, Average Variance Extracted must meet the minimum value of 0.50 (Hair et al., 2014; Limpin, 2018). The validated instrument was administered to students and a total of one hundred sixty-eight (168) responses were recorded after removing invalid responses. One hundred thirty-two (132) or 78.57% of the total responses are under the information technology program while thirty-six (36) or 21.43 % are enrolled in the computer engineering program. Of the total respondents, one hundred sixteen (116) are male students and fifty-two (52) are female. When asked about the use of instant message for group communication, ninety-seven (97) of the respondents or 58% primarily used this technology to communicate with classmates, thirty-two (32) or 19% with friends and thirty-nine (39) or 23% with family members.

4. Discussion of Results

The results of the survey were analyzed using Partial Least Squares – Structural Equation Model using smartPLS. This statistical tool provides a graphical user interface that is capable of supporting information systems research in multiple regression analysis (Hair et al., 2014; Wong, 2013). Furthermore, this statistical tool is able to reveal rich insights in empirical studies using a small sample size (Ringle, Sarstedt, & Straub, 2012). A bootstrapping technique was applied to the recorded responses using smartPLS. The results of the structural model validation are shown in Table 2. T-statistics values that are higher than 1.96 demonstrate that the path can be supported at a significant level.

Table 7

Results

	Statement	T-Statistics	Decision	Significant Level
H1	Social Presence (SP) has a positive influence on Attitude (ATT)	2.356	Accept	0.05
H2	Social Influence (SI) has a positive influence on Attitude (ATT)	2.157	Accept	0.05
H3	Social Influence (SI) has a positive influence in Social Presence (SP)	0.145	Reject	Not Significant
H4	Attitude (ATT) has a positive influence on the Usage Continuance (UC) intention to use instant messaging tools for collaboration	5.535	Accept	0.01
H5	Social Influence (SI) has a positive influence on the Usage Continuance (UC) intention to use instant messaging tools for collaboration	7.378	Accept	0.01

Social presence and social influence both positively influence the attitude of students to continually use instant messaging tools. The path of H1, social presence (SP) and attitude (ATT), has a value of 2.356 and we can infer that the connectedness of an individual with the rest of the group promotes positive attitude towards the usage continuance of instant messaging for collaboration. Recent years have seen notable improvements in interaction features that improve realness in digital interactions such as liking, sharing resources and video capabilities (Bere & Rambe, 2019). In a virtual group, social presence assumes a critical role in achieving shared learning objectives as individual members acquire group norms and interact with other members (Remesal & Colomina, 2013). Consistent with prior studies, social (SI) influence is a strong determinant of positive attitude (ATT) with a value of 2.157 supporting the path H2. People considered important by students have a significant influence on their attitude towards the continued use of instant messaging tools and confirms the findings of previous studies on the use of technology for collaboration (Huang, 2016).

Consistent with the theory of reasoned action and prior studies, attitude and social influence determines the behavioral intention to use instant messaging tools for collaboration confirming the validity of paths H4 and H5 (Hassandoust, Logeswaran, & Farzaneh Kazerouni, 2011; Olschewski et al.,

2013). The benefits acquired by students through IM groups encourage them to use these technologies beyond what is required in the course. Findings from other studies have intimated that participants expressed willingness to continually use these groups beyond the duration of their course (Tang & Hew, 2018). In the academic settings there is strong evidence that social influence is a strong predictor of behavioral intention. This influence comes from classmates or faculty members, aside from close friends and family members, who can exert influence to use available technology tools (Ramírez-Correa, 2017). Notable increase in the use of IM tools have been observed, and a big chunk of these users come from the age group of the participants.

Contrary to prior research of Huang (2016), social influence does not predict social presence and therefore, this study rejects the path H3. A possible explanation is that groupings were randomly selected. Findings suggest that students detect more interaction with familiar people and having a zero-history might influence the salience of other individuals in a computer-mediated interaction (Kreijns, Kirschner, & Jochems, 2003). The composition of the groups may also be an important factor in limiting group cohesion. The randomness of groupings might have affected the group cohesion which was found in prior research (Tang & Hew, 2018) to promote social presence in computer-supported collaborative environment.

5. Conclusion and Future Direction

In conclusion, this study reveals that social factors influence the students' attitude in the use of instant messaging as a collaborative tool. Confirming the theory of reasoned action, attitude has a direct influence on the students' intention in continuing their usage of apps such as WhatsApp to collaborate with their co-learners. Although there is a possible relationship between social influence and social presence, this cannot be supported based on the values revealed by the structural model. In this context, social influence and attitude are factors that exhibited strong influence on continued use. Academic institutions can promote collaboration tools by encouraging the teachers to embed these technologies in the course delivery as they have direct relationship with the students, and therefore can exert positive influence on the students' attitude in the use of technology (Ramírez-Correa, 2017). The importance of social factors is highlighted by this research. Therefore, developers for collaboration tools should consider incorporating features that would mimic real human interactions as previous studies have revealed that social factors are more important than technological factors in the usage continuance of collaboration technologies (Huang, 2016).

Although this paper contributes to the limited research on the usage continuance of instant messaging for collaboration, future research should exercise caution in interpreting the findings of this study for several reasons. First, the small sample size may limit the generalizability of the results of this research. Second, the duration of the study was limited to one semester, which means future research can use a longitudinal approach to improve the results of this study (Shen, Cheung, Lee, & Chen, 2011). Finally, a qualitative approach such as conducting in-depth interviews or by analyzing conversation logs is suggested in order to reveal deeper insights into the motivation of students in using instant messaging as a collaborative tool in a learning environment.

References:

Ajzen, I. (1975). Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research., *6*(2), 244. https://doi.org/10.2307/2065853

Bere, A., & Rambe, P. (2016). An empirical analysis of the determinants of mobile instant messaging appropriation in university learning. *Journal of Computing in Higher Education*, *28*(2), 172–198. https://doi.org/10.1007/s12528-016-9112-2

Bere, A., & Rambe, P. (2019). Understanding mobile learning using a social embeddedness approach : A case of instant messaging Aaron Bere Patient Rambe Central University of Technology , Free State , South Africa, *15*(2), 132–153.

Bouhnik, D., & Deshen, M. (2014). WhatsApp Goes to School: Mobile Instant Messaging between Teachers and Students. *Journal of Information Technology Education: Research*, *13*, 217–231. https://doi.org/10.28945/2051

Gon, S., & Rawekar, A. (2017). Effectivity of E-Learning through Whatsapp as a Teaching Learning Tool. *MVP Journal of Medical Sciences*, *4*(1), 19. https://doi.org/10.18311/mvpjms/0/v0/i0/8454

Graham, M., & Jones, N. (2019). Impact of a Social Network Messaging App on Team Cohesiveness and Quality of Completed Team Projects in an Undergraduate Team Project. *Journal of Educational Technology Systems*, *47*(4), 539–553. https://doi.org/10.1177/0047239518821937

Gronseth, S., & Hebert, W. (2019). GroupMe: Investigating Use of Mobile Instant Messaging in Higher Education Courses. *TechTrends*, *63*(1), 15–22. https://doi.org/10.1007/s11528-018-0361-y

Hair, J., Hult, G., Ringle, C., & Sarstedt, M. (2014). Partial least squares structural equation modeling (PLS-SEM). *Sage Publisher*. https://doi.org/10.1108/EBR-10-2013-0128

Hassandoust, F., Logeswaran, R., & Farzaneh Kazerouni, M. (2011). Behavioral factors influencing virtual knowledge sharing: theory of reasoned action. *Journal of Applied Research in Higher Education*, *3*(2), 116–134. https://doi.org/10.1108/17581181111198665

Huang, Y. M. (2016). The factors that predispose students to continuously use cloud services: Social and technological perspectives. *Computers and Education*, *97*, 86–96. https://doi.org/10.1016/j.compedu.2016.02.016

Ifinedo, P. (2018). Roles of perceived fit and perceived individual learning support in students' weblogs continuance usage intention. *International Journal of Educational Technology in Higher Education*, *15*(1). https://doi.org/10.1186/s41239-018-0092-3

Kreijns, K., Kirschner, P. A., & Jochems, W. (2003). Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: A review of the research. *Computers in Human Behavior*, *19*(3), 335–353. https://doi.org/10.1016/S0747-5632(02)00057-2

Limpin, L. (2018). Investigating the Factors Influencing the Participation in Ride-Sharing: The Case of the Philippines. *Proceedings of 2018 the 8th International Workshop on Computer Science and Engineering (WCSE 2018)*, (September), 374–379.

Lu, Y., Zhou, T., & Wang, B. (2009). Exploring Chinese users' acceptance of instant messaging using the theory of planned behavior, the technology acceptance model, and the flow theory. *Computers in Human Behavior*, *25*(1), 29–39. https://doi.org/10.1016/j.chb.2008.06.002

Mishra, D., Akman, I., & Mishra, A. (2014). Theory of Reasoned Action application for Green Information Technology acceptance. *Computers in Human Behavior*, *36*, 29–40. https://doi.org/10.1016/j.chb.2014.03.030

Mouakket, S. (2019). The influence of intrinsic and extrinsic gratifications on continuance motivation of mobile instant messaging: The United Arab Emirates context. *Journal of High Technology Management Research*, *30*(1), 40–49. https://doi.org/10.1016/j.hitech.2019.01.002

Murire, O. T., & Cilliers, L. (2017). Social media adoption among lecturers at a traditional university in Eastern Cape Province of South Africa. *SA Journal of Information Management*, *19*(1), 1–6. https://doi.org/10.4102/sajim.v19i1.834

Olschewski, M., Renken, U. B., Bullinger, A. C., & Möslein, K. M. (2013). Are you ready to use? Assessing the meaning of social influence and technology readiness in collaboration technology adoption. *Proceedings of the Annual Hawaii International Conference on System Sciences*, 620–629. https://doi.org/10.1109/HICSS.2013.101

Orta-Castañon, P., Urbina-Coronado, P., Ahuett-Garza, H., Hernández-de-Menéndez, M., & Morales-Menendez, R. (2018). Social collaboration software for virtual teams: case studies. *International Journal on Interactive Design and Manufacturing*, *12*(1), 15–24. https://doi.org/10.1007/s12008-017-0372-5

Ortiz De Guinea, A., & Markus, M. L. (2009). Why Break the Habit of a Lifetime? Rethinking the Roles of Intention, Habit, and Emotion in Continuing Information Technology Use. *MIS Quarterly*, *33*(3), 433–444.

Ramírez-Correa, P. E. (2017). Relationship Between Cyber Plagiarism and the Big Five Personality Traits: an Empirical Study in a Chilean University. *Holos*, *5*, 125. https://doi.org/10.15628/holos.2017.5191

Remesal, A., & Colomina, R. (2013). Social presence and online collaborative small group work: A socioconstructivist account. *Computers and Education*, *60*(1), 357–367. https://doi.org/10.1016/j.compedu.2012.07.009

Ringle, C. M., Sarstedt, M., & Straub, D. (2012). A Critical Look at the Use of PLS-SEM in MIS Quarterly. *MIS Quarterly*, *36*(1), iii–xiv. https://doi.org/10.1016/j.transci.2015.02.018

Shen, A. X. L., Cheung, C. M. K., Lee, M. K. O., & Chen, H. (2011). How social influence affects we-intention to use instant messaging: The moderating effect of usage experience. *Information Systems Frontiers*, *13*(2), 157–169. https://doi.org/10.1007/s10796-009-9193-9

Tang, Y., & Hew, K. F. (2018). Examining the utility and usability of mobile instant messaging in a graduate-level course: A usefulness theoretical perspective. *Australasian Journal of Educational Technology*, *35*(4), 128–143. https://doi.org/10.14742/ajet.4571

Wong, K. K.-K. (2013). Partial Least Squares Structural Equation Modeling (PLS-SEM) Techniques Using SmartPLS. *Marketing Bulletin*, *24*(1), 1–32. https://doi.org/10.1108/EBR-10-2013-0128

Yadegaridehkordi, E., Shuib, L., Nilashi, M., & Asadi, S. (2019). Decision to adopt online collaborative learning tools in higher education: A case of top Malaysian universities. *Education and Information Technologies*, *24*(1), 79–102. https://doi.org/10.1007/s10639-018-9761-z

Yousafzai, S., Foxall, G., & Pallister, J. (2010). Explaining Internet Banking Behavior: Theory of Reasoned Action, Theory of Planned Behavior, or Technology Acceptance Model? *Journal of Applied Social Psychology*, *40*(5), 1172–1202. Retrieved from http://dx.doi.org/10.1111/j.1559-1816.2010.00615.x

An Investigation of Affect within *Ibigkas!*: An Educational Game for English

Michelle P. BANAWAN[a]*, Raul Vincent W. LUMAPAS[a], Jaclyn L. OCUMPAUGH[b], & Ma. Mercedes T. RODRIGO[c]
[a]Ateneo de Davao University, Philippines
[b]Penn Center for Learning Analytics, University of Pennsylvania, USA
[c]Ateneo Laboratory for the Learning Sciences, Ateneo de Manila University, Philippines
*mpbanawan@addu.edu.ph

Abstract: We investigated the affective states (both individual and shared emotions) of students using a collaborative and educational game for English called *Ibigkas!* Our goal was two-fold: (1) To determine the incidence and persistence of affective states exhibited by the students when working individually and in groups, and (2) to adapt the Baker Rodrigo Ocumpaugh Monitoring Protocol for collaborative learning situations. Our findings for this study are as follows: (1) in single-player mode, students exhibited greater engaged concentration, pride, and frustration and less excitement, delight, and confusion compared to the multiplayer mode; (2) that individual emotions can be distinct from group emotions; (3) that negative emotions like frustration and blame/guilt were only felt at the individual level and were not observed as shared by all the members of the group; (4) affective states tended to persist more within an individualized game setting compared to the collaborative game setting where there was a greater number of opportunities to experience a wider range of emotions, hence the low chance of persistence; (5) students within an individualized setting spent more time solving the game rounds, had fewer incorrect answers, even as they experienced more frustration, and finally, (6) students within a collaborative setting had fewer errors when they had a higher incidence of excitement and had more errors when they appeared to be concentrating due to the presence of the "gaming the system" behavior.

Keywords: *Ibigkas!*, BROMP, student affect, English language learning

1. Introduction

Collaborative games are activities in which players must work together as a team in order to share payoffs and outcomes (Zagal, Rick, & Hsi, 2006). They differ from cooperative games, in which players' goals may vary. In a collaborative game, players have a common goal. The consequences of each decision, be they positive or negative, are shared by all members of the group. Some research has shown that collaborative games are fun, engaging, and motivating (Wendel, et al., 2013); promote positive learning attitudes, motivation, achievement, and self-efficacy (Sung & Hwang, 2013); and encourage the development of prosocial skills (Hromek & Roffey, 2009).

Despite their potential, the literature on collaborative games for learning or affective states experienced by players is limited. A systematic review of literature by Connolley and colleagues (2012) identified only 18 quality papers on affective and motivational outcomes of games in general while a follow up review by Boyle and colleagues (2016) identified only 22, 7 of which were games for learning. Furthermore, most of the methods used for collecting the data in these studies tended to be survey research.

Given these gaps, there is opportunity to contribute to the literature by analyzing student affect while using a collaborative and educational game, using data collection methods beyond or in addition to survey research. To this end, this study compares the affective states that students exhibit as they play individual and collaborative versions of the same game. We aim to answer the following questions:
- How can we adapt BROMP, a widely used quantitative field observation methodology, to account for collaborative learning activities?

- What is the incidence and persistence of students' affective states when playing an individualized game?
- What is the incidence and persistence of students' affective states when playing a collaborative game?
- What are the similarities or differences between the two patterns of affective states?

2. Adaptation of BROMP for Collaborative Learning

BROMP is a field observation methodology that enables trained research staff to collect affect and behavior observations systematically (Ocumpaugh et al., 2015). The affective states of interest observed were engaged concentration, confusion, frustration, delight, excitement and pride. The descriptions are as follows:

- **Engaged Concentration**. This is the affective state depicting engagement with the task where there is intense concentration, focused attention and total involvement (Baker, D'Mello, Rodrigo & Graesser, 2010). This affective state's observable indicators include focus on the task at hand, mouthing answers/solutions, pointing to the screen, among others.
- **Confusion.** This is the affective state depicting difficulty with the game and how to play it (Ocumpaugh et al., 2015). Observed manifestations include scratching the head, repeatedly looking at the same interface elements, consulting with a group mate or a facilitator, asking questions and verbalizing that they are confused and do not know how what to do nor how to proceed. It is noteworthy, though, that specific to the deployments for this study, when students experience confusion they were mostly laughing and making fun of their mistakes.
- **Frustration.** This is the affective state that depicts distress or annoyance with the game (Ocumpaugh, et al. 2015). Behaviors include heavy tapping on the phone screen, pulling his/her hair, deep sighing, and utterances such as "This is annoying!", "I am so stressed!", etc.
- **Delight.** This is the affective state often expressed when a participant feels pleasure when doing the task at hand. This is characterized as an affect with positive valence and medium arousal. Observed behaviors include clapping, smiling and utterances like "This is fun!".
- **Excitement.** This is the affective state often expressed when a participant starts to become very engaged and overwhelmed. This is characterized as positive valence and high arousal. Observed behaviors include standing up, tapping of the feet, and louder voices in utterances like "Go, go, go!".
- **Pride.** This is the affective state often expressed when a participant feels pleasure when achieving a goal or accomplishing a task. Observed indicators include tapping a groupmate on the back and utterances like "We did it!", "I solved it!" or announcing their scores out loud.

2.1   Norming BROMP for Group Observations

BROMP was originally designed for use with students engaged in individual work. While students were free to speak to a teacher, facilitator, or peer, these interactions were not mandatory as the tasks they had could be accomplished independently. It was possible to use BROMP, as how it was originally designed by its creators in collaborative learning situations, but doing so would make it difficult to capture additional characteristics of affective states and behaviors, such as to whom the affective states were directed to, e.g. to self, to the entire group, or to specific team members. It was therefore necessary to adapt BROMP to include these other phenomena of interest.

We conducted pre-tests to norm BROMP for group affect and behavior observations. We recruited 45 first year college students, 16–18 years old. If they agreed to participate, they signed a consent form indicating their willingness to participate in this test while those under 18 also had to ask their parents to complete a second consent form allowing them to join the study.

In groups of three members each, they played the game *Overcooked*. *Overcooked* is a restaurant game in which players act as any of the kitchen staff that who prepare the ingredients, cook, wash plates, and serve dishes. A team-based game, the players needed to divide the work strategically to complete as many orders as they can within the time limit. *Overcooked* was also fast paced so observing a wide range of emotions across different stages of gameplay was more possible than a game that took longer to win or finish. The students had three rounds of gameplay that lasted for around ten minutes. As they

played, the first and second authors observed each member of the group and the group as a whole, i.e. after each member of the group was observed, we also took note of the group affect and behavior of the majority, if not all, of the group members.

In the course of the pre-test, we found that affect or emotions have directionality, either directed towards self, a particular group-mate or towards the rest of the group. We found that members exhibited affective states that had a social dimension, specifically, blame and guilt. Utterances that depict blame include "It is your fault!" or "Who did this? Now, we lost!". Utterances that depicted guilt include "Sorry, my bad!" or "Shame on me!". We noted that the same negative valence and medium to low arousal occurred towards self (guilt) and others (blame).

To further verify our observations, we interviewed the participants and asked them what their general feelings and/or emotions were during the gameplay. Responses to the open-ended questions were transcribed and we used thematic analysis, i.e. coded according to common themes and computed the frequency and percentage of each theme from the entire dataset of responses. Some responses were coded with more than one theme as different feelings/affect were reported. This thematic analysis of interview responses led to the following findings: the more common affective states experienced by the students were confusion (65%) towards the game and their group mates, frustration (46%) towards the game and towards self, excited (54%), delight (38%), pride (8%) towards self and their group and blame/guilt (towards self) (8%).

Given the pre-test results, BROMP resulted to the normed BROMP-collab to include guilt/blame and directionality of the affective states of interest. We made use of both the original BROMP and the normed BROMP for collaborative learning (BROMP-collab) respectively to observe students as they played the single player and multiplayer versions of an educational mobile phone game for English called *Ibigkas!*

3. Ibigkas!

Ibigkas! is a drill-and-practice style game that helps learners develop fluency in identifying rhymes, synonyms, and antonyms in English. It was developed (as discussed more fully in Rodrigo et al., in press) by the Ateneo Laboratory for the Learning Sciences of the Ateneo de Manila University in the Philippines. It is available free of charge for both Android and iOS. It was intended for use by disadvantaged under-resourced students in grades 4, 5, and 6 students in Philippine public schools, where English is an official language, but is not necessarily the language of instruction.

Ibigkas! allows both a singleplayer and multiplayer modes. To play in singleplayer mode, the player first selects a content mode: rhymes, synonyms, or antonyms. When game play begins, the player receives a target word and three choices (Figure 1). The player must click on the choice that is the rhyme, the synonym, or the antonym of the target word.

To play in multiplayer mode, each student must have one a mobile phone each, with the game installed. The game does not require Internet access, but each device must have wifi. Phones have to be connected to the same network hotspot in order to communicate. When the game round begins, a random player from the team receives a target word (in Fig. 2a, the target word is KIT). All players receive lists of words, only one of which is the correct answer. In this example, the list of words received are MISS, NO, WRONG, ANOTHER, HIT and BAD. The correct answer is HIT which rhymes with the target word KIT, in Figure 1.

The player presented with the target word must say it aloud, so that the other players can hear it. The requirement to say the word aloud is the origin of the game's name, as *ibigkas* is the Filipino word for "pronounce" or "say out loud". All other players then check their list of words to see if they have the correct answer. The player with the correct answer should say the answer aloud and tap it. Once the correct answer is tapped, the round is over and a new round begins.

Figure 1. Sample screenshots of the game.

4. Field Study

The deployment and testing was conducted at Angels Here Abound (AHA!) Learning Center (ALC), a tutorial center in Makati, Metro Manila, Philippines that caters to public school students. Staffed in large part by volunteers, ALC is committed to providing supplementary holistic education to underprivileged children. The ALC staff selected students from Grades 4, 5, and 6 to participate in the study. A total of 32 students participated in the study: 12 from Grade 4, 12 from Grade 5, and 8 from Grade 6. These students were given informed consent forms that they and their parents had to complete in order to participate. During the study day, the participants were grouped by grade level. Each grade level had separate testing sessions because the research team had a limited number of cellular phones. The students were given 10 minutes to play *Ibigkas!* in single-player mode then 10 minutes to play in multiplayer mode. While they were playing in single-player mode, a trained observer recorded their affective states using the Baker Rodrigo Ocumpaugh Monitoring Protocol (BROMP). While the students were playing in multiplayer mode, the same observer used an adaptation of BROMP that included the collaborative nature of the game.

5. Analysis

5.1 Incidence and Persistence of Affective States

We computed the incidence of each affective state by dividing the number of times that a specific affective state has been observed by the total number of observations per student. We, then computed the overall incidence by averaging the incidence rates of the affective states across all students. We also did the same procedure for the observed group affect.

In the single-player mode, the students were mostly engaged (70.97%). They also exhibited the following affective states: pride in themselves when they are able to answer correctly (8.13%), delight (7.29%), confused (7.15%), and frustrated with either the game or themselves (4.79%). They were rarely excited (0.63%) and less likely felt blame (0.35%).

In the multiplayer mode, the students exhibited lesser engaged concentration (43.36%) than when they were in single-player mode. They also had more confusion (34.77%), felt more delight (9.07%), excitement (4.30%) and blame (0.78%). However, they exhibited no pride towards self but pride towards their group (0.39%). Frustration (1.95%) had fewer occurrences than when they were on single player mode. Also in multiplayer mode, when we compare the group emotions to the individual

members' emotions, we see that the group had around the same level of engagement (53.82%), confusion (35.59%), delight (7.47%), excitement (1.56%) and pride (0.30%). Blame and frustration were not present in the group emotions.

We used D'Mello's L (D'Mello & Graesser, 2012) as implemented by Karumbaiah (2018) to find out whether some of these states were more likely than chance to transition to each other. An L value of 0 means the transition occurs at chance. L values greater than 0 mean that a transition is more likely than chance to occur, while values less than 0 mean that a transition is less likely than chance to occur.

In the single-player mode, we found that the following affective states occurred more likely than chance: engaged concentration (L=0.44, p<0.01), delight (L=0.29,, p<0.01), confusion (L=0.58, p<001), frustration (L= 0.49, p<0.01) and pride (L=0.43, p<0.01). We also found that engaged concentration shifted to confusion (L=-0.05, p<0.05), engaged concentration shifted to frustration (L=-0.03, p<0.05) and vice versa (L=-0.68, p<0.01), delight shifted to engaged concentration (p<0.05), and pride shifted to engaged concentration (L=-0.44, p<0.05). These transitions, though, were less likely than chance.

In the multiplayer mode, we found that confusion (L = 0.15, p<0.01) persisted. and engaged concentration shifted to delight (L = 0.05, p<0.05) and vice versa (L = 0.40, p<0.05). Significant negative transitions found in the multiplayer mode are confusion to delight (L = -0.13, p<0.01) and vice versa (L = -0.12, p<0.05),

When we separated individual emotions and group emotions, we found that in a collaborative setting (multiplayer mode), individual emotions alone show that confusion (L=0.15, p0<0.01) persisted. Excitement to excitement (L=-0.5, p<0.01), although significant, occurred less likely than chance. Engaged concentration transitions to delight (L=0.06, p<0.05) and vice versa (L=0.38, p<0.05). Confusion transitions to delight (L=-0.14, p<0.05) but this is less likely than chance. For group emotions though, no significant transitions were computed because of the small size of the sample, i.e. there are only 8 groups with 7 observations per group. We noted, though, that the L-statistic for confusion and engaged concentration were above 0.

5.2   Aggregated Gameplay Logs

Ibigkas! produces logs of the gameplay. The logs contain information on the game, content mode and multiple rounds, including the type of content mode and difficulty. It also contains each player's attempts at all the rounds. The correct and wrong answers along with timestamps are captured in the said game logs. We aggregated the logs at the player level and summarized the incorrect answers, number of attempts at each round, and the time elapsed at every attempt.

For the singleplayer mode, the participants had an average of 1.73 (std dev = 0.94) seconds of gameplay and 0.41% error rate (std dev = 0.20).

For the multiplayer mode, the participants had an average of 9.81(std dev = 4.28) seconds of gameplay and 1.37% error rate (std dev = 0.65).

There were no significant difference between the groups of students or grade levels (grade 4, grade 5 and grade 6). Their gameplay performance based on the aggregated logs reveal homogeneity and grade level was not a factor that differentiated their gameplay results.

5.3   Correlating Affect Incidence Rates to the Ibigkas! Logs

We correlated the affect incidence rates during the singleplayer gameplay and the game logs also for the singleplayer gameplay. The only significant correlation was between frustration and wrong rate (R= -0.51) and average time and wrong rate (R = 0.69). Wrong rate, as previously mentioned, is computed as the total number of incorrect answers divided by the total number of attempts that the student made in the entire game. Average time is the average time that the student spent in answering all the rounds of his/her entire gameplay. For this study, when students spent more time in his attempts, they had fewer incorrect answers. This means that the students were spending more time solving the game rounds and were thinking of the correct answers when they were in single player mode.

For the multiplayer mode, we found that the wrong rate was significantly related to engaged concentration, (R= 0.36) and excitement (-0.45). Because the direct relationship between engaged

concentration and wrong rate seem to be surprising, we also computed the incidence rates of observed gaming behavior and found that gaming occurred 14.45% of the time during the gameplay. This could be the reason why the seeming engaged concentration was related to committing more errors/mistakes. Gaming the system has been observed among students even when they are engaged and concentrating (Pardos, et al., 2013). On the other hand, excitement being inversely related to the wrong rate corroborates prior research that positive emotions like excitement has been found to be related to knowledge acquisition and learning (Giannakos, 2013).

There were no significant relationship between the singleplayer and multiplayer aggregated logs.

6. Discussion

6.1 Incidence and persistence in individualized versus collaborative settings

Comparing the occurrence rates of affective states (see table 1) between an individual and a collaborative setting reveal that students were more engaged and concentrated more when working individually than when they were working with others. Confusion and excitement are also observably higher when in groups than within individual settings. Delight slightly increased while pride and frustration slightly decreased within the collaborative setting.

We observed that when a student works alone, he/she tended to figure out the answers and solve the games alone, hence explaining the higher engaged concentration, pride when successful, frustration when unsuccessful because he/she is accountable to only himself/herself and not to anyone else. On the contrary, within a collaborative setting, students interact with their groupmates, which make room for more instances of shared excitement, delight and fewer instances of focused concentration. Also, when failure happens, the students have other people to blame or feel more responsible when one fails.

Table 1

Comparison of Incidence of Affective States in a Singleplayer and Multiplayer modes

	Singleplayer (%)	Multiplayer (%)
Engaged Concentration	70.97	43.36
Delight	7.29	9.07
Pride	8.13	0.39
Confused	7.15	34.77
Frustrated	4.79	1.95
Excited	0.63	4.30
Blame/Guilt	0.35	0.78

For persistence, we observe that in an individual setting, there are more persistent affective states than in a collaborative setting. This may be due to the fact there are more interactions with a peer, making room for more transitions to other affective states. BROMP researchers have mentioned that coding affective states can become more challenging when there are interactions with other persons as

the conditions may not fit the typical BROMP scheme as some emotions, not originally part of the BROMP, may become more prominent (Ocumpaugh, et.al., 2015).

When we look at the transitions that occurred more likely than chance, we observe this only happened in multiplayer mode where engaged concentration shifted to delight and vice versa. This could be attributed to a more prominent feeling of delight when shared within a peer than alone.

6.2 Comparing individual emotions and group emotions

Differentiating the observations between individual participants and the group affect within the multiplayer mode, we found that frustration and blame/guilt was not among the group emotions observed. This can be explained by what prior research has shown that game goals matter to players but due to their "pretend/unreal" contexts, players are able to control or modulate negative emotions to (re)focus on game goals (Granic, Lobel & Engels, 2014).

We also found that, as expected, the group emotions occurrence rates were relatively similar to the occurence rates of the observed individual emotions but not all emotions at the individual level were observed at the group level.

This corroborates the operational definition of group emotions as a shared emotion and that not all individuals share the same group emotion (Smith, Seger & Mackie, 2007).

Blame/guilt and frustration being observed only at the individual level is also noteworthy. This can be explained by a previously researched phenomenon that the group dynamics within collaborative games promote positive feelings (Sung & Hwang, 2013), and for this study this has become more apparent given the observed incidence rates of affective states for both the individual and group modes of gameplay.

6.3 Relationships between affect and game performance in the singleplayer mode

From 5.3, we find that frustration has an inverse relationship to the student's wrong rate in the singleplayer mode. This implies that the more frustrated the student feels the fewer incorrect answers he/she had. At the onset, this relationship may appear to be counter intuitive but reviewing the observations involving frustration, we find that the students who have had episodes of frustration have actually exerted more effort to provide the correct answers. This phenomenon has been described as frustration-motivated exploration which may lead to learning (Wong, 1979) as frustration has also been previously found to be lesser associated to poorer learning (Baker, et al., 2010).

The multiplayer mode revealed that the wrong rate of the students while playing was significantly related to two affective states observed during this specific gameplay. Engaged concentration had a direct relationship to the wrong rate, which implies that, the more engaged the students were the more number of errors they had. Excitement was found to be inversely related to the wrong rate, i.e. the more excited the students became, the fewer errors they committed which corroborates prior work (Robinson, Murray & Isbister, 2018) that has found that pleasure and effort coexist or combine. Hence, with more positive emotion comes more effort and fewer errors.

7. Conclusion

We investigated the different affective states that the students go through during gameplay for *Ibigkas!* and normed BROMP to cover the recurring group affective states that occur in a collaborative and gamified learning environment. For the single-player mode of gameplay, the affective states that occurred more were engaged concentration and confusion and there were a few incidences of delight, pride, excitement, frustration and blame/guilt. For the multiplayer mode, the same affective states were most prominent, i.e. engaged concentration and confusion, while the other affective states were rarely observed. Within the multiplayer mode, we found that everyone in the group did not share frustration and blame/guilt. Hence, there was no incidence of frustration and blame/guilt in observations for group emotions. This work also reinforces the benefits of collaborative learning environments, in particular,

for educational game settings, i.e. it promotes positive emotion and removes negative emotions like frustration and blame/guilt.

Our findings corroborate prior work on collaborative games promoting engagement and positive attitudes and emotions like delight, fun and pride towards self and the group when they are able to achieve the game goals, i.e. answer the levels correctly. The results also show that while the pattern of emotions have some degree of similarity in terms of incidence (occurrence rates) and persistence, not all individuals share the observed group emotions and that group emotions are, indeed, distinct from individual-level emotions (Smith, Seger & Mackie, 2007).

In terms of recurrence rates, single-player modes had more persistent affective states (engaged concentration, delight, confusion, pride and frustration) as compared to only confusion as the persistent state in multiplayer mode.

We also found that frustration was more of an individual emotion than a shared or group emotion within *Ibigkas!* and that the more frustration there was, the student had fewer incorrect answers which implies that frustration may not be that undesirable within learning settings. With this finding, we corroborate studies about frustration having the potential to be a desirable affective state. Within the multiplayer mode or collaborative setting, we found that the more excited a student becomes, the fewer incorrect answers are given. Excitement, then, is a desirable emotion to have within teaching and learning settings.

Acknowledgements

References

Baker, R. S., D'Mello, S. K., Rodrigo, M. M. T., & Graesser, A. C. (2010). Better to be frustrated than bored: The incidence, persistence, and impact of learners' cognitive–affective states during interactions with three different computer-based learning environments. *International Journal of Human-Computer Studies*, *68*(4), 223-241.

Boyle, E. A., Hainey, T., Connolly, T. M., Gray, G., Earp, J., Ott, M., Lim, T., Ninaus, M., Ribeiro, C.,& Pereira, J. (2016). An update to the systematic literature review of empirical evidence of the impacts and outcomes of computer games and serious games. *Computers & Education*, *94*, 178-192.

Coates, D. J., & Tognazzini, N. A. (2012). The nature and ethics of blame. *Philosophy Compass*, *7*(3), 197-207.

Connolly, T. M., Boyle, E. A., MacArthur, E., Hainey, T., & Boyle, J. M. (2012). A systematic literature review of empirical evidence on computer games and serious games. *Computers & education*, *59*(2), 661-686.

D'Mello, S., & Graesser, A. (2012). Dynamics of affective states during complex learning. *Learning and Instruction*, *22*(2), 145-157.

Giannakos, M. N. (2013). Enjoy and learn with educational games: Examining factors affecting learning performance. *Computers & Education*, *68*, 429-439.

Granic, I., Lobel, A., & Engels, R. C. (2014). The benefits of playing video games. *American psychologist*, *69*(1), 66.

Hromek, R., & Roffey, S. (2009). Promoting Social and Emotional Learning With Games: "It's Fun and We Learn Things". *Simulation & Gaming*, *40*(5), 626-644.

Karumbaiah, S., Andres, J. M. A. L., Botelho, A. F., Baker, R. S., & Ocumpaugh, J. (2018). The Implications of a Subtle Difference in the Calculation of Affect Dynamics. In Yang, J. C. et al. (Eds.) (2018). Proceedings of the 26th International Conference on Computers in Education. Philippines: Asia-Pacific Society for Computers in Education.

Ocumpaugh, J., Baker, R.S., Rodrigo, M.M.T. (2015) Baker Rodrigo Ocumpaugh Monitoring Protocol (BROMP) 2.0 Technical and Training Manual. Technical Report. New York, NY: Teachers College, Columbia University. Manila, Philippines: Ateneo Laboratory for the Learning Sciences.

Pardos, Z. A., Baker, R. S., San Pedro, M. O., Gowda, S. M., & Gowda, S. M. (2013, April). Affective states and state tests: Investigating how affect throughout the school year predicts end of year learning outcomes. In *Proceedings of the Third International Conference on Learning Analytics and Knowledge* (pp. 117-124). ACM.

Robinson, R., Murray, J., & Isbister, K. (2018, April). You're Giving Me Mixed Signals!: A Comparative Analysis of Methods that Capture Players' Emotional Response to Games. In Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems (p. LBW567). ACM.

Rodrigo, M. M. T., Ocupaugh, J., Diy, W.D., Moreno, M., De Santos, M., Cargo, N., Lacson, L., Santos, D., Aduna, D., Beraquit, J. I., Bringula, R., Caparros, M. R. M., Choi, A.T., Ladan, S., Lim, J., Manahan, D. M. A., Paterno, J. M. G., Saturinas, K., Tabanao, E., Tablatin, C., Torres, J., Porayska-Pomsta, K., Olatunji, I., & Luckin, R. (in press). Ibigkas!: The iterative development of a mobile collaborative game for building phonemic awareness and vocabulary. *Computer-Based Learning in Context*.

Smith, E. R., Seger, C. R., & Mackie, D. M. (2007). Can emotions be truly group level? Evidence regarding four conceptual criteria. *Journal of personality and social psychology*, *93*(3), 431.

Soller, A., & Lesgold, A. (2000). Knowledge acquisition for adaptive collaborative learning environments. In AAAI Fall Symposium: Learning How to Do Things (pp. 251-262).

Sung, H. Y., & Hwang, G. J. (2013). A collaborative game-based learning approach to improving students' learning performance in science courses. *Computers & education*, *63*, 43-51.

Wendel, V., Gutjahr, M., Göbel, S., & Steinmetz, R. (2013). Designing collaborative multiplayer serious games. *Education and Information Technologies*, *18*(2), 287-308.

Wong, P. T. (1979). Frustration, exploration, and learning. Canadian Psychological Review/Psychologie canadienne, 20(3), 133.

Zagal, J. P., Rick, J., & Hsi, I. (2006). Collaborative games: Lessons learned from board games. Simulation & Gaming, 37(1), 24-40.

The Discourse of Pre-service Teachers on Designing an Online Learning Course

Chih-Hui SEET[*], **Chuan-Chih CHIANG, Huang-Yao HONG**
Department of Education, National Chengchi University, Taiwan
[*]105152014@mail2.nccu.tw

Abstract: This study aims to understand the collaborative discourse of the preservice teachers on their customly designed online learning course. The participants were 38 pre-service teachers from a teacher education program in Taiwan. Using a design-oriented instructional approach, two iteration of design thinking activities were scaffolded to help the participants work on their online course projects. To this end, the participants discussed how to design their online course/project in a knowledge building environment in which they were encouraged to generate and optimize their design ideas. Data mainly came from online discussion through posted notes. The findings indicate that although the number of posts is few, the design ideas in these posts showed some quality improvement. At the end of the course, it was also found that all groups were able to design interesting learning contents and activities personalized for their target students' online learning use for addressing some real-life problems.

Keywords: knowledge building, discourse, design thinking, personalization, online learning course

1. Introduction

The emergence of technology and big data brings us into a more convenient, personalized world that supplies more customized, ubiquitous services and products for today's digital natives. This context has also seen changes in education, from a more traditional teacher-centered pedagogy into a new technology-assisted, student-centered direction based on collaborative learning (Hargreaves, 2018; Persson, 2005; Schleicher, 2012). In Taiwan, the K-12 system and its new course outline now emphasize the cultivation of students' 21st-century core skills, especially in technology, similar to that of STEM education (Cheng, 2017; National Academy for Educational Research, 2019). Given that the direction of future education will focus on deep and transferable learning with aptitude based on related skills or knowledge, such a vision aims to develop students who can learn and apply knowledge elastically and hopefully achieve the habits of lifelong learning.

Consequently, teacher training institutions should seek to stimulate learners and transfer or strengthen their instructional design skills using particular digital resources. We believe that the roles of teachers of the future will be to operate as instructional designers, curriculum designers and learning guides, regardless of whether they are inside or outside the simulated world. Indeed, their work will involve creating interesting, customized and useful learning content for others to learn either independently or spontaneously (Grant & Basye, 2014). This study aims to understand the collaboration process enacted by pre-service teachers in designing a personalized online learning course in a knowledge-building environment and design thinking context. The research questions are: *(1) How were their discourses connected when applying a design thinking scaffold and when working in a team-based knowledge-building environment? (2) What were their main points of discussion and core values while designing an online learning course for future learners? (3) What were the final products/ design outcomes of their online learning course?*

2. Methods

2.1 Participants

This study adopted a design research method with two iterations of design thinking activities. The participants comprised 38 student teachers from a teacher education center in Taiwan, most of whom were at the sophomore level. Half had no previous relevant experience of being in a knowledge-building or student-centered class.

2.2 Instructional Design

In the two iterations' design thinking activities, the participants were divided into 10 groups, each with a leader, and were asked to design an online learning course that was directed more toward personalization and that could relate to students' daily activities. The aims of the activity were to develop participants' (pre-service teachers') ideas and to cultivate their design ability in order that they would be able to solve some structural problems that can be found on other online learning courses, such as all content being rote learning that learners cannot practice in real-world situations even where they own the "knowledge."

All of the teaching subject of the courses and targeted learners were freely determined by the participants, although they were required to design at least 150 minutes of online learning activities. The participants were encouraged to develop their ideas and work collaboratively in a computer-supported knowledge-building environment called Knowledge Forum 6 (KF6).

2.3 Instruments/Data Collection

All data were auto-recorded on the KF6, containing the discussion process of the participants, the learning plan and the final online learning course interface designed by each group. The discussion posts were then run on an analysis using the Knowledge Building Discourse eXplore (KBDeX) application, while the designed learning plans and interfaces were analyzed qualitatively.

3. Results

Research question 1: *In the process of designing the online learning courses, the participants held quite considerable discussions even where this was their first time learning through such knowledge-building environment/courses. Their performance on the KF6 included two main actions (read and modified note) displayed below in Table 1, which were integrated with the design thinking scaffold (the process: empathy, define, ideate, prototype, test), revealing dynamic and progressive behavior in order to construct a visionary learning product. The interaction process of the participants, extracted from their discussion posts, is shown below in Figure 1, while Figure 2 presents the personalization environment in which these participants worked collaboratively.*

Table 1 All groups' discussion performance

Group	Discussion Post Number	Read Note (%)	Modified Note (%)
1	46	12.67	16.31
2	22	6.92	8.56
3	71	11.56	17.42
4	41	6.02	5.51
5	48	15.29	17.57
6	38	5.46	2.83
7	32	10.82	7.37
8	40	7.95	7.07
9	39	9.95	10.65
10	26	13.37	6.70

The discourse by participant named "Itsyua" has offered some useful testing and feedback, aimed at empathizing like a learner and defining the problems identified on the online learning course designed by another group. Below, Figure 1 shows the connection between all of the discourse in the community; the thicker line indicates a stronger relationship mentioning the key words, as most of the participants were focused on the main topic in their discussion.

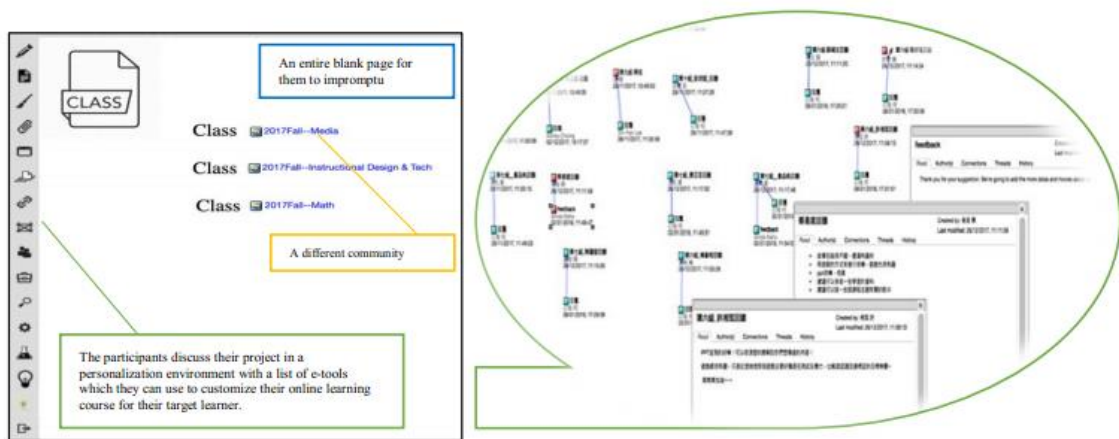**Figure 1: The discourse network in the community**

Figure 2: A personalized and collaborative working environment (left); according to the design thinking scaffold, the discussion content seems to define the problem and brainstorm the new ideas (right)

Research question 2: *Figure 3 (right) below presents the discussion result of the whole class, and the key element in the discourse covered by each group. They sought a more activities form's designated course wrapping contents with stories, tasks and games that are not only connected to learners' real lives, but are also related to what truly motivates learners. The teacher's guiding and discussion activity enables target learners to learn in a self-directed manner, hence they frame their course design using "experience," "course," "task," "story," "discussion," "life-connected," "guiding," "wrapping," "interesting," "design," "activities," "motivation," "games," and "experience." Figure 3 (left) displays the discussion post order by time, mentioning the key words above. It appears that they first discussed the desired framing of their online learning course design, followed by the construction of their different topics' contents for their individual learners.*
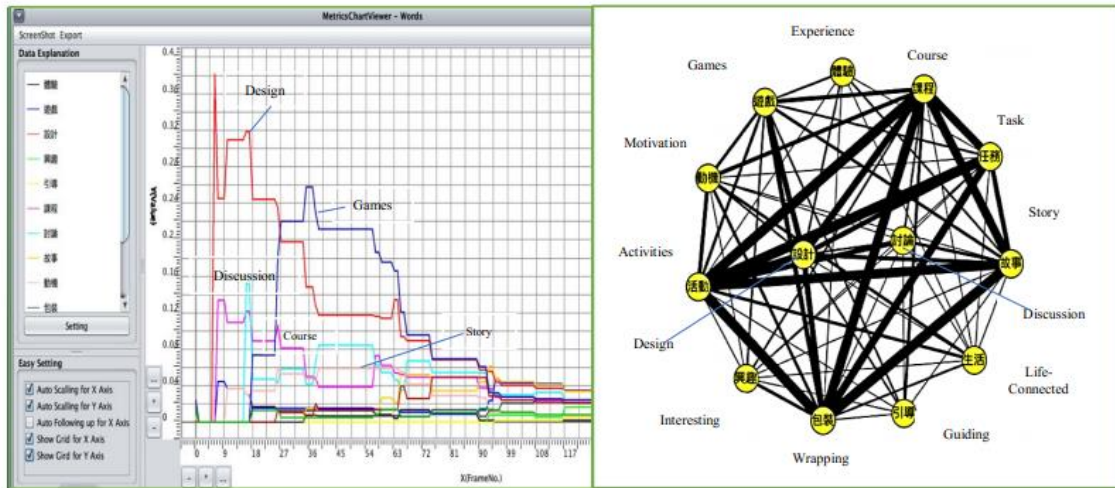
Figure 3 shows discussion core literacy (right) and the post order by time mentioning these key words (left).

Research question 3: *Figure 4 below is a small corner screenshot of one of the most representative group's online learning course interface. Their online learning course design looks like a tournament game, with different levels and tasks bringing the learner to the final destination (target of the learning). It also incorporates some important knowledge that might be adaptable in real life after the learner has completed the course, such as a safety concept and attitude.*

Figure 4: A small corner screenshot of Group 8's online learning course prototype.

4. Discussion and Conclusion

For most Asian students, it is not easy to participate in a course or environment that requires the learner to ask questions and discuss passionately or actively, because they have traditionally studied according to a teacher-centered teaching strategy. Consequently, relatively few posts were submitted in the KF6. Although the entire process of posting their discussions appeared to be rather passive, it nevertheless enabled a reasonable number of new knowledge-building learners. Further research must continue to encourage learners not to hesitate in publishing their ideas and opinions in advanced. Pre-service teachers are those who will nurture the next generation of society's pillars, and accordingly they need to improve their pedagogical knowledge time upon time. On the other hand, we found that the design thinking framework that operates in a knowledge-building environment is a great scaffold or support for

teachers to design and solve certain issues, and as they generate and advance their ideas through brainstorming, they will receive more and more feedback.

Owing to the convenience of newer technologies such as the Internet and the development of big data, future generations are today shaping themselves to become a more effective and productive nations. Relatedly, teachers are now seeking to facilitate more student-centered learning objects and instructional designs that support the comings era and 21st-century core literacy. It was encouraging to observe the discussion content produced by these participants increasingly take an active and postmodern design pattern, no longer based on rote learning, and successfully integrated with technology and notions of creativity that should meet current students' demands.

References

Cheng, K. M. (2017). Advancing 21st century competencies in East Asian education systems. *Center for Global Education. Asia Society*, 1-26.

Grant, P., & Basye, D. (2014). *Personalized learning: A guide for engaging students with technology*.

Hargreaves, A., & O'Connor, M. T. (2018). *Collaborative professionalism: When teaching together means learning for all*. California, US: Corwin Press.

National Academy for Educational Research (2019). Curriculum Guidelines of 12-Year Basic Education General Guidelines. Retrieved from https://www.naer.edu.tw/files/15-1000-14113,c639-1.php?Lang=zh-tw

Persson, M. (2005). *Learning for the future: dimensions of the new role of the teacher*. Retrieved from http://learningteachernetwork.org/wp-content/uploads/2017/10/learning_for_the_future_ltn_publication_2005.pdf

Schleicher, A. (2012). *Preparing Teachers and Developing School Leaders for the 21st Century: Lessons from around the World*. OECD Publishing. Retrieved from https://oecd.org/site/eduistp2012/49850576.pdf

Exploring the changes in teachers' teaching behavior in the environment of e-books

Xing-Juan WANG *, Dong-Ming QIAN

Department of Education Information Technology, East China Normal University , China
*wang_xingjuan @163.com

Abstract: E-book bags have become a major focus of information technology and education, and their application in education and teaching faces many challenges and problems. As the main actor of information technology and curriculum integration, teachers' teaching behavior changes in the e-book environment play a key role in the advantages of e-books in the field of education. To this end, this study relies on the feedback data of 3204 teachers' questionnaires collected at the end of the 2018 annual project of the S-city e-bag project, analyze the impact of e-books on teachers' teaching behaviors, and compare the previous 2016 and 2017 e-book annual reports to compare teacher behavior changes within three years. The study found that different teaching ages and the length of application of e-books have different effects on teachers' teaching behavior. In addition, the use of e-books has changed the teaching behavior of teachers to smaller every year.

Keywords: E-book bag; teacher behavior, change

1. Introduction

The e-book bag first appeared in Singapore in 1999 and has been in the field of education for nearly two decades. In 2012, BYOD (Bring your own device) was launched in various states and schools in the United States to effectively integrate e-books and other technologies into the school education system to optimize teaching and learning. In China, the 2010 National Information Technology Standardization Committee e-bag standard working group and the Ministry of Education Information Technology Committee set up the "e-textbook-e-book" standard group. The "Development and Publishing Industry's "Twelfth Five-Year Plan" Development Plan" proposed to "strongly support the electronic schoolbag project." The "Shanghai Medium- and Long-Term Education Reform and Development Plan (2010-2020)" proposes: "Promoting the development of 'e-books' and 'cloud computing'-assisted teaching. With the strong support of relevant policies, e-bag projects in all regions are well-organized. Advancement, among which, S City first carried out the experiment of changing the learning mode of digital curriculum environment construction, and after five years of exploration, formed a relatively complete project mechanism. It can be said that the education department of S city applied the electronic schoolbag in exploring education. The pace has been moving forward and never stopped.
However, with the rapid advancement of e-book projects, many difficulties and problems have arisen. Among them, teachers are the key factors for the application integration of e-books in the school context. The changes in teaching behaviors of teachers in the e-book environment will directly affect the advantages of e-books in the field of education. According to the survey, most teachers recognize the value of e-books and believe that e-books can promote teachers' teaching and student learning. At the same time, some studies have shown that using e-books to attend classes increases the burden on teachers. To this end, teachers are reluctant to step out of the comfort zone and change traditional teaching models, such as investigating teachers who are reluctant to use new information technology tools. In fact, e-books can help teachers to synchronize classroom teaching, capture students' learning trends in a timely manner, and adjust teaching organization. The teaching evaluation function of e-bags can also enable teachers to publish and correct exercises online, and realize the instant evaluation of the classroom. These changes are reflected in the teacher's use of e-books. To this end, it is necessary to explore the changes in teachers' teaching behavior in the e-book bag environment. It can not only reflect the teacher's attitude towards the use of e-bags, but also reflect the e-book bag. The actual influence of

education and teaching, thus promoting the continuous development and improvement of the application of e-books.

2. Research Design and Process

2.1 Research Methods and Data Sources

The data source of this study is the feedback data of the teacher survey questionnaire collected in the 2018 e-books pilot project of S City. Among them, the research through the peer experts and front-line teachers to discuss, combined with specific circumstances and needs to form the teacher survey questionnaire, the survey indicators are shown in Table 1. In addition, the study also compared the teacher survey data for 2016, 2017, and 2018, aiming to discover the behavioral changes of teachers in the e-book environment in three years.

Table 1

Survey Dimensions of Teacher Behavior in the Context of E-books

Theme	Indicator item
Teacher behavior in an e-book environment	1. The classroom atmosphere is often active when attending classes for students.
	2. Understand the students' knowledge of the knowledge points, and focus on the lectures.
	3. I like to ask students why
	4. I often feel very fulfilled and are generally loved by students.
	5. Always teach students the knowledge points during class
	6. I like to show the teaching content to the students through multimedia.
	7. Like to continuously guide students to learn independently
	8. I like to encourage students to express their ideas through face-to-face answers, phone calls and internet.
	9. I like to encourage students to communicate through channels such as face-to-face, telephone and internet.
	10. I like to share my teaching experience with my colleagues.

The questionnaire is mainly divided into five scales by the Likert scale (1. Very agree, 2. agree, 3. Uncertain, 4. Disagree, 5. Very disapproval). The lower the survey mean, the higher the recognition of the teacher's description of the teaching behavior. The reliability statistics of the above questionnaires were performed by spss22.0. The results are shown in Table 2. The value of KMO is .983, indicating that the structure of the questionnaire is of good validity, and the value of sig. indicates that the difference is significant.

Table 2

Analysis of the Validity of the Questionnaire

Testing by KMO and Bartlett		
Sample a sufficient Kaiser-Meyer-Olkin metric		.983
Bartlett's sphericity test	Approximate Chi-square	215118.017
	df	1275
	Sig.	.000

2.2 Study Sample Characteristics

There are 3,204 teacher samples in this study, of which the school stage spans elementary, middle, and high schools. In terms of gender distribution, most of them were concentrated in female teachers, accounting for 86.97% (explored) and 83.73% (not piloted) respectively, mainly because of the current

female teachers in primary and secondary school teachers. Most of the teachers have rich teaching experience. Only 33.07% of the pilot teachers and 20.14% of the non-pilot teachers have a teaching age of less than five years. The teachers surveyed are distributed in different disciplines, and they have more subjects in teaching Chinese, mathematics, and foreign languages. In the application time of e-books, among the pilot teachers, the application time reached 36.63% in the 0-2 semester; among the non-pilot teachers, the application time reached 04.03% in the 0-2 semester. The sample basic information statistics are shown in Table 3.

Table 3

Study Sample Basic Information Table

Independent variable	Independent variable Group	Pilot teacher		Untested teacher	
		Valid sample	Percentage	Valid sample	Percentage
Gender	Male	154	13.03%	329	16.27%
	Female	1028	86.97%	1693	83.73%
Teaching age	1~5 years	404	34.18%	423	20.92%
	More than 5 years	778	65.82%	1599	79.08%
Subject	Chinese	391	33.08%	642	31.75%
	Mathematics	274	23.18%	358	17.71%
	English	223	18.87%	339	16.77%
	Other disciplines	294	24.87%	683	33.78%
Application time	0~2 semester	433	36.63%	blank	
	2 semester or more	749	63.37%		

3. Analysis of the survey results

3.1 Comparison of the Changes in Teaching Behavior of Teachers of Different Teaching Ages in the Environment of E-books

Divide the teaching age into 1~5 years or more, and compare the teaching behaviors of the teachers of different teaching ages in the e-bag environment. Obtain the table 3. a It can be found that the new teachers who have been piloted in 2018 and have a teaching age of 1 to 5 years and the old teachers who have been teaching for more than 5 years have significant differences in the teaching behavior in the e-book environment. The overall behavior of the former is more positive.

Table 4

Statistical Table of Changes in Teaching Behavior of Teachers of Different Teaching Ages in the Environment of E-bags

Comparison of teachers of different teaching ages		N	Mean	Standard deviation	Significant
Indicator 1	1~5 years	404	1.99	.800	.028
	More than 5 years	778	1.98	.786	
Indicator 2	1~5 years	404	1.98	.784	.039

555

	More than 5 years	778	1.95	.780	
Indicator 3	1~5 years	404	1.99	.821	.041
	More than 5 years	778	1.95	.815	
Indicator 4	1~5 years	404	2.00	.797	.040
	More than 5 years	778	1.96	.792	
Indicator 5	1~5 years	404	2.38	.967	.035
	More than 5 years	778	2.46	.973	
Indicator 6	1~5 years	404	1.98	.817	.029
	More than 5 years	778	1.98	.808	
Indicator 7	1~5 years	404	1.93	.783	.039
	More than 5 years	778	1.88	.776	
Indicator 8	1~5 years	404	1.98	.808	.029
	More than 5 years	778	1.95	.808	
Indicator 9	1~5 years	404	2.01	.848	.042
	More than 5 years	778	2.00	.847	
Indicator 10	1~5 years	404	1.95	.808	.028
	More than 5 years	778	1.89	.784	

3.2 Comparison of Teaching Behavior Changes of Teachers in E-book Environment under Different Application Time

Divide e-book application time into 0~2 semesters and more than 2 semesters. Statistics on the changes in teaching behaviors in the e-book bag environment for teachers who have been piloted for different application times are given in Table 4. It can be found that the average teaching value of the two-semester teacher teaching behavior in 2018 has been lower, indicating that as the application time increases, teachers find that the application and teaching behavior of e-books have a positive impact.

Table 5

Comparison of Teacher Behavior Changes in E-book Environment under Different Application Time

Application time		N	Mean	Standard deviation	Significant
Indicator 1	1~2 semester	433	2.13	.808	.039
	2 semester or more	749	1.90	.769	
Indicator 2	1~2 semester	433	2.09	.789	.028
	2 semester or more	749	1.89	.767	
Indicator 3	1~2 semester	433	2.10	.838	.040
	2 semester or more	749	1.89	.794	
Indicator 4	1~2 semester	433	2.11	.799	.038
	2 semester or more	749	1.90	.781	
Indicator 5	1~2 semester	433	2.46	.895	.043

	2 semester or more	749	2.41	1.013	
Indicator 6	1~2 semester	433	2.12	.821	.039
	2 semester or more	749	1.90	.793	
Indicator 7	1~2 semester	433	2.06	.800	.038
	2 semester or more	749	1.81	.750	
Indicator 8	1~2 semester	433	2.10	.828	.040
	2 semester or more	749	1.88	.786	
Indicator 9	1~2 semester	433	2.12	.860	.030
	2 semester or more	749	1.93	.832	
Indicator 10	1~2 semester	433	2.06	.820	.039
	2 semester or more	749	1.82	.762	

3.3 Three Years of Vertical Comparison

Table 6 investigates the three-year mean statistical data and finds that the average value of the effect of teachers' changes in teaching behavior in the e-bag environment in 2018 is lower than the previous average. This shows that in the past two years, teachers have found that the use of e-books has become less obvious in changing the teaching behavior of teachers.

Table 6

Three-year Longitudinal Change of Teachers' teaching Behavior in the Environment of E-books

Three-year vertical comparison		N	Mean	Standard deviation	S.E.Mean
Indicator 1	2016	729	4.078	.8125	.0301
	2017	1004	3.89	.856	.027
	2018	1182	1.98	.023	.790
Indicator 2	2016	729	4.125	.7946	.0294
	2017	1004	3.95	.884	.027
	2018	1182	1.96	.023	.782
Indicator 3	2016	729	4.041	.8007	.0297
	2017	1004	3.96	.828	.026
	2018	1182	1.96	.024	.817
Indicator 4	2016	729	4.001	.7992	.0296
	2017	1004	3.90	.833	.026
	2018	1182	1.98	.023	.794
Indicator 5	2016	729	3.513	1.0069	.0373
	2017	1004	3.51	.951	.030
	2018	1182	2.43	.028	.971

Indicator 6	2016	729	4.038	.8312	.0308
	2017	1004	3.88	.851	.027
	2018	1182	1.98	.024	.810
Indicator 7	2016	729	4.143	.7907	.0293
	2017	1004	4.01	.818	.026
	2018	1182	1.90	.023	.778
Indicator 8	2016	729	4.074	.8271	.0306
	2017	1004	3.92	.854	.027
	2018	1182	1.96	.023	.808
Indicator 9	2016	729	4.019	.8417	.0312
	2017	1004	3.87	871	.027
	2018	1182	2.00	.025	.847
Indicator 10	2016	729	4.169	.7968	.0295
	2017	1004	4.01	.827	.026
	2018	1182	1.91	.023	.792

4. Summary and outlook

4.1 Under the Environment of E-books, the Teaching Behaviors of Teachers of Different Teaching Ages Changed Significantly, and the Teaching Behaviors of New Teachers Changed More Positively.

In the new century, the application of information technology to education and teaching is an inevitable requirement of the development of the times for education reform. In the e-book environment, teachers of different teaching ages realize that the use of e-books in the classroom can activate the classroom atmosphere, greatly motivate students' enthusiasm for learning, and promote the development of students' comprehensive quality; but for new teachers, Responsible for new things and dare to challenge, more effective in improving teaching behavior, and promoting e-books to serve the classroom.

4.2 The Teaching Behavior of Teachers with Long-term Application of E-books Shows a More Positive State.

In a certain period of time, the integration of e-bags and classroom teaching is inseparable from the practical experience of teachers. Compared with teachers who have long-term application of e-books and teachers who have short application time, the former has a higher sense of recognition of changes in teaching behavior in the e-book environment. which indicates that as time goes by, teachers are increasingly discovering e-book applications. And the teaching behavior has a constant positive impact.

4.3 Three-year Vertical Comparison Found that Teachers' use of E-books is Gradually Reducing the Changes in Teachers' teaching Behavior.

With the passage of time, the development of e-books is relatively mature, but it has also entered a bottleneck period. On the whole, teachers have formed a certain pattern in the use of e-books, which has made the use of e-books less effective in changing the teaching behavior of teachers. This status quo is one of the breakthrough points in the current development of e-books.

All in all, e-books continue to advance in controversy, and with the rapid development of ubiquitous technology and learning analysis technology, it will bring new development opportunities for e-books. To this end, both teachers and managers must gradually promote the application of e-books in the classroom, and make new breakthroughs for their better service to the classroom.

References

New Zheng Fa Fa [2011] No. 6. "Development and Publishing Industry "Twelfth Five-Year Plan" Development Plan". [2017-03-01]. http://www.gapp.gov.cn/contents/785/76075.html.

Shanghai Municipal Government. Outline of the development plan for Shanghai's medium and long-term education reform (2010-2020). [2017-03-01].
http://www.scio.gov.cn/ztk/xwfb/jjfyr/28/wqfbh/Document/649640/649640.htm.

Lin Wanxin. Influencing factors and countermeasures of the effect of primary and secondary school teachers' educational technology training. Research on Audio-Visual Education, 2009, 08:56-58.

Liu Fanhua, Yu Huijuan, Tan Fang. Research on Electronic Schoolbag and Its Educational Application[J]. Research in Audio-Visual Education, 2013(1): 73-76.

Yan Hanbing, Li Manman, Huang Xiaorui. Investigation on the Preparation of Primary and Secondary School Teachers' Application of Electronic Schoolbag Teaching[J]. Research in Audio-Visual Education, 2016(11):100-107.

Li Haidong. Research on School-based Practice of Promoting Teacher Professional Development with Electronic Schoolbag Application[J]. Journal of Multimedia and Network Education (Electronic Edition), 2017:54.

The Impacts of Digital Games on Learning Academic English: A Prior Knowledge Perspective

Guan-Lin Lin, Sherry Y. CHEN*

Graduate Institute of Network Learning Technology National Central University, Jhongli Taiwan
*sherry@cl.ncu.edu.tw

Abstract: In order to help learners improve the grammar concept of academic English, we developed an Academic English Competitive Solitaire Game (AECSG) where learners developed the understanding English academic writing via a problem-solving process. In addition, an empirical study was conduct to investigate how high prior knowledge (HPK)learners and low prior knowledge (LPK)learners reacted to the AECSG. The results indicated that HPK learners had better task scores and got fewer answer card errors in Task 1. Additionally, HPK learners favored to collect large-scaled information with the sentence hint so while LPK learners were keen to collect small-scaled information with the Chinese hint. On the other hand, no significant differences between HPK learners and LPK learners were found for the scores of Task 2. These finding suggested that practice could reduce the gap between LPK learners and HPK learners. In summary, the findings from this study contribute the understandings of how to develop personalized AECSG.

Keywords: competitive digital game-based learning, prior knowledge, experience

1. Introduction

Game-based learning (GBL) has been commonly used to improve English learning in educational settings (Hung, Yang, Hwang, Chu and Wang, 2018). In the meanwhile, most of scholars claimed that GBL was useful for student learning (Qian & Clark, 2016). For example, Zhonggen(2018) used a mixed-design research method to explore the impacts of serious game in English learning. Their results indicated that students who used an interactive serious game had significantly higher motivation than those who used the less interactive serious game and those who used a traditional approach. In addition, Fu , Lin, Hwang and Zhang (2019) proposed a mind mapping-based contextual gaming approach to improve university students' English writing performance. Their results indicated that their writing performance in English learning was indeed improved by this approach. Moreover, Hao, Lee, Chen and Sim(2019) developed a language learning mobile games to support seven-graders to learn English as a foreign language (EFL). Their results showed that this mobile game could make students have enjoyment and that their confidence in English learning could also be improved.

In spite of the aforementioned advantages, GBL is not always beneficial to students. For instance, DeHaan, Reed & Kuwanda (2010) found that students with a video game demonstrated poor performance. This is because video game caused cognitive load, which reduced their learning performance. In addition to cognitive load, past scholars also found that GBL had other disadvantages. For example, Koh, Kin, Wadhwa and Lim (2012) examined teachers' perception for GBL and problems with the use of GBL. Their results indicated that teachers were worry about game addiction because students lacked self-discipline in playing games. Additionally, Lai and Wen(2012) adopted an online role-playing game for elementary school students to learn English speaking. Their results showed that teachers were worried about the fact that students' eye-sight would get worse and that they spent too much time for using computers. Thus, GBL also had negative impacts.

The aforesaid conflicting results suggested that GBL may not suitable for all learners. Therefore, there is a need to examine the effects of individual differences in GBL, especially the impact of prior knowledge. For instance, Chen and Huang(2013) investigated how prior knowledge affected university students to use two GBL systems. One system provided procedural knowledge to help students learn

problem solving while the other system provided declarative knowledge to teach students to learn forensic science. Their result indicated that prior knowledge had positive influences on learning declarative knowledge while prior knowledge had negative effects on learning procedural knowledge. Furthermore, Zambrano, Kirschner, Sweller & Kirschner (2019) aimed to determine how prior knowledge affected student problem-solving, including individual learners and collaborative groups. Their results showed that high prior knowledge learners had better learning performance than low prior knowledge learners, regardless of individual or collaborative groups. On the other hands, Lee, Donkers, Jarodzka, & van Merriënboer (2019) used a medical simulation game to support medical professionals and medical students and investigated whether prior knowledge was an influential factor. Their results showed that their high prior knowledge students had relatively high accuracy in visual selection and lower cognitive load. In addition, they performed tasks faster than low prior knowledge students.

The results from aforementioned studies demonstrated that prior knowledge played an important role in GBL. Therefore, it is necessary to investigate the impact of prior knowledge on student learning in GBL. Consequently, this study had two aims. One aim was to develop an Academic English Competitive Solitaire Game (AECSG), which was applied to help students learn how to make meaningful English sentences while the other aim was to explore how prior knowledge affected student learning in the context of GBL.

2. Academic English Competitive Solitaire Game

The AECSG was implemented with the Unity3D and was applied to support students to learn Academic English. Accordingly, each learner and a virtual opponent needed to take turn make meaningful academic English sentences according to grammatical rules. More specifically, the learner and the virtual opponent were provided three academic sentences. Initially, only the middle word was visible in each sentence. For instance, there were 17 words in a sentence and the ninth word was visible. By doing so, learners could fill in English words by moving forward or backward (Figure 1). The AECSG possessed five major design features, which are presented below:

- Fair Treatment: There were two sets of cards, one of which could be selected by a learner while the other set was assigned to a virtual opponent. In each set, there were answer cards and non-answer cards (Table 1). The former presented a word associated with sentences that they made while the latter showed a reductant words unrelated to sentences that they made. Either the answer cards and non-answer cards were equally allotted into the learner and the virtual opponent so that there was fair treatment. On the other hand, the learner and the virtual opponent were equally provided 3000 points as basic task scores.
- Scaffolding Hints: During the gaming process, the AECSG provided a variety of scaffolding hints in order to reduce the learner's frustration, including the Chinese hint, Sentence hints and form of the Words. However, the learner's scores could be deducted (Table 2) when they used the scaffolding hints so that the reliance of the hints and tools could be minimized.
- Playing by Helping: To help learners solve problems during the gaming process, the AECSG provided two types of tools, which were the Helper and Exchange Cards. The Helper provided five cards, one of which presented a correct answer. By doing so, the range of the answer could be minimized and learners could get additional support. On the other hand, the Exchange Cards allowed the learner to swap a card with the virtual opponent when he/she thought that he/she did not have an answer card. These two types of tools allowed learners to get help in time so that their interest and motivation could be promoted. However, the learner's scores could be deducted (Table 2) so that he/she could not rely on them too much (Table 3).
- Learner Control: Learners were given freedom to control the order of the learning tasks. More specifically, they could decide which sentence they would like to start and where they would like to start based on their preferences. In addition, they could decide whether they would like to use hints and tools provided by the AECSG and which hints or tools they would like to use. By doing so, the AECSG could accommodate the preferences of various learners.
- Sense of competition: To make learners have the sense of competition during the gaming process, there were leaderboard and punishment mechanisms to enhance learner's motivation. The

leaderboard was applied to constantly show the scores that the learner and virtual opponent possessed (Figure 4). The punishment mechanism was that learners' scores could be deducted when they gave a wrong answer. In particular, their scores would have been deducted more if an answer card were not properly selected.

Table 1

The punishment mechanism in the AECSG.

Project	Deduction
Answer card error	-20 points
Non-answer card error	-10 points

Table 2

The costed points of each Scaffolding Hint in the AECSG.

Scaffolding Hints	**Costed Points**
Chinese translation	10 points
Ford of the word	10 points
Sentence hints	30 points

Table 3

The costed points of each tool in the AECSG.

Tools	**Costed Points**
Helper	50 points
Exchange cards	20 points

Figure 1. Overview of the AECSG

.

3. Methodology Design

This study took s a quasi-experimental research method. The independent variables were students' prior knowledge and the dependent variables were learning performance and learning behavior.

3.1 Experimental subject

In this study, the participants were 14 research students from a university in the north Taiwan and all of them had computing skills and basic English skills.

3.2 Experimental procedure

The experiment was conducted once a week and lasted four weeks. At the beginning of the experiment, students were asked to use a laptop computer to connect to the wireless network to play with the AECSG. Subsequently, each student competed with a virtual opponent. More specifically, either the student or the virtual opponent needed to compete two tasks. Task 1 was conducted in the first week and the second week, and Task 2 was conducted in the third week and fourth week. In each task, they needed to take turn to make three meaningful academic English sentences without grammatical errors. Each sentence included 17 words. When students performed the task, their behavior was recorded in log files.

4. Results and Discussions

4.1 Task performance

In this study, we used an independent t-test to analyze task scores, which pertained to scores obtained from Task 1 and Task 2 (Table 4). More specifically, differences of the task scores between HPK learners and LPK learners were analyzed. The results indicated that there were significant score differences between HPK learners and LPK learners, including the Overview and Task 1. More specifically, the task scores of LPK learners were significantly lower than those of HPK learners. It might be due to the fact that reorganizing sentences was difficult for LPK learners, who did not have sufficient prior English knowledge. Thus, they might need some practices to improve their English abilities. After doing such practice, they could make some improvement. This might be the reason why no significant differences existed between HPK learners and LPK learners for the scores of Task 2. These results implied that the practice could reduce gap between LPK learners and HPK learners.

Table 4

Task scores between the HPK and the LPK

		M	**SD**	**t**	**p**
Overview	LPK	509.28	284.10	-3.531	.0009***
	HPK	762.85	252.28		
Task 1	LPK	475.00	302.98	-3.267	.003**
	HPK	766.43	139.92		
Task 2	LPK	543.57	270.74	-1.872	.0725
	HPK	759.29	335.52		

**p<.01, ***p<.001

4.2 Task Behavior

We used an independent t-test to analyze the number of hints used by the HPK learners and that by the LPK learners. The results indicated that there were significant differences, including the Overview or Chinese translation (Table 5). Regarding the Overview, the LPK learners used more hints than the HPK learners. This might be because the LPK learners encountered more difficulties than the HPK learners. Furthermore, the LPK learners more frequently used the Chinese hint than the HPK learners. This finding suggested that LPK learners did not know sufficient vocabulary so that they needed to use the Chinese hint to understand the meaning of words presented in each sentence However, no significant differences were found for remaining hints.

In addition, we also used an independent t-test to analyze the error frequencies of the answer and non-answer card. The results (t=3.043, p=.0036**) indicated that LPK learners (Mean=34.35, SD=25.56) significantly had more errors for the answer cards than HPK learners (Mean=17.39,

SD=14.71). In addition, the results (t= 4.227, p=.0001**) also showed that LPK learners (Mean= 5.82, SD=3.67) significantly had more errors for the non-answer cards than HPK learners (Mean=2.42, SD=2.13).

Table 5

Hints use between the HPK and the LPK

		M	**SD**	**t**	**p**
Overview	LPK	52	28.999	2.061	.0440*
	HPK	37.96	21.365		
Chinese translation	LPK	12.82	12.362	3.227	.0021*
	HPK	4.35	6.302		
Helper hint	LPK	10.07	6.164	0.910	.3669
	HPK	8.39	7.568		
Exchange cards	LPK	14.28	20.531	1.714	.0922
	HPK	7.28	6.726		
Form of the Words	LPK	0.10	0.315	1.029	.3081
	HPK	0.03	0.189		
Sentence hints	LPK	14.71	7.980	-1.245	.2184
	HPK	17.89	10.894		

*p<.05

4.3 Behavior Sequences:

The LSA was employed to explore behavior sequences that HPK learners and LPK learners demonstrated. Table 6 shows the behavioral coding of the sequence analysis, thereby generating the results of two sets of sequence analysis (Figure 2). More specifically, Figure 1 shows (a) behavior sequences that learners showed when performing Task 1, and (b) behavior sequences that learners showed when performing Task 2.

Table 12

The coding scheme of learning behavior.

Behavior	Codes	Description
Game Start	B	Start the game.
Correct	Y	Get the correct answer.
Wrong	W	Get the wrong answer.
Send cards	S	Send the selected card to the selected sentence position
Use sentence hints	L	Use the hint for display Chinese sentences in English
Use Exchange cards	Q	Use the hint for selected a card to exchange with a random answer card of the computer.
Use Helper hint	H	Use the hint for display a correct answer and four wrong answers, and have a chance to answer the error without penalty points
Use Chinese translation hint	D	Use the hint for explain the meaning and form of each word.
Use Form of the Words	R	Use the hint for explain the Form of the Words and form of each word.
Game Over	E	All of sentences are completely filled.
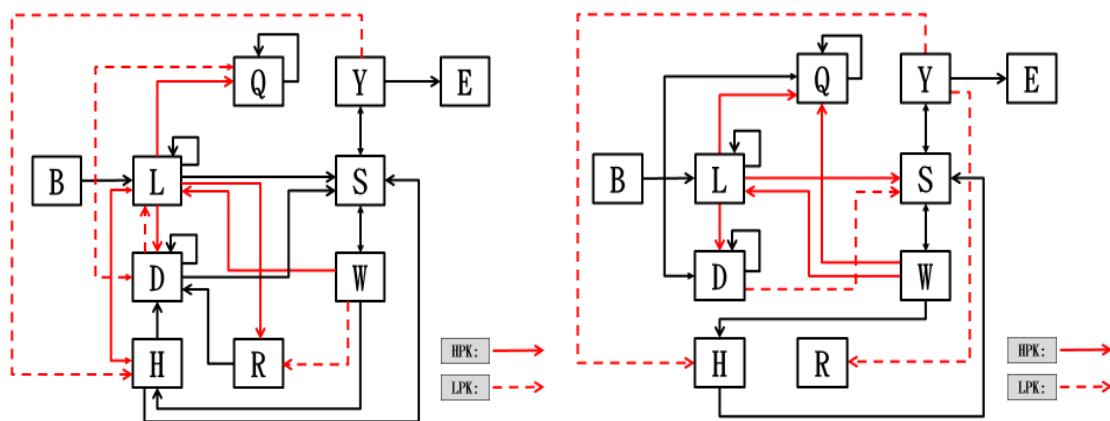
Figure 2. The behavioral transition diagram of Task 1 (left) and the diagram of Task 2 (right).

4.3.1 Task 1

The results from the LSA indicated that HPK learners and LPK learners demonstrated some similar behavior sequences when performing Task 1, i.e., B→L↔L, S↔Y→E, S↔W→H→S, R→D→S, and H→D↔D. The details are explained below.

- B→L↔L: When the game starts, learners repeatedly used the sentence hints.
- H→D↔D: Learners repeatedly used the Chinese translation hint after using the Helper hint.
- S↔W→H→S: Learners repeatedly sent the answer and got wrong answers before using Helper hint, and finally sent the answer.
- R→D→S: Learners used the form hint before using the Chinese translation hint, and finally sent the answer.
- S↔Y→E: Learners completed all of sentences after repeatedly getting correct answer.

The aforementioned findings suggested that learners were keen to use the sentence hint and the Chinese translation because they repeated used these two hints. The former was used at the beginning of doing the tasks (B→L↔L) while the latter was adopted after using the Helper (H→D↔D). In addition to combining with the Chinese hint, learners also used the Helper when they repeatedly sent the wrong answers(S↔W→H→S). On the other hand, they also used the Chinese hint and the form of the words together (R→D→S). Such findings implied that learners tended to use various hints together. The other interesting finding was that learners repeatedly got the correct answer when they nearly completed the tasks (S↔Y→E). In other words, time let them acquire some experience so that they could have better outcome in the end.

In addition to similarities, learners with the HPK and those with the LPK also demonstrated some different behavior sequences when performing Task 1. These different behavioral sequences are presented below.

- L→D (HPK) vs. D→L (LPK): HPK learners used the sentence hints before using the Chinese t hint while the LPK learners used the Chinese hint before using the sentence hints.
- L→Q (HPK) vs. D↔Q (LPK): HPK learners used the sentence hints before exchanging cards while LPK learners repeatedly switched between the Chinese hint and the card exchange.
- L→R (HPK) vs. None (LPK): HPK learners used the sentence hints before using the form of the words. Conversely, LPK learners did not have such behavior.
- W→L (HPK) vs. W→R (LPK): HPK learners got the wrong answer before using the sentence hints while LPK learners got the wrong answer before using the form of the words.
- L↔H (HPK) vs. Y→H (LPK): HPK learners repeatedly switched between the Helper hint and the sentence hints. However, LPK learners got the correct answer before using the Helper hint.

The aforementioned findings showed that HPK learners combined to use the sentence hint with various hints or tools, including the Chinese translation (L→D), form of the words (L→R), card exchange cards (L→Q) and Helper (L↔H) while the LPK learners combined to use the Chinese hint with other hints, including the sentence hint (D→L) and card exchange (D↔Q). Such behavior suggested that the former favored to use the sentence hint while the latter were keen to use the Chinese translation. Unlike the Chinese translation, which showed small-scaled information, the sentence hint could provide large-scaled information. The HPK learners are good at incorporating new information into old knowledge (Moreno & Mayer,1999) so they could make the best use of the large-scaled information provided by the sentence hint. Conversely, the LPK lacked sufficient knowledge so they tended to use small-scaled information obtained from the Chinese translation. Furthermore, the HPK learners sought help from the sentence hint after getting the wrong answer (W→L). Conversely, the LPK learners attempted to obtain support from the form of the words after getting the wrong answer (W→R). Additionally, the LPK learners did not use the Helper at the right timing. This was due to the fact that they used the Helper after getting the correct answer (Y→H). In other words, the LPK learners did not effectively use the hints.

4.3.2 Task 2

The results from the LSA indicated that HPK learners and LPK learners demonstrated similar behavior sequences when performing Task 2. i.e., B→L↔L, S↔Y→E, and S↔W→H→S. Such results were as same as those found in Task 1. These findings suggested that such behavior was necessary to learners. However, the following behavioral sequence was found for Task 2 only, i.e., Q↔Q→D↔D. The details are explained below.

- Q↔Q→D↔D: Learners repeatedly used the Exchange cards before repeatedly using the Chinese translation hint.

The aforementioned finding was slightly related to Task 1. When undertaking Task 1, learners would repeatedly use the Chinese hint after using the Helper hint (H→D↔D). On the other hand, they would repeatedly use the Chinese hint after repeatedly using the card exchange in Task 2 (Q↔Q→D↔D). In other words, learners moved to rely on the card exchange, instead of the Helper, when performing Task 2. Information provided by the Helper included five options, but using the card exchange could obtain a new word only. In other words, the Helper provided a broad range of information while the card exchange offered a specific range of information. This might be the reason why learners were keen to use the card exchange. However, learners might not know the new words from the card exchange so they had to use the Chinese hint to know the meanings of such a word. Therefore, learners tended to use the card exchange and Chinese translation hint together in Task 2.

Further to similarities, HPK learners and LPK learners demonstrated some different behavior sequences when performing Task 2. These different behavioral sequences are presented below.

- L→Q, L→D (HPK) vs. None (LPK): HPK learners used the sentence hints before using the card exchange or Chinese hint. Conversely, the LPK learners did not have such behavior.
- L→S (HPK) vs. D→S (LPK): HPK learners used the sentence hints before sending the answer. However, the LPK learners used the Chinese hint before sending the answer.
- W→L, W→Q (HPK) vs. Y→H, Y→R (LPK): HPK learners got the wrong answer before using the sentence hints or card exchange. However, LPK learners got the correct answer before using the Helper or the form of the words.

Like Task 1, HPK learners combined to use the sentence hints with various tools or hints, including the card exchange (L→Q) and Chinese hint (L→D). Furthermore, they used the sentence hints before sending the answer (L→S). Such behavior suggested that HPK learners were still keen to use the sentence hints which provided large-scaled information. On the other hand, LPK learners used the Chinese hint before sending the answer (D→S). In other words, LPK learners sill favored to use the Chinese hint when undertaking Task 2. The other interesting finding was that HPK learners and LPK learners used at different timing. More specifically, HPK learners used various tools or hints after

getting the wrong answer (W→L) (W→Q). In other words, they used various tools or hints at the right timing. However, LPK learners used such hints or tools after getting the correct answer (Y→H) (Y→R) so they did not use the various tools or hints at the right timing. In other words, HPK learners effectively used the hints and tools while LPK learners ineffectively used the hints and tools.

5. Conclusions

In this study, we aimed to examine how HPK learners and LPK learners reacted to the AECSG. The results showed that HPK learners had higher task scores and got fewer answer card errors than LPK learners in Task 1. Additionally, HPK learners favored to collect large-scaled information with the sentence hint while the latter were keen to collect small-scaled information with the Chinese hint. Furthermore, HPK learners could effectively use the hints at right timing while LPK learners could not effectively use hints at right timing. Therefore, the former had higher learning performance than the latter. However, no significant differences between HPK learners and LPK learners were found for the scores of Task 2. These finding suggested that LPK learners accumulated some experience so that the gap between HPK learners and LPK learners could be removed.

The finding from this study can contribute for the development of personalized AECS. However, there were several limitations in this study. First, the sample is small, so we need to extend the sample to provide more evidence in the future. Second, this study only investigated prior knowledge so future research can consider other individual differences, such as cognitive style and gender difference. The results from such future works will be helpful to develop personalized GBL systems.

References

Chen, S. Y., & Huang, P. R. (2013). The comparisons of the influences of prior knowledge on two game-based learning systems. *Computers & Education*, *68*, 177-186.

DeHaan, J., Reed, W. M., & Kuwanda, K. (2010). The effect of interactivity with a music video game on second language vocabulary recall. *Language Learning & Technology*, *14*(2), 74-94.

Fu, Q. K., Lin, C. J., Hwang, G. J., & Zhang, L. (2019). Impacts of a mind mapping-based contextual gaming approach on EFL students' writing performance, learning perceptions and generative uses in an English course. *Computers & Education*, *137*, 59-77.

Hao, Y., Lee, K. S., Chen, S. T., & Sim, S. C. (2019). An evaluative study of a mobile application for middle school students struggling with English vocabulary learning. *Computers in Human Behavior*, *95*, 208-216.

Hung, H. T., Yang, J. C., Hwang, G. J., Chu, H. C., & Wang, C. C. (2018). A scoping review of research on digital game-based language learning. *Computers & Education*, *126*, 89-104.

Koh, E., Kin, Y. G., Wadhwa, B., & Lim, J. (2012). Teacher perceptions of games in Singapore schools. *Simulation & Gaming*, *43*(1), 51-66.

Lai, A. F., & Wen, S. S. (2012, June). Evaluating an online role playing game for promoting the elementary school students' English speaking abilities. In *2012 8th International Conference on Information Science and Digital Content Technology (ICIDT2012)* (Vol. 3, pp. 610-615). IEEE.

Lee, J. Y., Donkers, J., Jarodzka, H., & van Merriënboer, J. J. (2019). How prior knowledge affects problem-solving performance in a medical simulation game: Using game-logs and eye-tracking. *Computers in Human Behavior*.

Moreno, R., & Mayer, R. E. (1999). Gender differences in responding to open-ended problem-solving questions. *Learning and Individual Differences*, *11*(4), 355-364.

Qian, M., & Clark, K. R. (2016). Game-based Learning and 21st century skills: A review of recent research. *Computers in Human Behavior*, *63*, 50-58.

Sweller, J., Clark, R., & Kirschner, P. (2010). Teaching general problem-solving skills is not a substitute for, or a viable addition to, teaching mathematics. *Notices of the American Mathematical Society*, *57*(10), 1303-1304.

Zambrano, J., Kirschner, F., Sweller, J., & Kirschner, P. A. (2019). Effects of prior knowledge on collaborative and individual learning. *Learning and Instruction*, *63*, 101214.

Zhonggen, Y. (2018). Differences in serious game-aided and traditional English vocabulary acquisition. *Computers & Education*, *127*, 214-232.

Learning Conversation with a Mobile Robot

Wing-Kwong WONG[*], Wen-Jia KUO , Ting-Sheng WEI, Kai-Ping CHEN

Depart. of Electronic Engin., National Yunlin University of Science and Technology, Douliu, Taiwan

*wongwk@yuntech.edu.tw

Abstract: This study proposes to design a mobile robot to assist language learning. This should motivate learners to practice speaking and listening in order to improve their English skill. This project provides a low-cost robot for all students who are willing to spend time learning English inside and outside the classroom. This research proposes to deliver a robot with wheels, cameras, microphones and speakers. Raspberry Pi 3 and Arduino provide the computation power to interact with and control the robot. The robot converses with English learners to accomplish specific tasks. In one task, a learner asks the robot to travel on a street map with simple roads and locations such as a library, a park, and an elementary school. The utterances of the learner are recognized with a Google cloud service, and the voice response of the robot is generated with text-to-speech technology. When the robot walks on a street map, it does image processing to follow lanes and recognize intersections and a number of prescribed locations. An empirical experiment was run to study the learning process of learners. Some interesting results were found.

Keywords: Robot-assisted Language Learning, Language Teaching, Mobile Robot, Image Processing, Speech Recognition

1. Introduction

With the huge political and economic influence of English-speaking countries, English has become tone of the most important communication languages in the world. According to statistics, "English is the most widely learned second language and is either the official language or one of the official languages in almost 60 sovereign states. [...] It is estimated that there are over 2 billion speakers of English".[1] English is the main language in the fields of books, music, international business, science, air traffic control and news media. In a transnational, cross-cultural society, English language skills are even more important. Therefore, in today's globalized society, international language—English—has become a capability that should be learned.

Most people in Taiwan also regard English as the first foreign language. In the syllabus of the 12-year Basic Education issued by the Ministry of Education, English is one of the major subjects. Students must learn English from the third grade of the Elementary School.[2] However, English is a big obstacle for many students. This maybe due to the fact that English is not our native language, and there is no good English learning environment. As a result, many students fail to achieve satisfying results and reject learning it (Shih, 2016). The anxiety of English communication is a well-known problem for the learners. Listening and speaking have been relatively weak, making students afraid to speak English in English classes. A survey by Hamouda (2013) suggests that the anxiety of English learners might be due to the following reasons: low English proficiency, fear of speaking in front of others, fear of making mistakes, negative evaluation, shyness and lack of confidence and preparation.

Robot-Assisted language learning provides a novel approach and has gained more and more attention as robot technologies become more mature and available at lower cost. The development of hardware and the advancement of technology, including artificial intelligence and machine learning, have made this teaching method more feasible. Robot-assisted language learning might offer several

---

[1] English language, at https://en.wikipedia.org/wiki/English_language (last visited 04/20/2019).

[2] National Academy for Educational Research, at https://english.naer.edu.tw/ (last visited 04/08/2019).

advantages over traditional teaching. For example, for teaching that requires repeated practice, robots are not as tired and impatient as teachers due to long hours of teaching, and the students have less fear of getting negative feedback from others. Moreover, in robot-assisted language learning, the data of learners can be stored and used as a reference for teaching.

There have been many related studies on the research and development of language robots. In Turkey, Kose (2011) did a study on sign language teaching for 106 preschool children using the NAO H25 humanoid robot. The purpose was to assess children's ability to learn sign language from robots. The study was very successful and the children achieved a high percentage of correctness in a test. In South Korea, Lee (2011) designed an English course to let students interact with robots. After post-testing and comparison, it was found that although there was no significant improvement in listening, the improvement in speaking was significant. It also increased student satisfaction, interest, self-confidence and motivation. In recent years, there are similar research projects in Taiwan. Huang (2017) explored the impact of using English robots on the effectiveness of learning English for young children. Kang (2017) also did a study on the effectiveness of robot-assisted language learning for Taiwanese primary school children's language learning. This result indicated that the students in the experimental group were more focused, confident and had more positive attitude than the students in the control group. It can be known from the above research results that robots are used in secondary language learning, and robots can have better learning outcomes for students than traditional teaching methods.

A goal of this research is to evaluate our design of activities of robot-assisted language learning. In our design, students use English to communicate with robots. After voice recognition, the robot responds verbally or executes the task according to the instructions. The task location is on a simplified street map. Students can order the robot to move to a designated location on the map, or command the robot to go forward, turn right, or turn left. Through this oral and visual interaction with the robot, students can learn English in a different way than before. The evaluation results of the learners are discussed in this paper.

2. Dialog Mechanism and Image Processing of Robot

2.1 Dialog Process

The dialog between the user and the robot is controlled according to a flowchart implemented as a Python program (Figure 1). When a learning session starts, the robot constantly listens for a wake-up word from the user. In our case, the wake-up word is "YunBot", which is the name of the robot. When the robot hears the wake-up word, the sound input of the next five seconds will be recorded and sent to a speech recognition service of Google Cloud, which will return the recognized text. For now, there is an assumption of short input utterances of less than five seconds. The recognized text is matched with a number of prescribed inputs. Once a match is found, a response text is converted into a voice output.

According to the different dialogues, it can be divided into three types. The general dialogue does not need to do other things. If it is a place dialogue, it will enter the next state. First calculate the path to the specified location, and then find out whether there is an ArUco tag from the captured image. If there is, determine whether the tag ID is the specified location ID, and if so, end the move and return to the conversation state. Next, judge whether you encounter an intersection, because after the intersection, you should turn according to the path calculated beforehand, and then follow the lane to move. If the dialogue used is a mobile conversation, it is judged whether the direction indicated by the user has a lane to walk, and if it is possible, the movement starts. It is necessary to capture the image to make the judgment of the ArUco tag at the intersection and location. If it is found, return to the conversation state, wait for the next user's instruction, and if not, follow the lane movement.

Among them, the path of the street map, the calculation of the moving path, the detection of the ArUco tag, the detection of the intersection, the calculation of the lane image, etc., the data (image) is transmitted to the computer. Because the processing speed of the computer is much faster than that of the Raspberry Pi, the Raspberry Pi is prevented from being overloaded and the reading frame rate is reduced. The rest is handled on the Raspberry Pi.
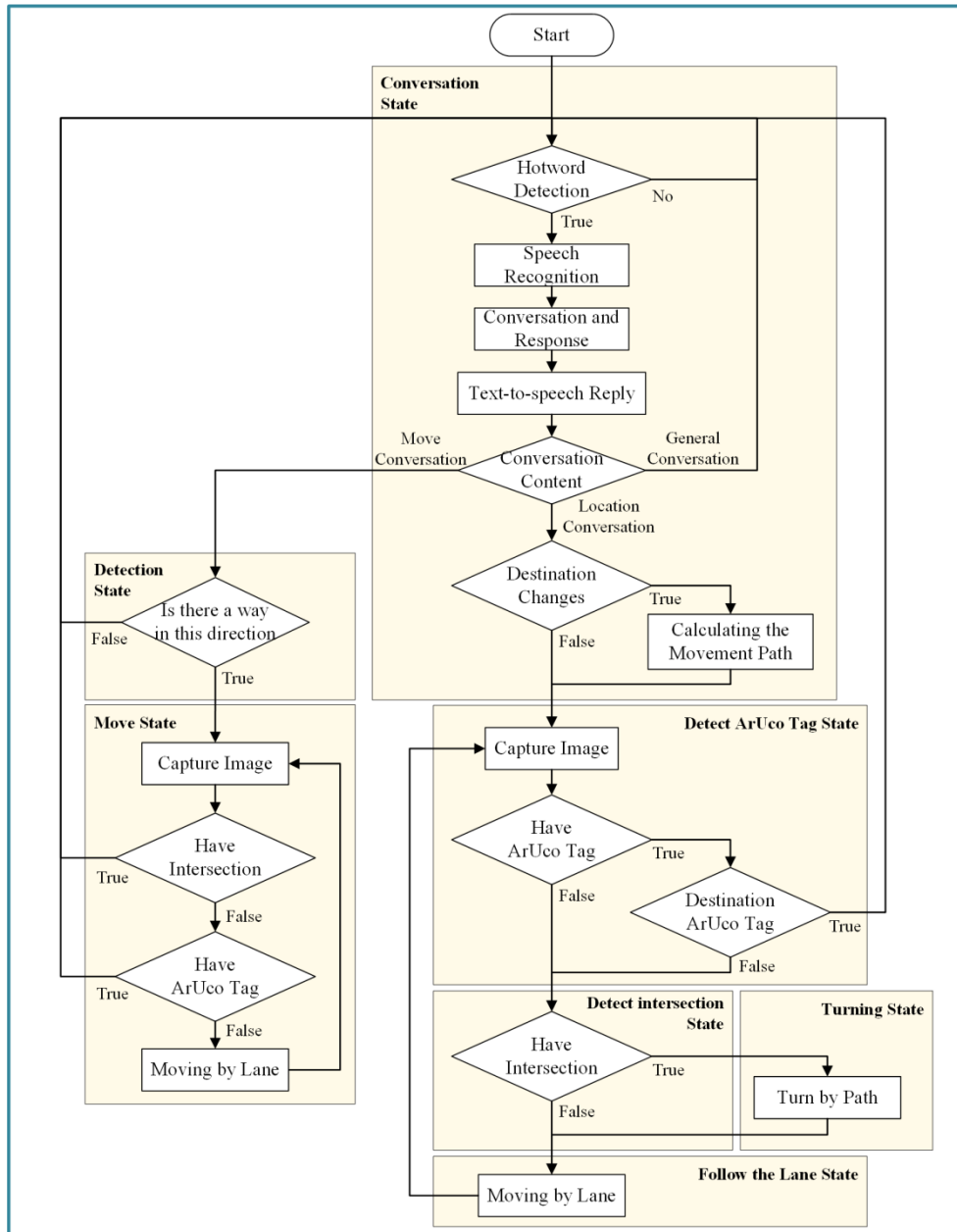
Figure 1. Robot program overall flow chart

2.2 Dialogue and Response Mechanism

The dialogue and response mechanism works as follows. First, the previous input string of the user is saved for subsequent decision making, and then the robot waits for the user's input. After an utterance is received and converted to a text string with Google cloud service of speech recognition, the string is preprocessed. String preprocessing involves removing punctuation and duplicate white spaces, and converting all English to uppercase to make it easier to match to target strings. This completes processing the user's input.

In the response stage, the string of the previous response is also saved at the beginning, and the state is set to "TO UNDERSTAND". Then the robot determines whether the user enters a null value or repeatedly enters a null value. If so, the state is set to "NULL INPUT" or "NULL INPUT REPETITION" accordingly. In both cases, the robot reminds the user that no input is received so that the user knows that he should say something to the robot.

At this point, the robot must have obtained some input string from the user. Next, the input string is matched to some templates in the language database. If no match is found, the state is set to

"BOT DOESN'T UNDERSTAND" and the robot picks one expression from several choices all of which mean that the robot does not understand the user's utterance. Otherwise, the matched template generally provides multiple choices of responses. Then one choice is randomly selected and the choice would be pre-processed. For example, if the user says "YOU ARE MY ROBOT", a matched template can be "YOU ARE $REMAIN_STRING". One response of this template is to prepend "SO, YOU THINK THAT I'M" to $REMAIN_STRING, resulting in an utterance "SO, YOU THINK THAT I'M MY ROBOT." This sounds illogical because of the clause "I'M MY ROBOT," which should be "I'M YOUR ROBOT." This correction can be achieved if there is a check on whether there are pronouns in any of the input string. Any first person pronoun is replaced by a second person pronoun and vice versa. For example, "I" is replaced by "YOU", "MY" is replaced by "YOUR", etc. In addition, any subsequent be-verb following the pronoun should be changed accordingly. For example, "AM" is replaced by "ARE". In the previous example, the response statement becomes "SO, YOU THINK THAT I'M YOUR ROBOT." Then the robot determines whether the response has been used in the last 10 responses. If yes, the current response is replaced by another random choice provided by the matched template. Otherwise, the conversation record is saved, and the response is uttered. Table 1 lists some of the user's utterances and the possible response of the robot.

All dialogue can be roughly divided into three types. The first one is a general conversation that requires no motion from the robot. The robot only needs to find the corresponding response and convert it into voice output. It does not need to control other hardware, like "What can you do?", "Nice to meet you." In order to avoid repeating the same response, which might bore the student, one of the equivalent responses is chosen at random. For example, the student says "How are you", the robot may respond "Fine, thank you.", "I'm very well.", "Pretty good! ", or "I'm doing OK.", and if the selected response was used before, another random choice of response will be selected.

Table 1

General Conversation

Student talk	Robot choices of responses
General dialogue	
How are you?, What's up?, Are you alright?	Fine, thank you./I'm very well. Thank you./Pretty good!/Never better!/So far so good./I'm doing OK./Just so-so./Not bad./As usual.,/Nothing special.
What's your name?	My name is Yunbot./I am Yunbot.
Nice to meet you.	Nice to meet you too/Thank you. It's very nice to meet you as well.
Location dialogue	
Go to the School.	Ok, go to the School. (Action: Move to the School.)
Go to the Library.	Ok, go to the Library. (Action: Move to the Library.)
Move dialogue	
Go forward.	Ok, Go forward. (Action: Go forward.)
Turn right.	Ok, Turn right. (Action: Turn right.)

The second type is about asking the robot to get to a destination. For example, if the user says "Go to the school.", the robot will answer "OK, go to the school.", the destination of school will be noted by the robot, which then plans the path from the current location to the school. After the planning is done, the robot starts moving again. When moving, the robot will continuously recognize the boundary lines of the lane on the ground through a camera, so that it will try to stay inside the lane. When it comes to an intersection, it will stop and then turn to the correct direction according to its plan, and finally will arrive at the destination. Upon arrival, the robot will say "I have arrived at the school."

The last type of dialog is an interactive, step-by-step instructive conversation. When the user commands the robot to move, it will respond verbally and then move according to the command. When the robot visually detects an ArUco tag, which specifies a location, or a road intersection, the robot will

stop. At an ArUco location, the robot will say it has arrived at the location. At an intersection, the robot will say "I am at an intersection. What should I do now?" The user can also ask the robot to go forward, or turn left or right. Then the robot will determine if there is a road in the stated direction. If yes, then it moves to that direction. Otherwise, it will say there is no road and waits for further instruction. The process repeats until it reaches the destination.

2.3 Image Processing

When people see, closer objects look bigger and further objects look bigger. This is the same with a camera. In order to recognize the two white lines bounding a lane with a camera, the images must be preprocessed with perspective transformation, resulting in images of resolution 420*240 where the two lines are parallel (Figure 2).

Next, the white lanes are separated from the black background with color filtering. Because the three channels of the original RGB color space are not very stable with different levels of brightness and saturation, color filtering is difficult with RGB images. So the RGB color space is first converted to the HSV color space, which includes hue (H), saturation (S), and brightness value (V). With HSV space, color filtering can be done more effectively.
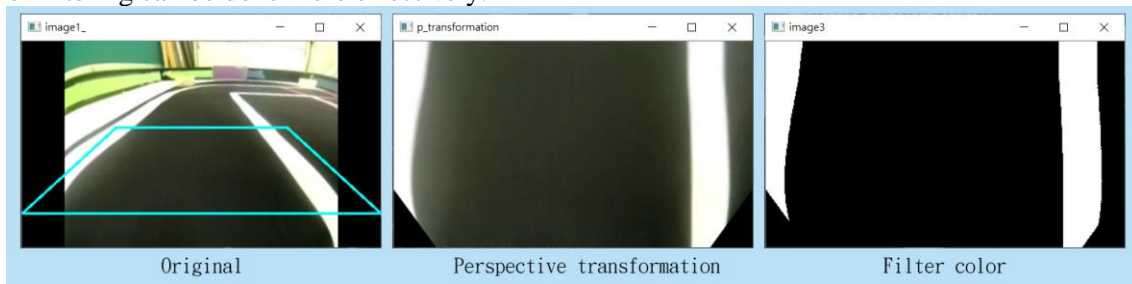
Figure 2. Perspective transformation and Filter color result

After perspective transformation and color filtering, the images are further processed to find the left and right boundary lines of the lane on which the robot moves. The robot always tries to stay in the center of the lane. Another task is the detection of lane curvature with image processing. Upon detecting a curvature, the robot turns to move along the curvature, aiming to stay within the two bounding lines,.

3. Empirical Results

In order to test the integrity of the study, the system was tested by five subjects, who were graduate students in the laboratory. According to the three dialogue modes explained above, there were three tasks: general conversation where the robot did not move, a command to ask the robot to move to a destination, an interactive, step-by-step dialog commanding the robot whenever it stopped at an intersection or a location on the map.

In the empirical experiment, there were several problems. Sometimes a subject forgot to wake up the robot first before talking to the robot. Moreover, because there were only few samples recorded for the wake-up word "YunBot", different accents of the subjects caused the failure of speech recognition by the robot. After the wake-up word was recognized, the robot would only record the subject's utterance for five seconds, which was not be enough for longer utterances.

For the general dialogue task, there was sometimes a problem of low volume from the subject so short utterances sometimes failed to be recognized. For example, the sound of "Hello" was recognized as "Hole". On the contrary, longer utterances such as "How are you?" were usually recognized correctly. Another problem was the small size of the current dialog templates so that some utterances of the subjects were not found in the prepared templates.

The move-to-destination dialog task was relatively easy because only one command was needed from the subject. The interactive, step-by-step dialogue task was easy since the subjects used only three kinds of instructions: go forward, turn left, and turn right.

4. Conclusion and future work

The main goal of this research is to build a robot to assist language learning in a game-like manner involving motion from the robot, where communication can break down and mistakes can be made by both the robot and the subject. There are three modes of conversation: general dialogue, command to move to a destination, and interactive, step-by-step instruction dialogue. In a preliminary empirical experiment, five subjects of graduate students conversed with the robot. Despite a number of problems during their conversation, the subjects found the learning experience novel and interesting.

After the experiment, the subjects made a few suggestions. First, they wished the robot could provide hints on what utterances the subjects could say at various situations. The subjects wished there could be more instructions on how the robot moved, for example, "move backward". Overall speaking, practicing dialog with a robot in the above scenarios were novel and interesting to the subjects, compared to the traditional ways of learning.

In future work, more artificial intelligence and deep learning techniques can be employed to improve the performance of image detection and speech recognition. More interesting tasks should be designed for children so that the robot can be used in real language learning sessions in elementary schools. Like it or not, robots are going to play more roles in real life, in addition to language learning.

Acknowledgements

References

Hamouda, A. (2013). An Exploration of Causes of Saudi Students' Reluctance to Participate in the English Language Classroom. International Journal of English Language Education, 1(1). doi:https://doi.org/10.5296/ijele.v1i1

Huang, Ta-Yang (2017). A Study on Robot-based English Learning for Infancy/探討運用英語機器人對於幼兒學習英語成效之影響. Department of Software Engineering and Management, National Kaohsiung Normal University. Kaohsiung. Retrieved from https://hdl.handle.net/11296/897nf8

Jeonghye, H., Miheon, J., Vicki, J., & Jun, J. H. (2008). Comparative Study on the Educational Use of Home Robots for Children. Journal of Information Processing Systems, 4(4), pp. 159-168. doi:10.3745/JIPS.2008.4.4.159

Kang, Shih-Min (2017). Effects of Using Robot Assisted Language Learning for Promoting Taiwanese Young EFL Learners' Intonation Acquisition/機器人輔助語言學習對台灣國小學童語調習得成效之研究. Graduate Institute of Children's English, National Changhua University of Education. Changhua County. Retrieved from https://hdl.handle.net/11296/h9a9hf

Kose, H., & Yorganci, R. (2011). Tale of a robot: Humanoid robot assisted sign language tutoring. 2011 11th IEEE-RAS International Conference on Humanoid Robots, (pp. 105-111). Bled.

Lee, S., Hyungjong, N., Jonghoon, L., Kyusong, L., Gary, L. G., Seongdae, S., & Munsang, K. (2011). On the effectiveness of Robot-Assisted Language Learning. ReCALL, 23(1), pp. 25-58. doi:10.1017/S0958344010000273

Shih, Yo-Ting (2016). A Study of English Learning Motivation and Learning Disturbances: a theoretical perspective/英語學習動機與學習困擾:理論的觀點. Taiwan Educational Review Monthly, 5(7), 111-128

WORKSHOP 16 - The 2nd Workshop on Innovative Technologies for Enhancing Interactions and Learning Motivation

Unforeseen Impediments Emerging in the Process of Flipped Learning: A Lesson Learned in FIBER

Morris Siu-Yung JONG[a]*, Gaowei CHEN[b], Vincent TAM[c], Yichao JIANG[a], & Mengyuen CHEN[a]

[a]*Faculty of Education, The Chinese University of Hong Kong, Hong Kong*
[b]*Faculty of Education, The University of Hong Kong, Hong Kong*
[c]*Faculty of Engineering, The University of Hong Kong, Hong Kong*
*mjong@cuhk.edu.hk

Abstract: Flipped Issue-Based Enquiry Ride (FIBER) is a pedagogical framework to integrate flipped learning into the approach of issue-based enquiry in social humanities education. This working paper presents the work that we conducted in the first research cycle (the first year) of a piece of two-cycle design-based research (DBR) on implementing FIBER in the context of formal curriculum learning and teaching in Hong Kong. The entire DBR involved 9 teachers (from 9 different secondary schools at different academic bands) and their Secondary-5 classes in two consecutive school years. In this paper, we focus on discussing the unforeseen impediments emerging in the course of FIBER that hindered students' learning in the first research cycle. The findings not only shed light on how to improve and optimize the current teacher facilitation acts in FIBER to be enacted in the second research cycle of the DBR, but also alert "flipped" educators and researchers to the potential problems occurring in the course of flipped learning.

Keywords: Flipped learning, design-based research, issue-enquiry learning, social humanities education

1. Introduction

Flipped learning (or inverted learning or flipped classroom) is an instructional strategy that merges online direct-instruction learning outside the school and student-centric learning inside the school (Bergmann et al., 2015; Bishop et al., 2013). According to the K-12 edition of the New Media Consortium Horizon Report 2015 (Johnson et al., 2015), flipped learning is regarded as one of the most important pedagogical approaches in the current decade for possibly transforming students from passive learners into constructivist ones. In Hong Kong, promoting the incorporation of flipped learning in formal curriculum teaching is one of the government's core initiatives for information technology in school education (Education Bureau, 2018).

Empirical studies on harnessing flipped learning in K-12 contexts are on the increase. For example, Lo et al. (2018), Sun et al. (2017), and Zummo et al. (2016) have investigated the adoption of flipped strategies in learning and teaching of Biology, Chemistry, Mathematics, Physics, etc. While most of the current flipped learning instances (with desirable pedagogical results) in the field are related to mathematics or science subjects, flipped learning in social humanities education is rarely discussed.

Based on the theoretical foundations of (i) Hwang's (2016) conceptual framework of flipped learning and (ii) Stripling's (2008) enquiry learning model, we have proposed *Flipped Issue-Based Enquiry Ride (FIBER)* — a pedagogical framework to integrate flipped learning into learning and teaching of Liberal Studies (LS) (a subject of social humanities education in senior secondary schools in Hong Kong). Regardless of the initial positive results in terms of students' knowledge acquisition in our early study (Jong, 2017), we have further aimed to, through design-based research (DBR), improve and optimize the teacher facilitation acts in FIBER for enhancing its pedagogical effectiveness in the context of formal curriculum learning and teaching. The entire DBR is composed of two research cycles (1 cycle per year), involving 9 teachers (from 9 different secondary schools at different academic bands) and their Secondary-5 classes in two consecutive school years. This working paper presents the work

that we conducted in the first research cycle, particularly focusing on discussing the unforeseen impediments emerging in the course of FIBER that hindered students' learning.

2. Related Works

2.1 Flipped Learning and Bloom's Taxonomy

Flipped learning is commonly regarded as a combination of (i) individual learning outside the classroom through direct instructional videos, and (ii) teacher-facilitated student-centric learning inside the classroom (Bishop et al., 2013). Hwang (2016) has further conceptualized flipped learning in terms of Bloom's Taxonomy (Anderson et al., 2001). Outside the school, pupils preliminarily gain basic knowledge via direct-instruction videos in the forms of remembering- and/ or understanding-based activities (i.e., the lower tier of the taxonomy). Back to the school, pupils deepen their knowledge gained outside the school via participating in teacher-facilitated higher-order tasks in the forms of applying-, analysing-, evaluating-, and/ or creating-based activities (i.e., the upper tier of the taxonomy).

2.2 Liberal Studies (LS) and Issue-based Enquiry

LS, which is a core subject in Hong Kong senior secondary schools, aims to equip students with knowledge and interdisciplinary perspectives for enquiring into various real-life societal issues. The LS curriculum is composed of a number of thematic areas and each area consists of a number of enquiry modules. For example, "Society and the Environment" is one of the areas, in which "Globalisation," "Environment & Sustainable Development," and "Influences of Energy Technology" are the modules therein. In the normal practice, a nine-day teaching cycle is used to cover an enquiry module; there are three 70-minute face-to-face lessons evenly distributed in the cycle. The statutory curriculum document (Curriculum Development Council, 2014) spells out that issue-based enquiry should be the primary pedagogy to be used in LS. Stripling's (2008) enquiry learning model is a common issue-based enquiry approach adopted by LS teachers (Fok et al., 2014; Jong et al., 2018). The model is composed of a number of enquiry phases, including *Connection*, *Exploration*, *Comprehension*, *Construction*, *Expression*, and *Reflection*.

2.3 Flipped Issue-Based Enquiry Ride (FIBER)

FIBER is a teacher-facilitated pedagogical framework to harness flipped learning in LS (Jong, 2017). Specifically, it aims to, in the setting of authentic formal LS learning and teaching, integrate the "flipped" strategy into the course of issue-based enquiry learning. Despite leveraging Hwang's (2016) conceptual framework of flipped learning, FIBER still adopts Stripling's (2008) enquiry learning model as the primary theoretical basis. Figure 1 illustrates the design and implementation of FIBER with respect to learning and teaching of an enquiry module in a nine-day teaching cycle (Jong et al., 2019, in-press).

2.4 Design-Based Research (DBR)

DBR is usually harnessed to develop "usable" interventions for addressing problems or issues related to education, such as curricula, classroom teaching, educational and school-based policies, etc. (Anderson et al., 2012; Design-based Research Collective, 2003). In general, two or more research cycles are needed for gathering sufficient research data in order to improve and/ or optimize the original design of the interventions. Different from other research approaches, DBR is a collective effort between both researchers and practitioners (Wang et al., 2005), targeting to co-develop pragmatic knowledge for building and/ or revamping educational practices (McKenney et al., 2012).
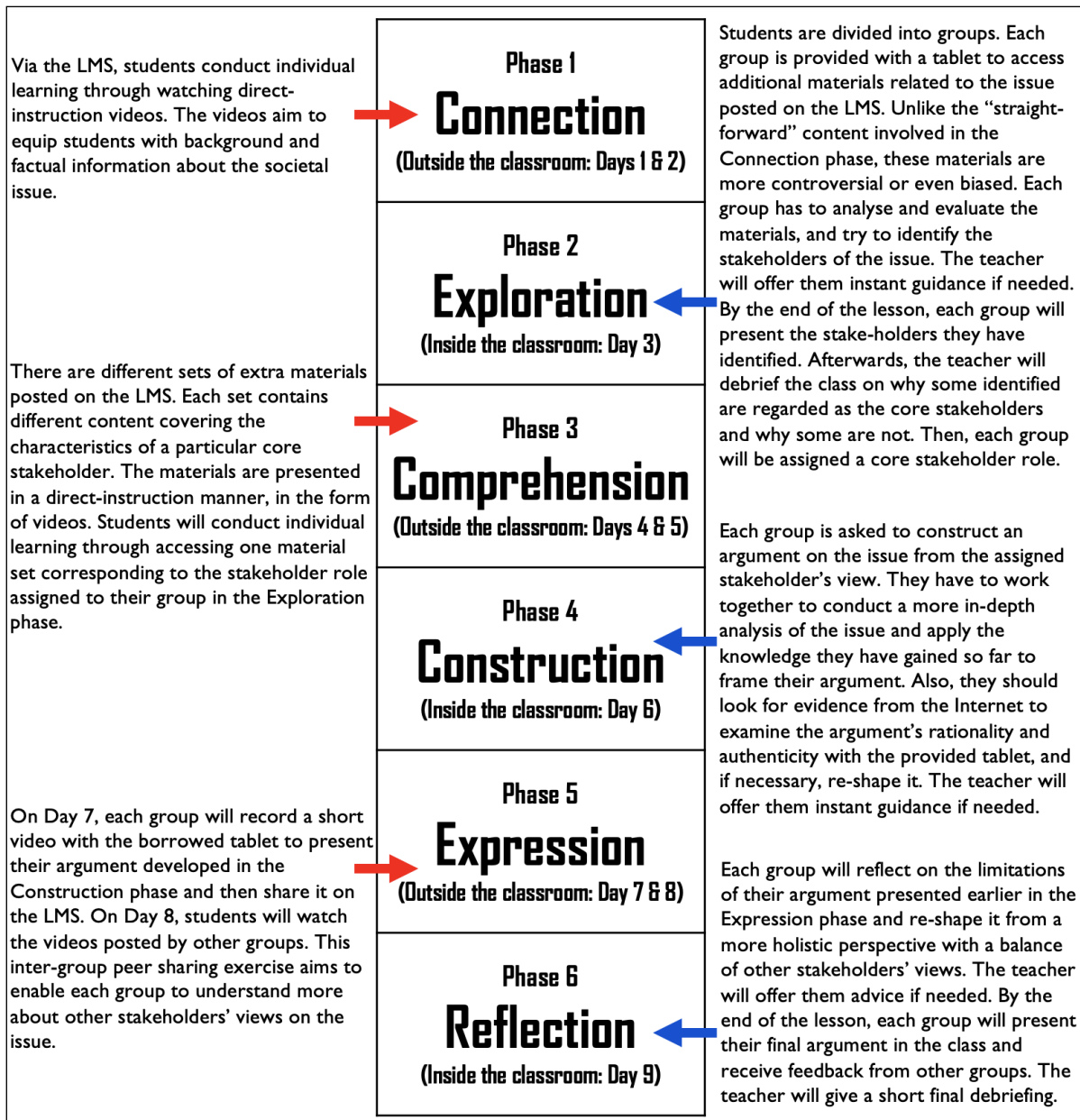
Via the LMS, students conduct individual learning through watching direct-instruction videos. The videos aim to equip students with background and factual information about the societal issue.

Phase 1

Connection

(Outside the classroom: Days 1 & 2)

Students are divided into groups. Each group is provided with a tablet to access additional materials related to the issue posted on the LMS. Unlike the "straight-forward" content involved in the Connection phase, these materials are more controversial or even biased. Each group has to analyse and evaluate the materials, and try to identify the stakeholders of the issue. The teacher will offer them instant guidance if needed. By the end of the lesson, each group will present the stake-holders they have identified. Afterwards, the teacher will debrief the class on why some identified are regarded as the core stakeholders and why some are not. Then, each group will be assigned a core stakeholder role.

Phase 2

Exploration

(Inside the classroom: Day 3)

There are different sets of extra materials posted on the LMS. Each set contains different content covering the characteristics of a particular core stakeholder. The materials are presented in a direct-instruction manner, in the form of videos. Students will conduct individual learning through accessing one material set corresponding to the stakeholder role assigned to their group in the Exploration phase.

Phase 3

Comprehension

(Outside the classroom: Days 4 & 5)

Phase 4

Construction

(Inside the classroom: Day 6)

Each group is asked to construct an argument on the issue from the assigned stakeholder's view. They have to work together to conduct a more in-depth analysis of the issue and apply the knowledge they have gained so far to frame their argument. Also, they should look for evidence from the Internet to examine the argument's rationality and authenticity with the provided tablet, and if necessary, re-shape it. The teacher will offer them instant guidance if needed.

On Day 7, each group will record a short video with the borrowed tablet to present their argument developed in the Construction phase and then share it on the LMS. On Day 8, students will watch the videos posted by other groups. This inter-group peer sharing exercise aims to enable each group to understand more about other stakeholders' views on the issue.

Phase 5

Expression

(Outside the classroom: Day 7 & 8)

Phase 6

Reflection

(Inside the classroom: Day 9)

Each group will reflect on the limitations of their argument presented earlier in the Expression phase and re-shape it from a more holistic perspective with a balance of other stakeholders' views. The teacher will offer them advice if needed. By the end of the lesson, each group will present their final argument in the class and receive feedback from other groups. The teacher will give a short final debriefing.

Figure 1. Design and Implementation of FIBER (Jong et al., 2019; in-press).

3. Research Design

3.1 Participating Schools and Teachers

In Hong Kong, secondary schools are divided into three bands based on students' academic ability. Band-1, Band-2, and Band-3 are respectively the top, middle, and bottom. We recruited nine LS teachers from 9 different secondary schools (3 schools from each band) who possessed comparable academic background and LS teaching experience with issue-based enquiry. Before the present study, three of them had observed the implementation of FIBER in our pilot study (Jong, 2017), and six of them had participated in our introductory workshop on flipped learning. Moreover, their schools were using the same type of learning management system (LMS).

3.2 Procedures

We have employed Design-based Research Collective's (2003) four-stage methodology which models the research process with iterative cycles of *Design*, *Enactment*, *Analysis* and *Redesign*. Observing the page limit (6 pages in total) of this working paper, the following will briefly describe the work we and each teacher did at the stages of Design, Enactment and Analysis in the first research cycle.

Design. In each school, we conducted a refresher training on flipped learning and FIBER for the teacher, in which the findings of the previous study (Jong, 2017) were also discussed. After that, the teacher participated in a quasi-experiment[1] in which s/he piloted to implement FIBER (Jong et al., 2019, in-press). Further, we assigned the teacher an enquiry module in the thematic area of "Society and the Environment," as well as re-examining and adjusting together with the teacher (i) the FIBER resources previously developed for the assigned module (Jong et al., 2017) and (ii) the existing facilitation acts in FIBER based on the school context.

Enactment. We supported the teacher in implementing FIBER to facilitate a Secondary-5 class to study the assigned module. We conducted data collection inside and outside the classroom during the entire implementation process from both teacher and student sides, as illustrated in Figure 2. We also conducted formative analysis on the collected data so as to provide the teacher with just-in-time information for adjusting his facilitation act if needed.
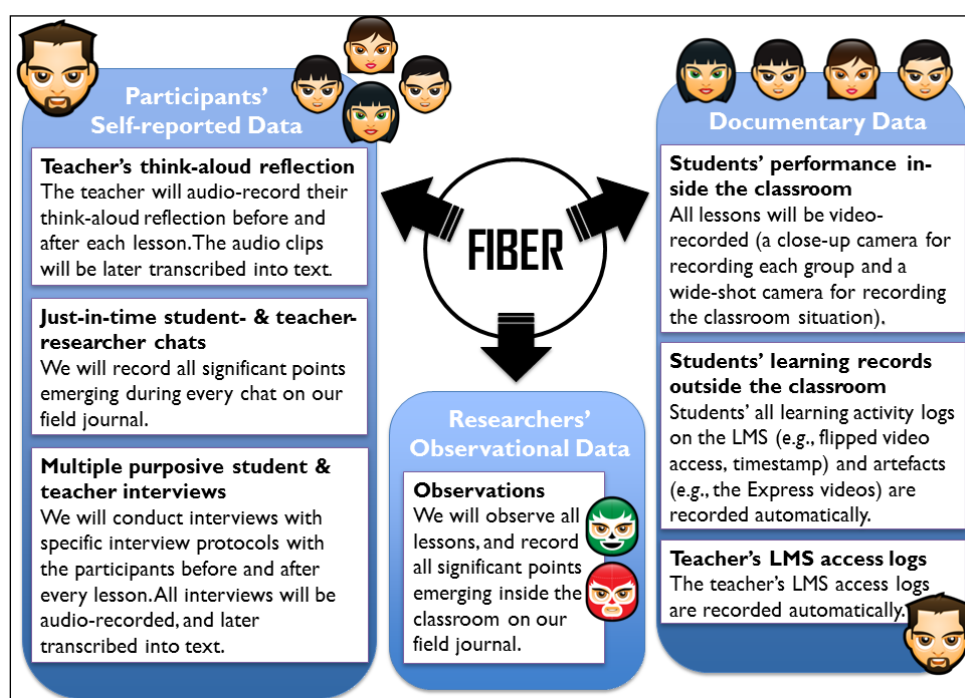
Figure 2. Data Collection Work at the Enactment Stage of the First Research Cycle.

Analysis. After the implementation, the class took a knowledge test[2] in which the questions were derived from the LS public examination questions (within the recent 5 years) related to the assigned module. The test and marking scheme were validated by a review panel which was composed of educators from local universities, curriculum officers and non-participating LS teachers. In addition to analysing the students' performance in the knowledge test, we also conducted post-learning interviews with some students to probe into their experience with FIBER. We employed Creswell's (2018) analytical strategies of theme layering and theme interrelating to study the qualitative data collected in both Enactment and Analysis stages.

---

[1] After the training and the discussion of the previous research findings, most of the teachers deemed that it would be much better if they could gain some real FIBER implementation experience before enacting the facilitation work at the Enactment stage of the DBR. Also, they were interested in knowing, in particular, would the pedagogical effectiveness of FIBER be really better than the conventional issue-based approach's in their own school. As agreed and consented by all teachers and their schools, before the Enactment stage in the first research cycle, each of them piloted to implement FIBER to teach a module ("Globalization") via an quasi-experiment (in comparison with the conventional approach) with 2 Secondary-4 classes (Jong et al., 2019, in-press).

[2] The test results in this cycle will later be compared with the results to be obtained in the next research cycle.

4. Findings

Observing the page limit, this working paper focuses on presenting the unforeseen impediments emerging in the implementation process of FIBER that hindered students' learning in the first research cycle, as summarized in Table 1. At the Redesign stage of this cycle, we set up three working groups with the nine teachers to optimize FIBER through addressing these unforeseen impediments. The three teachers from the same schools' academic band were grouped together. Through meetings and electronic communications, we (i) discussed the findings obtained in the first research cycle with the groups, and (ii) worked together to derive interventions for improving the empirical implementation of FIBER. The "optimized" teacher facilitation acts in FIBER to be enacted in the second research cycle of the DBR and their effectiveness will be presented and discussed in our upcoming papers.

Table 1

A Summary of the Common and Unique Impediments Emerging in the Band-1, Band-2, and Band-3 Schools at the Enactment Stage in the First Research Cycle

Band-1 schools	Band-2 schools	Band-3 schools
• Some students were unmotivated to watch the flipped videos in the phases of Connection (out-of-class) and Comprehension (out-of-class) because the presenter in the videos was not their own teachers. • Some students from families in low socio-economic-status were inexperienced in using the tablets, having difficulties to participate in the phases of Exploration (in-class), Construction (in-class), and Expression (out-of-class, Day 7). • Some students complained that the lesson time was too short for them to accomplish the required collaborative tasks in the phases of Exploration (in-class), Construction (in-class), and Reflection (in-class). • Some students were unable to recall some vital knowledge/ conceptions gained in the phases of Connection (out-of-class) and Comprehension (out-of-class), hindering their participation in the phases of Exploration (in-class) and Construction (in-class). • Some students realised that they should have been given more time to plan and create their short videos for presenting their arguments in the phase of Expression (out-of-class, Day 7).		
• Some students were less motivated to learn with FIBER as they deemed that the conventional issue-based enquiry approach was more effective to help them do well in the examination. • Some students in the same group had very divergent views while conducting the discussions in the phases of Exploration (in-class), Construction (in-class), and Reflection (in-class), provoking serious verbal conflicts. • Some students were too dominating in the phases of Exploration (in-class), Construction (in-class), Expression (out-of-class, Day 7), and Reflection (in-class), hindering other groupmates to elaborate their views.	• Some students had poor Internet-searching skills and were frustrated when conducting the task in the phase of Construction (in-class). • Some students did off-task activities with their tablets (e.g., watching unrelated YouTube® videos) in the phases of Exploration (in-class) and Construction (in-class). • Some students found that the contents of the flipped videos in the phases of Connection (out-of-class) and Comprehension (out-of-class) were too abstract to understand, and eventually they came up with serious misunderstandings of some important conceptions. • Some students were unwilling to interact with their groupmates in the phases of Exploration (in-class), Construction (in-class), and Reflection (in-class). • Some students were too shy when recording their videos to be shared in the LMS in the phase of Expression (out-of-class, Day 7), hindering the peer-sharing exercise in the phases of Expression (out-of-class, Day 8) and Reflection (in-class).	• Some students regarded that the contents of the flipped videos in the phases of Connection (out-of-class) and Comprehension (out-of-class) were too hard to understand, and eventually they skipped watching the videos before the phases of Exploration (in-class) and Construction (in-class). • Some students were unwilling to participate in the group discussions and present their ideas in front of the class in the phases of Exploration (in-class), Construction (in-class), and Reflection (in-class), and show up their faces when recording the videos in the phase of Expression (out-of-class, Day 7).

5. Conclusion

FIBER is a teacher-facilitated pedagogical framework to integrate flipped learning into the approach of issue-based enquiry in social humanities education. The present two-cycle DBR spans two consecutive school years with the aim of enhancing the pedagogical effectiveness of FIBER in the context of formal curriculum learning and teaching in Hong Kong. This paper has presented the former part (the first research cycle) of the entire research. The findings of the unforeseen impediments emerging in the course of FIBER not only shed light on how to improve and optimize the current teacher facilitation acts in FIBER to be enacted in the second research cycle of the DBR, but also alert "flipped" educators and researchers to the potential problems occurring in the process of flipped learning.

Acknowledgements

References

Anderson, L. W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., Raths, J., & Wittrock, M. C. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. Essex: UK: Pearson.

Anderson, T., & Shattuck, J. (2012). Design-based research: A decade of progress in education research? *Educational Researcher, 41*(1), 16–25.

Bergmann, J., & Sams, A. (2015). *Flipped learning for social studies instruction*. Eugene, OR: International Society for Technology in Education.

Bishop, J. L., & Verleger, M. A. (2013). *The flipped classroom: A survey of the research*. Paper presented at the 120th America Society for Engineering Education (ASEE) Annual Conference and Exposition, Atlanta, GA.

Curriculum Development Council. (2014). *Liberal Studies: Curriculum and assessment guide (Secondary 4–6)*. Hong Kong: Education Bureau.

Design-based Research Collective. (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher, 32*(1), 5–8.

Education Bureau. (2018). *Information technology in education 2018*. Hong Kong: Education Bureau

Fok, P. K., & Yu, Y. C. (2014). The curriculum reform in new senior secondary education of Hong Kong: Change and immutable. *Journal of Curriculum Studies, 9*(1), 1–32.

Hwang, G. J. (Ed.) (2016). *Flipped classroom: Theories, strategies and applications*. Taipei: Higher Education Press.

Johnson, L., Adams Becker, S., Estrada, V., & Freeman, A. (2015). *NMC Horizon Report: 2015 K-12 Edition*. Austin, Texas: The New Media Consortium.

Jong, M. S. Y. (2017). Empowering students in the process of social inquiry learning through flipping the classroom. *Educational Technology & Society, 20*(1), 306–322.

Jong, M. S. Y., Chan, T., Hue, M. T., & Tam, V. (2018). Gamifying and mobilising social enquiry-based learning in authentic outdoor environments. *Educational Technology & Society, 21*(4), 277–292.

Jong, M. S. Y., Chen, G. W., Tam, V., & Chai, C. S. (2019). *FIBER: A flipped pedagogy for social humanities education*. Paper presented at America Educational Research Association Annual Meeting 2019 (AERA 2019), Toronto, Canada.

Jong, M. S. Y., Chen, G. W., Tam, V., & Chai, C. S. (in-press). Adoption of flipped learning in social humanities education: The FIBER experience in secondary schools. *Interactive Learning Environments*.

Lo, C. K., Lie, C. W., & Hew, K. F. (2018). Applying "First Principles of Instruction" as a design theory of the flipped classroom: Findings from a collective study of four secondary school subjects. *Computers & Education, 118*, 150–165.

McKenney, S., & Reeves, T. C. (2012). *Conducting educational design research*. New York: Routledge.

Stripling, B. K. (2008). Inquiry: Inquiring minds want to know. *School Library Media Activities Monthly, 25*(1), 50–52.

Sun, J. C. Y., Wu, Y. T., & Lee, W. I. (2017). The effect of the flipped classroom approach to OpenCourseWare instruction on students' self-regulation. *British Journal of Educational Technology, 48*(3), 713–729.

Wang, F., & Hannafin, M. (2005). Design-based research and technology-enhanced learning environments. *Educational Technology Research and Development, 53*(4), 5–23.

Zummo, L., & Brown, B. A. (2016, April). *Implementing flipped instruction in high school biology classrooms: Learning outcomes and student perceptions*. Paper presented at America Educational Research Association Annual Meeting 2016 (AERA 2016), Washington, DC.

Designing Metacognitive and Motivation Tutor: A Pedagogical Agent to Facilitate Learning in Blended-Learning Environment in A Higher Education Context

Ati Suci Dian MARTHA[a]*, Harry Budi SANTOSO[a], Kasiyah JUNUS[a], & Heru SUHARTANTO[a]
[a]*Faculty of Computer Science, Universitas Indonesia, Indonesia*
*aciantha@gmail.com

Abstract: In this paper, we present the initial results of research that is still ongoing in building metacognitive and motivation tutor, a pedagogical agent used to facilitate students in blended learning in a higher education context. The MeMo Tutor, which stands for "**Me**tacognitive and **Mo**tivation **Tutor**", is a pedagogical agent in the form of a conversational agent that integrated into the Moodle Learning Management System. The metacognitive and motivation tutor aims to provide feedback to students using an integration of metacognitive scaffolding and motivation scaffolding. The main objective of the pedagogical agent is to maintain and enhance student engagement and motivation in blended-learning environment. This paper presents the first results in ongoing research efforts. In this work, we attempt to design the components of the proposed pedagogical agent, consisting of a learning environment, character design, and system architecture.

Keywords: Pedagogical agent, blended-learning, higher education, metacognitive scaffolding, motivation scaffolding, learning environment, character design, architecture design

1. Introduction

Blended-learning is learning that commits instructors and students working together through a mixed approach, technology mediated and face-to-face, which is supported pedagogically through assignments, activities, and assessments that are tailored to the approach given (McGee & Reis, 2012). Engagement and motivation in the blended-learning process are important issues in the e-learning research field. Since engagement and motivation are potential to promote increased learning outcomes (Johnson & Lester, 2018). Numerous studies have been done by researchers and educators to promote and maintain student engagement and motivation in online learning. One of them is a pedagogical agent. Pedagogical agents are virtual characters in an online learning environment that function as learning tools by providing assistance, guidance, procedures or examples to support the learning process (Martha & Santoso, 2019). Pedagogical agent research continues to develop along with technological developments. The use of Natural Language Processing (NLP) technology in an intelligent agent environment has proven its success in the past. The input boxes on NLP forces students to express ideas explicitly and identify difficult fields (Carlson et al., 2012).

Scaffolding is a learning strategy that is considered most appropriate with the perspective of social constructivism (Olney & Cade, 2013). Pedagogical agents using scaffolding learning strategies have the potential to improve learning outcomes. At present, the use of scaffolding approach in pedagogical agent research has been carried out, but only focuses on metacognitive scaffolding. Based on the perspective of self-regulated learning, the success of online learning is influenced by two contributing components, namely metacognition and motivation (Eflkides, 2011). Motivation influences the level of student achievement, the level of engagement, and the quality of work (Hartnett, 2016). However, the design of pedagogical agents using a motivation approach is still very limited (Martha & Santoso, 2018). Therefore, the motivation scaffolding approach that integrates with the metacognitive scaffolding approach needs to be included in developing a pedagogical agent.

In this paper, we developed a pedagogical agent using a conversation interface, which was integrated with Moodle's Learning Management System. The character of the pedagogical agent is static. The pedagogical agent that is built has the purpose of maintaining and increasing student learning engagement and motivation, through stimulation from an integration of metacognitive and motivation scaffolding during the individual and collaborative learning process.

We recognize that the development of agents that are capable of supporting individual and collaborative learning through group settings is complex. In addition, the integration of metacognitive and motivation scaffolding also has a very complex construction in each part. Therefore, we limit the agent's design goals to one blended learning topic. The learning scenario of the topic will be explained in part four of this paper.

This paper begins with a brief summary of related works of pedagogical agent research, followed by illustrating the design of the learning environment to apply the developed pedagogical agent. Then we describe the overview of our proposed system. In the end, we provide conclusions and discuss our future work from the system being built.

2. Related Works

In the last ten years, the number of publications of scientific articles on pedagogical agents has continued to increase and further improve the features of existing pedagogical agents (Martha & Santoso, 2019). Some pedagogical agent studies, both those using metacognitive and motivation scaffolding methods, are presented in this section.

MIMIC is a pedagogical agent with three roles, namely motivator, expert, and mentor (Baylor & Kim, 2005). MIMIC works by using metacognitive scaffolding strategies. These three agents are able to simulate instructional roles effectively in accordance with student perceptions.

Betty's Brain is a pedagogical agent in the form of teachable agents (Biswas et al., 2009; Leelawong & Biswas, 2008; Roscoe et al., 2013). Betty's Brain acts as an agent taught by students. With the metacognitive scaffolding strategies, Betty's Brain is able to improve student self-regulated learning. Students with metacognitive skills are able to monitor the content and quality of their learning outcomes.

The Wayang Outpost uses motivation scaffolding strategies in the context of mathematics tutoring (Arroyo et al., 2011). Wayang Outpost focuses on gender issues in solving math problems. Wayang Outpost as a pedagogical agent is able to improve the affective outcomes of students in general and especially for female students, who feel more anxious when working on mathematical problems.

MetaTutor is a pedagogical agent acting as scaffolders using the metacognitive scaffolding strategies (Duffy & Azevedo, 2015; Harley et al., 2018; Taub et al., 2014; Trevors, Duffy, & Azevedo, 2014). In their research, the MetaTutor used prior knowledge to influence learning activities and subsequent learning outcomes.

The four pedagogical agents mentioned above use the learning context in the STEM (Science, Technology, Engineering, and Mathematics) field. This is in accordance with the results of the meta-analysis conducted by Schroeder et al. (2013), that the benefits of pedagogical agents appear to be slightly greater for the context of STEM learning than for the humanities. Several reasons were raised regarding the learning context (Cook, 2017). Firstly, the ability of pedagogical agents to signal possible and most critical information when studying abstract content or processes that are more general in the STEM context. Secondly, researchers argue that, if students have a perception that STEM content is more challenging rather than content in the humanities, the effects of increased engagement from agents can help them survive and work harder, leading to better learning outcomes.

This research will implement pedagogical agents in the context of STEM learning, specially linear algebra in the Faculty of Computer Science, Universitas Indonesia. The linear algebra course was chosen because this course has been offered in blended-learning for more than 10 years and the instructor has a long teaching experience. With the integration of metacognitive and motivation scaffolding in pedagogical agents, pedagogical agents are expected to be able to act as scaffolders that can increase engagement and motivation in blended-learning in higher education.

3. Methodology

This study is a part of a larger and ongoing research on pedagogical agent (Martha & Santoso, 2018; Martha & Santoso, 2019). The research in this study aims to create a pedagogical agent model. This type of research is a compensation type. In the type of compensation, qualitative analysis can compensate for the small sample size in quantitative studies (Venkatesh et al., 2013), therefore the quantitative methods should to be done first, followed by qualitative ones. Thus, the mixed-methods sequential explanatory approach (Cresswell, 2014) is the methodology applied in this study.

The stages of the mixed-methods sequential explanatory approach are as follows.

1) This study utilize a purposive sampling technique to select participants in the class at a state university in Indonesia, based on the homogeneity of scores in the level of e-learning readiness. The selected class is a class with students who have the same level of e-learning readiness. The instrument used to measure the level of e-learning readiness is the E-learning Competencies which was developed by Parkes and Reading (2013) which was adapted by Junus et al. (2017).

2) In the quantitative phase, quasi-experimental non-equivalent methods (Cresswell, 2014) are used. This method has several stages, as follows.

   a. Pre-test; the experimental group and the control group will be given a pre-test using the Metacognition Questionnaire (Garrison & Akyol, 2015). This questionnaire was chosen because the items reflect metacognitive monitoring and managing skills when students are engaged in individual (self-regulated learning) and group settings (co-regulated learning) (Garrison & Akyol, 2015). The questionaires has been translated and adapted by Junus et al. (2019). According to Garrison and Akyol (2013) in Junus et al. (2019), the metacognition construct was built to understand the role of students in the learning process, both as individuals and as group members. In Junus et al. (2019), the metacognition questionnaire can measure the metacognition of the experimental class using cognitive approaches in the asynchronous discussion process with significant results.

   b. Experiment; the experimental group will learn with a pedagogical agent (the MeMo Tutor) and control groups will learn without pedagogical agents.

   c. Post-test; the experimental group and the control group will be given a post-test using the same instrument in the pre-test.

3) In the qualitative phase, there will be an in-depth survey of the experimental group regarding user experience (Santoso et al., 2016) when studying with a pedagogical agent (the MeMo Tutor).

4) The next stage is analyzing and comparing the results of measurements from the experimental group and the control group.

However, the stages of the method above are still in the form of plans and have not been implemented. Overall the research schedule is illustrated in Figure 1.
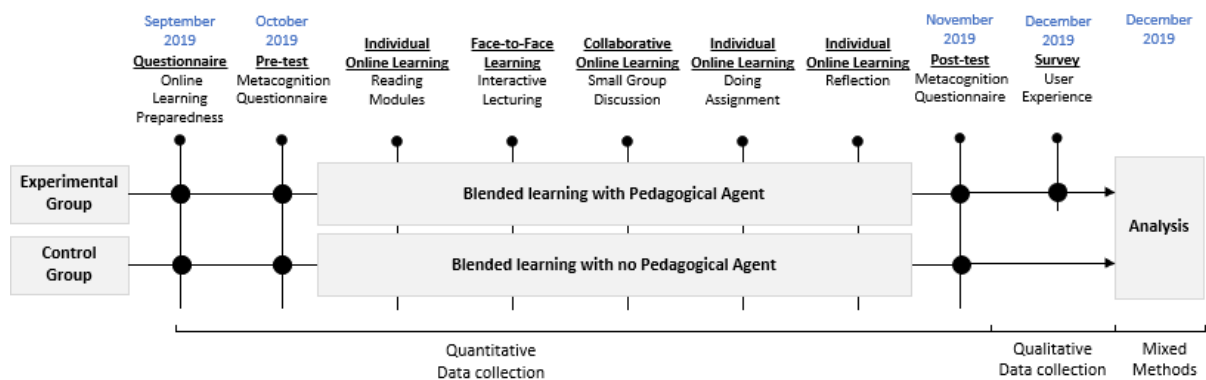
Figure 1. Research Plan.

Based on the research plan above, implementation will be carried out on the topic of linear algebra in blended-learning. In the experimental group, blended-learning activities (individual online learning, collaborative online learning and face-to-face learning) will be carried out with a pedagogical

agent. While in the control group, blended learning activities will be carried out with no pedagogical agents.

4. Proposed Pedagogical Agent

The design of the proposed pedagogical agent is discussed in six subsections, i.e. learning environment, character design, stages of work, overview of the system, system features, and learning scenario.

4.1 Learning Environment

The learning environment from the perspective of a teacher (Bates, 2016) is used to describe the learning environment in which the pedagogical agent implemented. The learning environment in this study consists of six components, i.e., learner characteristics, content, skills, learner support, learning resources, and learning assessment. The complete learning environment is illustrated in Figure 2.

The learning environment described in this paper is a learning environment that is commonly used in pedagogical agent research. To compare our study and previous research, we limit the citation of the learning environment to pedagogical agent research that focuses on the use of metacognitive and motivation scaffolding. The development carried out in this study is illustrated by a blue dashed line.
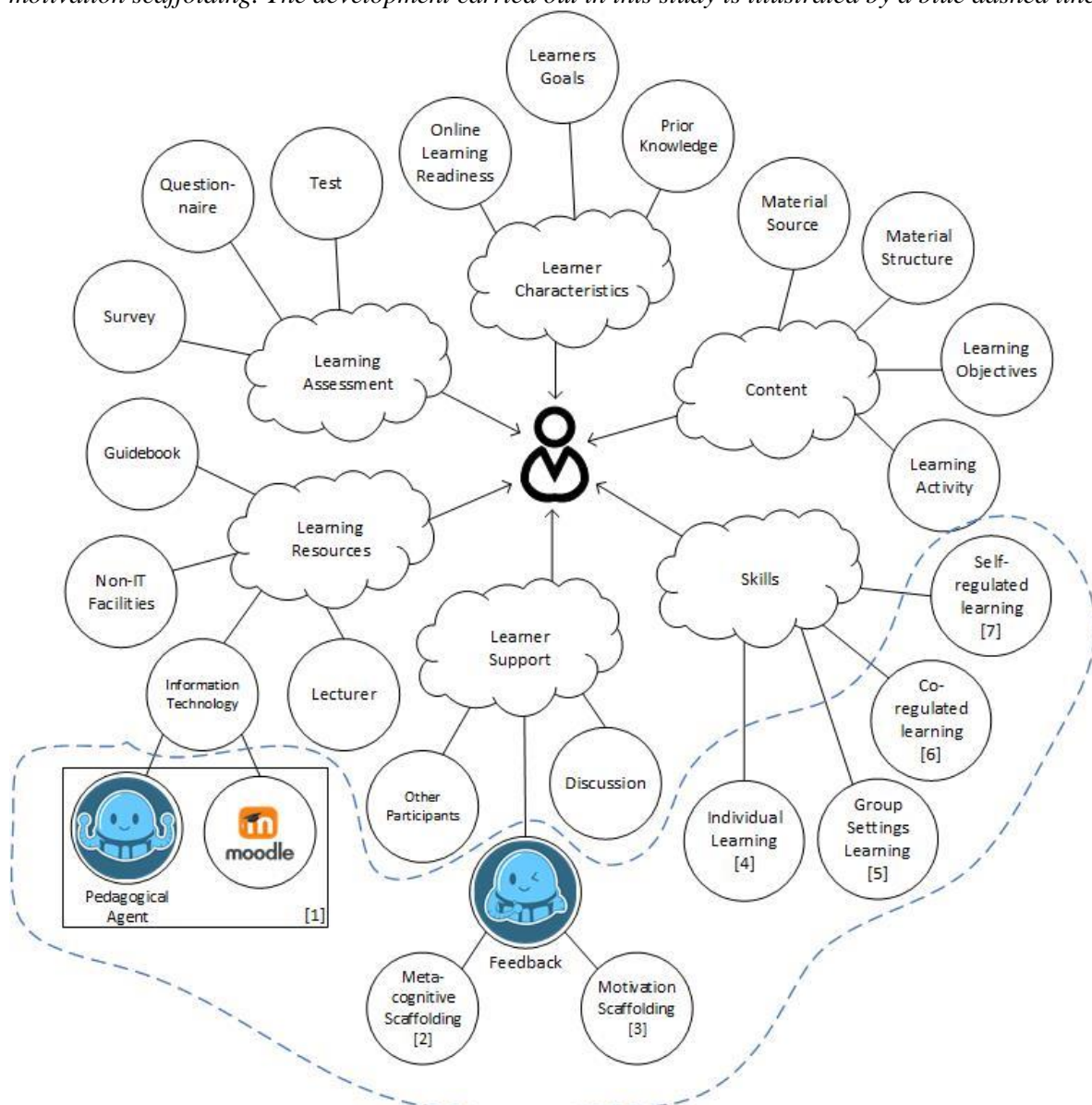
Figure 2. Learning Environment.

584

Previous studies in the learning environment according to the numbers in the Figure 2, as follows.

[1] The use of Moodle as a tool for pedagogical agents in interacting with students has been done considerable. However, research that focuses on the use of metacognitive and motivation scaffolding is mostly done using standalone applications. The utilize of the open source Moodle platform makes it easy for teachers to make updates to course content, so students can directly learn material content with the latest version (Yilmaz et al., 2017 and Yilmaz & Yilmaz, 2019).

[2] The utilizes of metacognitive strategies in pedagogical agents is often done. This is rational with the statement of cognitive science researchers, that metacognition has an important role in the development of effectiveness, both in class and outside the classroom (Baylor & Kim, 2005; Biswas et al., 2009; Duffy & Azevedo, 2015; Harley et al., 2018; Leelawong & Biswas, 2008; Roscoe et al., 2013; Taub et al., 2014; Trevors et al., 2014; Yilmaz et al., 2017; and Yilmaz & Yilmaz, 2019).

[3] The presence of pedagogical agents with motivational scaffolding strategies can motivate students in the learning process (Arroyo et al., 2011 and van der Meij et al., 2015).

[4] The implementation of pedagogical agents in individual learning can identify the performance of each student, therefore student achievement can be analyzed more deeply (Arroyo et al., 2011; Baylor & Kim, 2005; Biswas et al., 2009; Duffy & Azevedo, 2015; Leelawong & Biswas, 2008; Roscoe et al., 2013; Taub et al., 2014; Trevors et al., 2014; van der Meij et al., 2015, and Yilmaz et al., 2017).

[5] The implementation of pedagogical agents in collaborative learning can describe student engagement in learning (Harley et al., 2018 and Yilmaz & Yilmaz, 2019).

[6] Co-regulated learning can diagnose how students are able to support one another in learning (Harley et al., 2018).

[7] Self-regulated learning can provide a comprehensive picture of how students are able to set and implement learning strategies (Biswas et al., 2009; Duffy & Azevedo, 2015; Leelawong & Biswas, 2008; Roscoe et al., 2013; Taub et al., 2014; Trevors et al., 2014; and Yilmaz et al., 2017).

In this study, we integrate the pedagogical agent with Moodle to facilitate learning in higher education. The Pedagogical agent provide feedback to students by using the integration of metacognitive and motivation scaffolding. Pedagogical agent implementation will be carried out in individual learning and group settings. The use of pedagogical agent during the blended-learning process is expected to enhance students' self-regulated learning and co-regulated learning.

4.2 Character Design

The MeMo Tutor is an acronym for Metacognitive and Motivation Tutor. The first idea when modeling the character of the MeMo Tutor is to create static cartoon characters. The cartoon character taken is a form of a robot (non-humanoid), as shown in Figure 3. The non-humanoid characters was chosen to avoid bias from gender use which might affect interaction with students.

Figure 3. The MeMo Tutor.

The MeMo Tutor is intended as a pedagogical agent that helps students to study online in higher education. Therefore, the character of the MeMo Tutor is described by a simple figure with an uncomplicated face so that learning activities become more enjoyable. The smile on the MeMo Tutor's face indicates that this character is friendly and warm. While the two hands raised up to characterize the

spirit. Overall, the default character of the MeMo Tutor means a friendly and warm character that gives spirit in learning activities.

Some gestures are added to the characters used when giving explanations or feedback. The gesture consists of talking/explaining, thinking, learning, good work, sad, and surprise. The six gestures are illustrated in Table 1.

Table 1

The MeMo Tutor Gesture

Gesture	Image	Description	Example
Talking/ explaining		Shown in: • Planning (metacognitive scaffolding)	Guide students in preparing for learning or assignments, such as identifying assignments, distribution of tasks in groups, etc.
		• Establish task value (motivation scaffolding)	Encourage students to choose to do their most preferred assignments first.
		• Evaluation (metacognitive scaffolding)	Helping students correct mistakes.
Thinking		Shown in: • Monitoring (metacognitive scaffolding)	Provide support when students study the material, comment on the activities of each group member in the discussion, etc.
Learning		Same with talking/explaining gesture.	
Good work		Shown in: • Promoting mastery goals (motivation scaffolding)	Give feedback, give appreciation, etc.
		• Promote emotional regulation (motivation scaffolding)	Provide emotional support when working on a difficult task, helping students know the causes of failure and how to overcome them.
Sad		Shown in: • Evaluation (metacognitive scaffolding)	Point out failure when completing a task.
Surprise		Shown in: • Reflection (metacognitive scaffolding)	Provide performance feedback, provide suggestions or criticisms, etc.
		• Promoting autonomy (motivation scaffolding)	Provide information on student learning goals.

4.3 Stages of Work

The pedagogical agent built using an integration of metacognitive and motivation scaffolding in providing feedback. The pedagogical agent model in this study has several stages of work. Stage 1: Students begin interactions with the MeMo Tutor through Moodle LMS. Students need to choose topic to be studied. Stage 2: The MeMo Tutor identifies student profiles and presents learning statistics about selected topics to students. Stage 3: The MeMo Tutor provides material reviews on selected topics (containing questions and answers between agents and students to improve student understanding).

Stage 4: Next the MeMo Tutor provides quizzes/assignments (containing questions that need to answer by students). Stage 5: The MeMo Tutor provides the results of the evaluation of the learning performance that has been carried out by students.

4.4 System Overview

The Pedagogical agent in this study has a role as scaffolding who will provide questions and answers, evaluations, and feedback. The pedagogical agent will be integrated into the conversation interface in the Learning Management System Moodle version 3.3+. The language used is Bahasa Indonesia, according to the language used by students in this research experiment. This is important, to ensure students to feel comfortable when interacting with pedagogical agents during the learning process.

We use the Dialogflow API (Gelfenbeyn, 2010) as an NLP API tool in building conversation interfaces. This is because building NLP components from the start is very complex and will take time. By using Dialogflow API, we can focus more on the main objectives of the development of the pedagogical agent than the NLP design.

Overview of the system architecture shown in Figure. 4 shows the process of how the pedagogical agent works through web platforms. The proposed system allows students to interact with the pedagogical agent on material topics to be studied in a session. This system works by utilizing Node.js so that the Moodle database and the MeMo Tutor database can communicate. In addition, Node.js is also used to make feedback queries with a combination of metacognitive scaffolding strategies and motivation scaffolding (this integration of the scaffolding is not discussed in this paper). The use of Node.js was also conducted to monitor student activities, as well as identify student profiles.
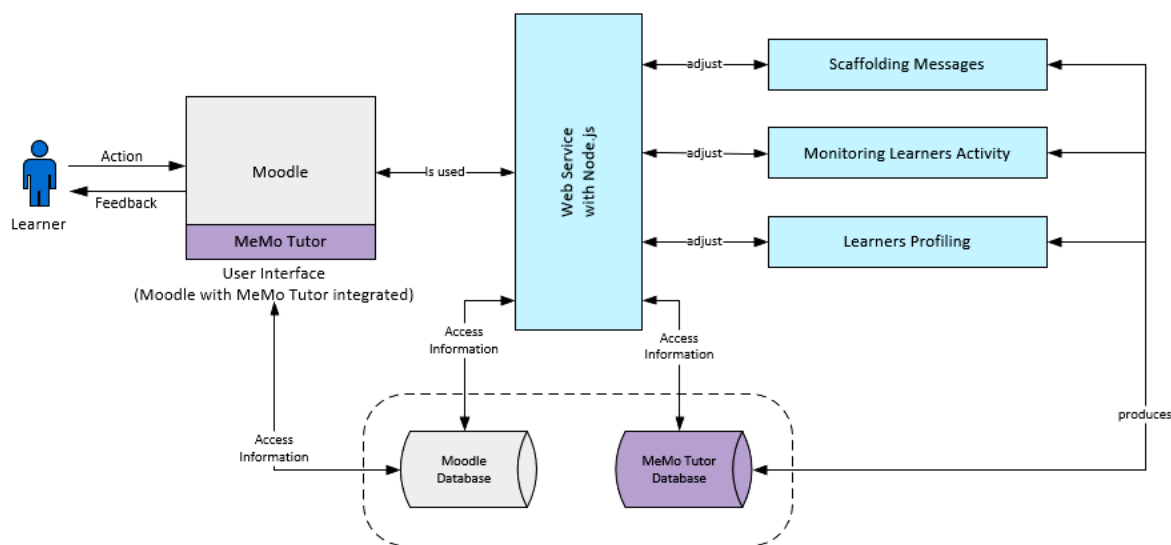
Figure 4. An Overview of Proposed Architecture Systems.

4.5 System Features

The MeMo Tutor is a pedagogical agent that functions as a learning tool used on the Moodle platform. The MeMo Tutor facilitates students to study online in individual and in group settings. This pedagogical agent consists of two main modes: Individual Mode and Group Setting Mode.

Previous research on pedagogical agents using metacognitive scaffolding and motivation scaffolding, was carried out only on individual or collaborative learning. From the results of the previous studies, pedagogical agents can significantly improve students' self-efficacy (Baylor & Kim, 2005; van der Meij et al., 2015), showing better self-regulated behavior (Biswas et al., 2009; Duffy & Azevedo, 2015; Leelawong & Biswas, 2008; Roscoe et al., 2013; Taub et al., 2014; Trevors et al., 2014; Yilmaz et al., 2017), increasing affective outcomes especially for female students who are more often frustrated and lacking confidence when solving math problems (Arroyo et al., 2011), and increasing engagement in groups (Harley et al., 2018; Yilmaz & Yilmaz, 2019).

In contrast to previous studies, in this study pedagogical agents will be used in individual learning and collaborative learning with group settings. This is in accordance with the objectives of this study, i.e. improving self-regulated learning (individual mode) and co-regulated learning (group setting mode) of students.

In individual mode, the proposed pedagogical agent helps students when reading modules, doing exercises or assignments, and provides reflections on student performance. In group setting mode, the proposed pedagogical agent acts as an adviser in the discussion of the topic given. The discussion contains an understanding of the material and assignments that must be completed by a group of 3-4 students. The system will store student log data, student action/answer data, and discussion data. These data are expected to provide information about the level of student engangement in the learning process.

Based on these system features, we proposed four hypotheses that fit the research objectives, as follows:

Hypothesis 1: an experimental group that conducts learning with a pedagogical agent, understands the material better than the control group.

Hypothesis 2: the experimental group that did learning with pedagogical agents, had a higher score on the test compared to the control group.

Hypothesis 3: the experimental group that did learning with pedagogical agents, had better discussion skills compared to the control group.

Hypothesis 4: Overall, based on log data and discussion data, the experimental group provided better engagement than the control group.

4.6 Learning Scenario

Pedagogical agents will be implemented on a topic in a linear algebra course. The learning scenario of the topic is illustrated in Table 2 below.

Table 2

Learning Scenario

Course	Linier Algebra
Topic	Linear Dependency, Basis, and Dimensions
Goal	1. If given vector space, students can construct subspaces, and determine whether a subset with certain requirements is subspace. 2. If given set vectors in a vector space, students are able to determine the linear dependency relationship between vectors. 3. If given a finite vector space and set of vectors, students are able to construct vector bases and determine their dimensions.
Roles	1. Support staff: Lecturer, Assistant. 2. Learner
Learning resources	Presentations files, lecture notes, textbook.
Type of learning setting	Lecture, exercise, and self-learning.
Teaching-learning environment	Blended-learning: Face-to-face, individual online learning, and collaborative online learning.
Technology-based platform	LMS Moodle, pedagogical agent.
Learning activities	Reading modules, interactive lecturing, small group discussion, doing assignment, and reflection.
Individual work	Reading modules, doing assignment, and reflection.
Collaboration	Small group discussion.
Assessment	Test and Discussion.

5. Conclusion and Future Works

In this paper, we propose a design of a pedagogical agent, called the MeMo Tutor, utilized in a blended-learning environment for a higher education context. The MeMo Tutor facilitate students in learning a subject by applying an integration of metacognitive and motivation scaffolding. The proposed pedagogical agent uses conversation interfaces as a communitcation tool. The language chosen for communication is Bahasa Indonesia, the national language of Indonesia.

The MeMo Tutor scaffolds students in designed phases tailored to the abilities of students. This pedagogical agent help students to expand their knowledge and apply it in the new context to promote student engagement and motivate them to learn online.

Prior the completion of the development of the agent, the effectiveness of the agent in promoting online learning will be conducted. The domain selected for the quasi experiment of a Linear Algebra course, since this course has been offered in a blended-learning approach for more than ten years and the instructors have long teaching experience. The course consists of eight topics. The study will evaluate the implementation of the agent on each topic and evaluate the results.

References

Arroyo, I., Woolf, B. P., Cooper, D. G., Burleson, W., & Muldner, K. (2011). The impact of animated pedagogical agents on girls' and boys' emotions, attitudes, behaviors and learning. In *IEEE 11th International Conference on Advanced Learning Technologies (ICALT)* (pp. 506-510). Athens, GA: IEEE.

Bates, A. W. (2016). *Teaching in a Digital Age: Guidelines for Designing Teaching and Learning.* Vancouver BC: Tony Bates Associates Ltd.

Baylor, A. L, & Kim, Y. (2005). Simulating instructional roles through pedagogical agents. *International Journal of Artificial Intelligence in Education, 15*(2), 95-115.

Biswas, G., Roscoe, R., Jeong, H., & Sulcer, B. (2009). Promoting self-regulated learning skills in agent-based learning environments. In *Proceedings of the 17th International Conference on Computers in Education (ICCE)* (pp. 67-74). Hong Kong: Asia-Pacific Society for Computers in Education.

Carlson, R., Keiser, V., Matsuda, N., Koedinger, K. R., & Rosé, C. P. (2012). Building a conversational SimStudent. Intelligent Tutoring System. In S. A. Cerri, W. J. Clancey, G. Papadourakis, & K. Panourgia (Eds), *Lecture Notes in Computer Science* (pp. 563-569). Crete, Greece: Springer.

Cook, C. (2017, Dec 14). *Avatars and instruction: How pedagogical agents can improve digital learning.* Retrieved from https://medium.com/inspired-ideas-prek-12/avatars-and-instruction-how-pedagogical-agents-can-improve-digital-learning-e7930f3b1e01. McGraw-Hill Education.

Creswell, J. W. (2014). *Research Design – Qualitative, Quantitative, and Mixed Method Approaches, fourth edition.* United States of America: SAGE Publications, Inc.

Duffy, M. C., & Azevedo, R. (2015). Motivation matters: Interaction between achievement goals and agent scaffolding for self-regulated learning within an intelligent tutoring system. *Computers in Human Behavior, 52,* 338-348.

Efklides, A. (2011). Interaction of metacognition with motivation and affect in self-regulated learning: The MASRL model. *Educational Pyschologist, 46*(1), 6-25.

Garrison, D. R., & Akyol, Z. (2015). Toward the development of a metacognition construct for communities of inquiry. *Internet and Higher Education, 24,* 66-71.

Gelfenbeyn, I. (2017, October 10). *Introducing Dialogflow, the new name for API.AI.* Retrieved from https://blog.dialogflow.com/post/apiai-new-name-dialogflow-new-features/.

Harley, J. M., Taub, M., Azevedo, R., & Bouchet, F. (2018). Let's set up some subgoals: Understanding human-pedagogical agent collaborations and their implications for learning and prompt and feedback. *IEEE Transaction on Learning Technologies, 11*(1), 54-66.

Hartnett, M. (2016). *Motivation in Online Education.* Singapore: Springer Nature.

Johnson, W. L., & Lester, J. C. (2018). Pedagogical agents: Back to the future. *AI Magazine, Summer 2018, 39*(2), 33-44.

Junus, K., Sadita, L., Santoso, H. B., Soradijono, S. H., & Suhartanto, H. (2017). Assessing students' e-learning competencies in online learning environment. In *International Conference on Advanced Computer Science and Information Systems (ICACSIS)* (pp. 489-493). Bali, Indonesia: IEEE.

Junus, K., Suhartanto, H., R-Suradijono, S. H., Santoso, H. B., & Sadita, L. (2019). The community on inquiry model training using the cognitive apprenticeship approach to improve students' learning strategy in the asynchronous discussion forum. *Journal of Educators Online, 16*(1), 70-86.

Leelawong, K., & Biswas, G. (2008). Designing learning by teaching agents: The Betty's Brain system. *International Journal of Artificial Intelligence and Education, 18*(3), 181-208.

Martha, A. S. D., & Santoso, H. B. (2018). Investigation of motivation theory on pedagogical agents design in the online learning environment. In *Proceedings of the 10th International Conference on Education Technology and Computers* (pp. 217-222). Tokyo, Japan: ACM.

Martha, A. S. D., & Santoso, H. B. (2019). The design and impact of the pedagogical agent: A systematic literature review. *Journal of Educators Online, 16*(1), 87-101.

McGee, P., & Reis, A. (2012). Blended course design: A synthesis of best practices. *Journal of Asynchronous Learning Networks, 16*(4), 7-22.

Olney, A. M., & Cade, W. L. (2013). Matching learner models to instructional strategies. *Design Recommendations for Intelligent Tutoring Systems – Volume 1: Learner Modeling,* 1. R. Sottilare, A. Graesser, X. Hu, and H. Holden, Ed. Orlando, Florida: U.S. Army Research Laboratory, 2013, 23-28.

Parkes, M., & Reading, C. (2013). The competencies required for effective performance in a university e-learning environment. *Australasian Journal of Educational Technology, 29*(6), 777-791.

Roscoe, R. D., Segedy, J. R., Sulcer, B., Jeong, H., & Biswas, G. (2013). Shallow strategy development in a teachable agent environment designed to support self-regulated learning. *Journal of Computers & Education, 62*(C), 286-297.

Santoso, H. B., Schrepp, M., Isal, R. Y. K., Utomo, A. Y., & Priyogi, B. (2016). Measuring user experience of the student-centered e-learning environment. *Journal of Educators Online, 13*(1), 58-79.

Schroeder, N. L., Adesope, O. O., & Gilbert, R. B. (2013). How effective are pedagogical agents for learning? A meta-analytic review. *Journal of Educational Computing Research, 49*(1), 1-39.

Taub, M., Azevedo, R., Bouchet, F., & Khosravifar, B. (2014). Can the use of cognitive and metacognitive self-regulated learning strategies be predicted by learners' levels of prior knowledge in hypermedia-learning environments? *Journal of Computers in Human Behavior, 39*(C), 356-367.

Trevors, G., Duffy, M., & Azevedo, R. (2014). Note-taking within MetaTutor: Interactions between an intelligent tutoring system and prior knowledge on note-taking and learning. *Educational Technology Research and Development, 62*(5), 507-528.

van der Meij, H., van der Meij, J., & Harmsen, R. (2015). Animated pedagogical agents effects on enhancing student motivation and learning in a science inquiry learning environment. *Education Technology Research Development, 63*(3), 381-403.

Venkatesh, V., Brown, S. A., & Bala, H. (2013). Bridging the qualitative-quantitative divide: Guidelines for conducting mixed methods research in information systems. *MIS Quarterly, 37*(1), 21-54.

Yilmaz, F. G. K., Olpak, Y. Z., & Yilmaz, R. (2017). The effect of the metacognitive support via pedagogical agent on self-regulation skills. *Journal of Educational Computing Research, 56*(2), 159-180.

Yilmaz, F. G. K., & Yilmaz, R. (2019). Impact of pedagogic agent-mediated metacognitive support towards increasing task and group awareness in CSCL. *Computers & Education, 134*, 1-14.

Incorporating Farming Feature into MEGA World for Improving Learning Motivation

Zhong-Xiu LU a, Maiga CHANG a*, Rita KUO b, & Vivekanandan KUMAR a

[a] *School of Computing and Information Systems, Athabasca University, Canada*

[b] *Department of Computer Science and Engineering, New Mexico Institute of Mining and Technology, USA*
*maiga.chang@gmail.com

Abstract: *Although educational games have been proved to be useful to get students motivated in doing learning activities, one of the most attractive game feature – farming – has rarely taken into consideration while designing and assessing an educational game. In this research, we design and develop the farming feature, also known as player versus environment (PvE) subsystem, for an educational game platform MEGA World (Multiplayer Educational Game for All). We discuss the operation workflow that the PvE subsystem communicates with MEGA World main system and design correspondent mechanic and required modules to assist students' learning. The subsystem has two game modes and the students can use the knowledge or skills they have learned in the course to fight with the monsters and earn the rewards. We expect this subsystem can improve students' learning motivation and performance. In order to verify our expectation, we design a semester-long experiment that involves four groups of undergraduate students.*

Keywords: Learning Performance, Learning Motivation, Educational Game, Gameplay, Player versus Environment

1. Introduction

Prensky and Berry (2001) claim that students or learners in 21st century have more different ways to learn than the students before. The students live in a media-rich environment where they can learn different knowledges from innovative and interactive ways such as games (Chang & Kinshuk, 2010). There are a lot of research have revealed that educational game is an effective way to improve student's learning performance and motivation. In 2018, Barr (2018) uses qualitative interview data to find the undergraduate students' attitude about using commercial video games to develop useful skills and competencies. Their research result shows that the students have in overall positive perception toward the use of video games to assist learning and believe the way can develop their communication skill. Furthermore, Wouters, Van Nimwegen, , Van Oostendorp and Van Der Spek (2013) find out that using digital game to assist learning activities can improve students' learning motivation and make them be more active on doing problem-oriented learning activities.

There are a lot of different types of games. Gros (2007) list seven game genres which are agreed broadly. These genres include (1) action game that is a kind of response-based games; (2) adventure game that allows players to progress though levels by solving problems in the virtual world; (3) fighting game in which players can fight against with non-player characters (NPCs) or other players; (4) role-playing game allows players to play a role of fictional character to explore the virtual world; (5) simulation game in which players have to achieve pre-specified goals though the game modelled after natural or man-made systems or phenomena; (6) sports game that is based on different kinds of sports; and (7) strategy game in which players adopt an appropriate strategy to achieve the goal in the recreate historical scenes or fictional scenarios.

In those game genres, role-playing game's educational potential has been proved and is worth to pay attention on it. Podjačevs and Skorobogatova (2017) indicate that using role-playing in learning is one of the most efficient methods to learn the foreign language. It not only can help leaning the

foreign language but also develop player's mental personality. The game-play in role-playing game is aligned with developing skills of decision-making, cooperation, problem-solving, and social interactions (Chang & Lin, 2014).

According to the evidence above, we can understand that using role-playing game to assist learning activities is an effective way to improve students learning performance and motivation. Therefore, this research chooses a role-playing game called MEGA World (Multiplayer Educational Game for All) as the research platform which developed by Chang and Kinshuk (2010). The goal of this research is to design and develop the player versus environment subsystem which provides farming feature for MEGA World and expect to find out how this feature affect student's learning performance and motivation.

The rest of the paper is organized as follows: Section 2 talks the educational game elements and the MEGA World this research is built on. Section 3 explains the workflow between the MEGA World and the PvE subsystem while Section 4 reveals the prototype of the PvE subsystem. An evaluation plan for verifying the two hypotheses this research has is described in Section 5. At the end, Section 6 briefly makes a summary and discusses the limitation.

2. Research Background

2.1 Educational Game

The educational game is the game which designed for educational purpose. The goal of educational game is helping players to understand certain subjects or practice certain professional skills. In 1996, Hogle indicates that there are four major advantages of using educational games which aim to assist learning activities.

The first advantage is that the curious because interactivity and the fantasy of game story in the game can enhance players' interest and learning motivation. The second one is improving memory retention; for instance, simulation games can have better effect on memory retention compared to the traditional learning activities. The third advantage is providing chances to practice and immediate feedback – that is, players can practice their professional skills repeatedly and receive the immediate feedback from the game; therefore, players can assess their learning outcomes and improve their skills or knowledge.

The last advantage is improving their higher order skills. The game design of educational game aligns with the cognitive structure of human beings. Players solve problems and make their own choices in the game repeatedly which means players need to integrate what they have learned to deal with the situation they encounter in the game. Therefore, the knowledge can repeatedly be remembered into players' memory.

2.2 Educational Game Elements

The advantages of educational game are mostly based on the engagement of players. Alexiou and Schippers (2018) identify three components of educational game which can engage players' cognition and emotion, including the game system (game rules and game mechanics), narrative (theme, story, characters) and aesthetics (audiovisual elements, fidelity, aesthetic choices). In order to fully use the advantages of educational game, a well-design and attractive educational game is required. Alexiou and Schippers (2018) also mentions there are four main elements which majorly determine the engagement of the player in designing the educational game, including goals, rewards, challenge, and feedback.

Locke, Shaw, Saari and Latham (1981) also present that the digital game use a series of objectives and quests to achieve the goals that become larger as the game progresses. The clear, specific, and challenging goals can enhance players' persistence and performance. After players achieve the goals, they can earn the rewards. McKernan and the research team (2015) claim the players' effort, progress and performance generally related to the reward systems. The unpredictable rewards can have more effects to players' engagement than steady and predictable rewards (Howard-Jones & Demetriou, 2009).

The third element is challenge. Csikszentmihalyi Mihaly and Csikszentmihalyi Isabella (1975) believe that if the given challenges are high but the players' skill level can still handle, the players will

feel extreme absorption, enjoyment and achievement. Therefore, the relationship between challenges and skill level also determines the players' engagement. During the gameplay, players use the knowledge learned to solve the problem. The feedback mechanism can help the players to learn from the mistakes as well as enhancing the engagement and maintaining the cognitive engagement (Beserra, Nussbaum, & Grass, 2017; Gresalfi & Barnes, 2016).

2.3 Multiplayer Educational Game for All

MEGA World[1] (Multiplayer Educational Game for All) is a web-based multiplayer role-playing educational game which designed and developed by Chang and Kinshuk (2010). They develop the system and used it to help students to assess their Java programming skills as Figure 1 shows.
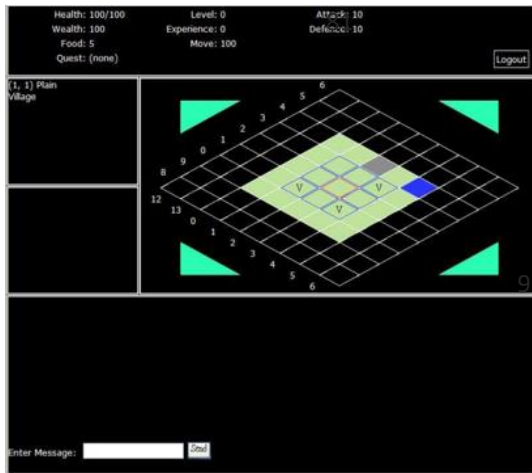
<table>
<tr><td>(a) Chessboard-like game world</td><td>(b) A Java programming quest</td></tr>
</table>

Figure 1. The original MEGA World (v1.0) in 2010.

Figure 2. MEGA World v2.1.

Teachers can design several learning activities from different learning objectives in the game, and the students can control their avatars to explore the chessboard-like game world and assess their professional skills or knowledge through complete those learning activities (Kuo, Chang, Kinshuk, &

---

[1] https://megaworld.game-server.ca/

Liu, 2010). Teachers use the learning materials to create different types of quests, including greeting, item collection, delivery, sorting, treasure hunting and digging, calculation, fill-in-the-blank, short answer, multiple choices, true/false, and speaking-based conversation (Chang, Chen, Wu, & Yu, 2019), and assign to particular Non-Playing Characters (NPCs). Students meet the NPCs to receive the quests and complete the quests to stealth assess their learning outcome as well as earning the game rewards.

However, almost none of educational games includes MEGA World taking the farming feature which is one of the attractive game features in role-playing games into the game design. Therefore, this research aims to design and develop the player versus environment (PvE) subsystem for the latest version of MEGA World which shows in Figure 2.

3. Workflow between MEGA World and PvE Subsystem

The PvE subsystem is an expanded module of MEGA World which is mainly based on PHP, JavaScript and AJAX (Asynchronous JavaScript And XML). During the development, we cannot modify the MEGA World main system except the necessary connection between two systems.

When a student moves his/her avatar around the game world, MEGA World sends the player's location information in a package in JSON (JavaScript Object Notation) format to the PvE subsystem. The data passed in JSON format can be interpreted and looked like Figure 3a. The PvE subsystem then checks the database to see whether there is any monsters at that location. If there are monsters at that location, there will be 40 percent chance for the student to encounter the monsters. If the PvE subsystem is triggered, the subsystem sends the monsters' information in a JSON-based data package (see Figure 3b) back to MEGA World.

```
⊟{
    "MapTypeName":"city",
    "MapID":"16",
    "X":"1",
    "Y":"1",
    "ProfessionID":"2",
    "ProfessionLevel":10,
    "AverageQuestLevel":10
}
```

```
⊟{
    "BattleType":"Normal",
    "Monsternumber":3,
    "Monster":⊟[
        ⊟{
            "Monsterid":"1",
            "MonsterName":"Slime",
            "MonsterRace":"Demon",
            "MonsterLV":2,
            "MonsterHP":12,
            "MonsterATK":4,
            "MonsterDEF":4,
            "MonsterDEX":4,
            "MonsterGold":44,
            "MonsterEXP":18,
            "ImageID":"1537867333",
            "ImageFileType":"png",
            "AttackType":⊟[
                ⊟{
                    "AttackTypeName":"magic_attack",
                    "CD":"2",
                    "FileType":"gif"
                }
            ]
        },
        ⊟{
            "Monsterid":"1",
            "MonsterName":"Slime",
```

(a) The "Find Monster" query   (b) The "Monster" found

Figure 3. JSON-based data package sent from/to between main game and the PvE subsystem.

In order to prevent the data package from the interception and modified by the end user or any hacker, the PvE subsystem will also send a CRC (Cyclic Redundancy Check) code together with monster information. The code is generated by encrypting the data package with public-key

cryptography. The subsystem will adopt SHA1 algorithm to get the hash code of the data package before apply public-key cryptography.

Once MEGA World receives the monster information and the CRC code, it will redirect student's browser to the PvE battlefield and forward the monster information, CRC code, student's information in JSON string and a hash value of the student's information got through SHA1 algorithm.

The PvE battlefield will decrypt the CRC code and get the hash value for the received monster information with SHA1 to compare two the two hash values to check whether or not the monster information has been modified by others. Also, the battlefield will do the same thing for the received player's information to check whether or not the player's information has been modified.

When the battle between the student and monster(s) is over, the PvE battlefield will send the battle result information once again in JSON format (see Figure 4) as well as a CRC code back to MEGA World. Similarly, the CRC code is generated based on the hash value of the data package with SHA1 algorithm and public-key cryptography.

```
{
  "PlayerID":412,
  "RemainHP":250,
  "RemainMana":50,
  "RewardGold":300,
  "RewardEXP":60,
  "Items":[
    {
      "item_guid":"2e08a600aa5a2cd7259a5c965287af43"
      ,
      "item_amount":1
    },
    {
      "item_guid":"41292110bad3ccl0d510400b41196a7f"
      ,
      "item_amount":1
    }
  ],
  "DropItems":[
    {
      "item_id":"201120001",
      "item_amount":1
    },
    {
      "item_id":"201120001",
      "item_amount":1
    }
  ]
}
```

Figure 4. JSON-based data package of the battle result sent from PvE subsystem.

4. Prototype of the PvE Subsystem

There are five areas in the gaming field as Figure 5a shows, including information area, display area, health bar, game play area and action area. The information area is on the top of the gaming field which shows the student's information include attacking power, defending power, and dexterity. The display area shows the background image and the monsters' image and information like monsters' name, health and cool down time for next attack as well as all the attacking animations. To help the student to identify his/her avatar's remaining health, there is a health bar below to the display area. The health bar decreases when the avatar is hit by monsters. The student will do the most of operations at the game play area, including choosing different attack types of attacks, answering assessment questions and using the items in his or her bag. The action area contains three different action options include attack, use item and escape.

There are two game modes in the PvE subsystem: regular fighting mode and assessment question mode. At the beginning of the game, the game play area shows the items the student has and he or she needs to choose three different types of armors to protect his or her avatar and three different levels of weapons to trigger the three different levels of attacks. After the student has chosen the equipment, the game starts.

In the normal fighting mode, game play area shows three attack options: easy attack, normal attack and hard attack, each one represents one weapon that the student just chose. There are damages and accuracy for an attack option and the higher attack level option will have lower accuracy. Figure 5b shows the prototype of the gaming field. The student can choose one of the monsters shown in the display area as the target by clicking on the image of the monster and then choose an attack option to trigger the attack. The display area will show the animation for the attack that the student chose if the attack is successful taken.
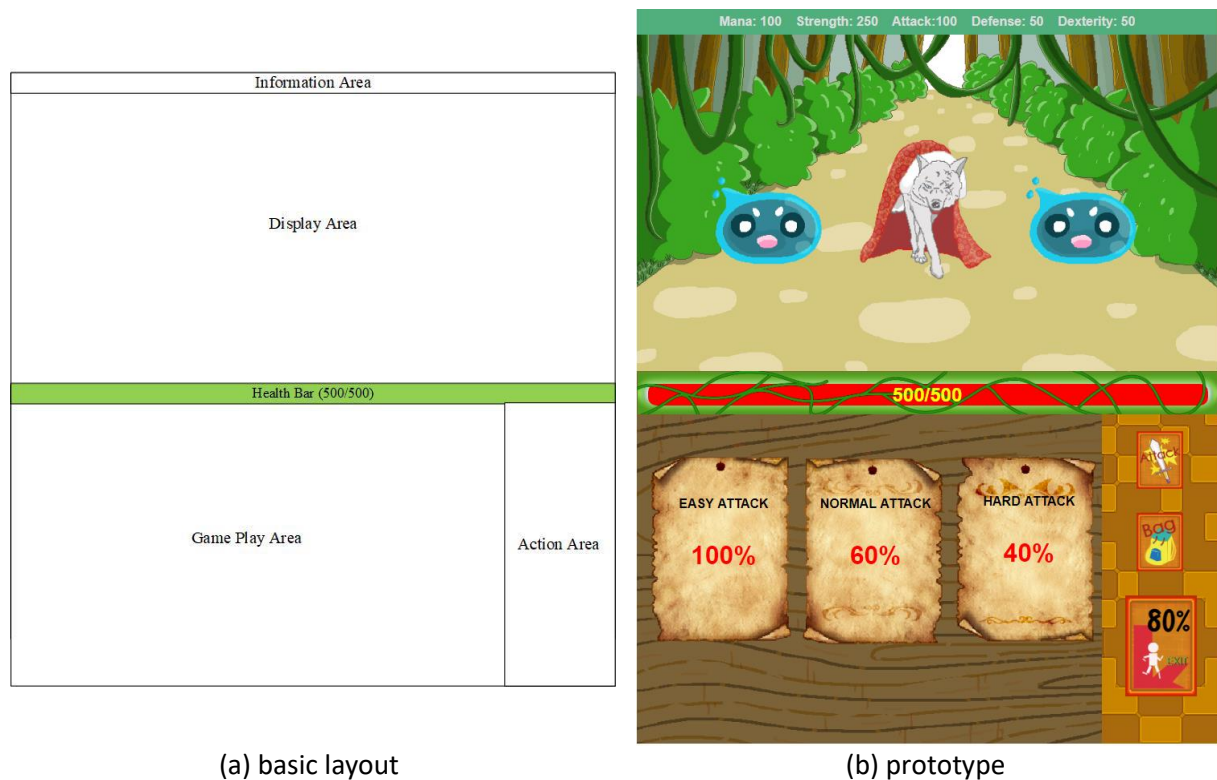
(a) basic layout   (b) prototype
Figure 5. The layout and prototype of gaming field in the regular fighting mode

On the other hand, the game play area also shows three different attack options in the assessment question mode. Figure 6 shows that the game play area has the assessment question whose difficulty is depending on the level of the attack option the student chose. The student needs to answer the question in a limited time correctly to trigger the attack, and the attack will absolutely hit the monster – which means 100% accuracy rate for correct answer in the assessment question mode.

The student can use an item in the bag before choosing the attack option by clicking the "use item" option in the action area to see all of the items he or she has in the game play area. After the student chooses the item he or she wants to use, he or she can go back to the attack options by clicking the "attack" option in the action area. If the student encounters the monsters that are too strong or the student wants to skip the fight, he or she can choose "escape" option in the action area that has the successful rate of escaping shown on it.

After the student choses to attack or escape (but the escape action is failed), the round ends and the cool down timers for attacking that the monsters have decrease. When a monster's cool down timer becomes zero, the monster attacks the student's avatar to cause damages and reset its cool down timer. The game ends when the student's health points become zero or all the monsters are defeated. The student can earn the award items, gold and experience points if he or she wins the battle. On the other hand, there will be gold deduction if the student loses the battle.

| (a) basic layout | (b) prototype |
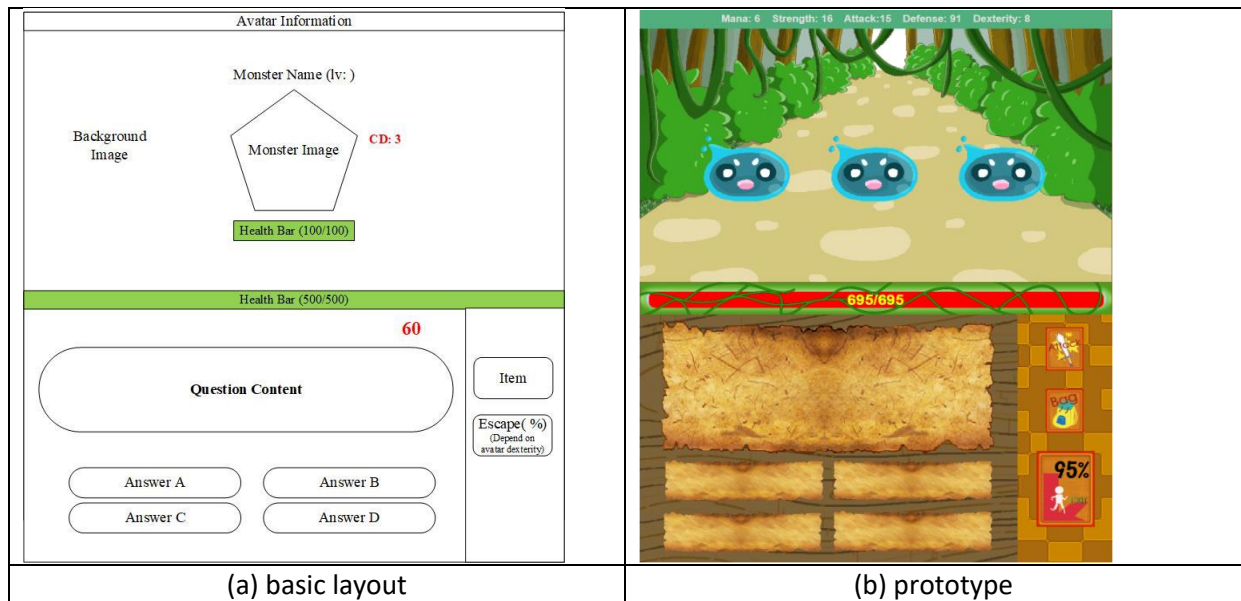
Figure 6. The layout and prototype of gaming field in the question assessment mode.

5. Evaluation Plan

In order to evaluate the effectiveness of the PvE subgame designed and developed in this research and verify the hypothesis "the farming feature in the educational role-playing game can enhance student's performance and motivation," this research plans to recruit undergraduate students who enroll Java programming course and separate them into four groups to conduct a full semester experiment. The first group is the control group which will not play any educational game; the second group will play MEGA World with the PvE subsystem that only uses the regular fighting mode; the third group will also play the game with the PvE subsystem that only uses the assessment question model; and the fourth group will play the game with the subsystem that uses both of the two game modes randomly.

At the beginning of the semester, the students will be asked to fill out a pre-questionnaire that is asking for their attitude in terms of playing games and their gaming experience as well as their learning motivation towards the course. During the semester, the students will need to play the game after the class to review the learning content each week. The course instructor will record the students' progress in the game, including their avatar's current level, experience points and gold at the end of each week. There will be several quizzes delivered to the students in the class from time to time in the semester and the instructor will also record their performances of every quiz, midterm exam and final exam.

At the end of the semester, the students will be asked to fill out a post-questionnaire that is asking their perceptions toward the use of educational game and their learning motivation towards the course. The research will use SPSS to verify the reliability and validity of the questionnaires and their collected data as well as use *t*-test to analyze and compare the collected data.

The expected results include the PvE subsystem that we design and develop can improve students' learning motivation and performance. Moreover the mixed of regular fighting and question assessment mode can have the significant differences in terms of making students have more learning motivations and better learning performance. The research team also expect to see both of the gaming experience and students' attitudes toward computer games won't make any difference.

6. Conclusion

There are many evidences show that using educational game to assist learning is an innovative and effective way to improve the students' learning performance and motivation. In this research, we propose an extend module of MEGA World called Player versus Environment (PvE) subsystem. This subsystem allows student to encounter and fight against with the monsters and earn the rewards by defeating the monsters. The student can use the knowledge he or she has learnt from the class to defeat the monsters. In order to evaluate the system's effectiveness and verify the research hypotheses, the research designs a semester-long experiment with four groups of students who enroll the undergraduate

level Java programming course. However, this research still has limitations. Since we expect to find out the relations between the PvE subsystem and students' learning motivation, we cannot force the students to play the game. The cooperation of the course instructor and the students are very crucial for this research.

References

Alexiou, A., & Schippers, M. C. (2018). Digital game elements, user experience and learning: A conceptual framework. *Education and Information Technologies*, *23*(6), 2545–2567. https://doi.org/10.1007/s10639-018-9730-6

Barr, M. (2018). Student attitudes to games-based skills development: Learning from video games in higher education. *Computers in Human Behavior*, *80*, 283–294. https://doi.org/10.1016/j.chb.2017.11.030

Beserra, V., Nussbaum, M., & Grass, A. (2017). Using a fine-grained multiple-choice response format in educational drill-and-practice video games. *Interactive Learning Environments*, *25*(6), 717–732. https://doi.org/10.1080/10494820.2016.1172244

Chang, M., Chen, C.-T., Wu, K.-H., & Yu, P.-S. (2019). Conversation Quest in MEGA World (Multiplayer Educational Game for All). In *the Proceedings of International Conference on Smart Learning Environments* (ICSLE 2019), Denton, TX, USA, March 18-20, 2019, 77-82.

Chang, M., & Kinshuk. (2010). *Web-based Multiplayer Online Role Playing Game (MORPG) for Assessing Students' Java Programming Knowledge and Skills*.

Chang, S.-M., & Lin, S. S. J. (2014). Team knowledge with motivation in a successful MMORPG game team: A case study. *Computers & Education*, *73*, 129–140.

Csikszentmihalyi, M., & Csikszentmihalyi, I. (1975). *Beyond boredom and anxiety* (Vol. 721). Jossey-Bass San Francisco.

Gresalfi, M. S., & Barnes, J. (2016). Designing feedback in an immersive videogame: supporting student mathematical engagement. *Educational Technology Research and Development*, *64*(1), 65–86.

Gros, B. (2007). Digital games in education: The design of games-based learning environments. *Journal of Research on Technology in Education*, *40*(1), 23–38.

Hogle, J. G. (1996). *Considering games as cognitive tools: In search of effective*.

Howard-Jones, P. A., & Demetriou, S. (2009). Uncertainty and engagement with learning games. *Instructional Science*, *37*(6), 519.

Kuo, R., Chang, M., Kinshuk, & Liu, E. Z.-F. (2010). Applying Multiplayer Online Game in Actionscript Programming Courses for Students Doing Self-Assessment. *In the Proceedings of Workshop on New Paradigms in Learning: Robotics, Playful Learning, and Digital Arts*, 351–355. Putrajaya, Malaysia.

Locke, E. A., Shaw, K. N., Saari, L. M., & Latham, G. P. (1981). Goal setting and task performance: 1969–1980. *Psychological Bulletin*, *90*(1), 125.

McKernan, B., Martey, R. M., Stromer-Galley, J., Kenski, K., Clegg, B. A., Folkestad, J. E., Rhodes, M. G., Shaw, A., Saulnier, E. T., Strzalkowski, T. (2015). We don't need no stinkin'badges: The impact of reward features and feeling rewarded in educational games. *Computers in Human Behavior*, *45*, 299–306.

Podjačevs, P., & Skorobogatova, O. (2017). Computer Role-Playing Games as One of the Most Efficient Methods of Teaching and Learning In Higher Education. *International Journal on Information Technologies and Security*, *9*, 65–78.

Prensky, M., & Berry, B. D. (2001). Do they really think differently? *On the Horizon*, *9*(6), 1–9.

Wouters, P., Van Nimwegen, C., Van Oostendorp, H., & Van Der Spek, E. D. (2013). A meta-analysis of the cognitive and motivational effects of serious games. *Journal of Educational Psychology*, *105*(2), 249.

Students' Conceptions of Interactive Spherical Video-based Virtual Reality Supported Chinese Writing Learning

Mengyuan CHEN*, Morris Siu-Yung JONG, Ching-Sing CHAI, & Xiaohua ZHOU
Department of Curriculum and Instruction
The Chinese University of Hong Kong
*chenmy@link.cuhk.edu.hk

Abstract: This qualitative study reports the results of a phenomenographic analysis of students' conceptions of Interactive Spherical Video-based Virtual Reality (ISVVR) supported Chinese writing. In the study, six Grade-9 students in Hong Kong participated in an ISVVR supported Chinese writing learning program. Data were collected through semi-structured interviews. Three qualitatively different themes related to ISVVR supported Chinese writing learning were revealed: 1) purpose of learning Chinese writing, 2) use of ISVVR to improve Chinese writing, and 3) motivation of using ISVVR to learn Chinese writing. Different conception categories of the themes form a hierarchy and show a trajectory that writing paradigm shifts from learner-oriented to author-oriented. This study offers an empirical reference for teachers and researchers to have a closer look at students' conceptions of Chinese writing and ISVVR supported Chinese writing.

Keywords: Interactive Spherical Video-based Virtual Reality (ISVVR); Chinese education; writing education; students' conceptions

1. Introduction

1.1 Background

Innovative technologies are changing the way people live and work, as well as the way of teaching and learning. Technology-enhanced learning (TEL) considers "the use of information communication and technology (ICT) in its widest sense to support and improve the learning experience" (Gordon, 2014). Spherical videos, also known as 360-degree videos, can provide an all-round view of places at the same time. Interactive spherical video-based virtual reality (ISVVR) may be a new educational tool to support the learning and teaching activities in which "students' observation" is an important pedagogic component (Geng, Chai, Jong & Luk, 2019).

Writing education is one possible area that may benefit from the ISVVR technology. According to the "Hong Kong diploma of secondary education (HKDSE) examiners' report", some students' writing performance was less satisfactory. Their compositions lacked detailed and varied descriptions, and they failed to convey sincere and delicate emotions (Hong Kong Examination and Assessment Authority, 2018). The report alluded that students may lack observation in daily life and they may lack understanding of people, communities, and society. Therefore, improvements of Chinese writing education by facilitating students' observation and understanding of people, communities, and society is needed.

Compared with traditional field trips, ISVVR is not constrained by time and space. It provides students with extended opportunities and perspectives for observing places and the people therein. Moreover, as a form of situated learning (Lave & Wenger, 1991), virtual reality can help students experience the places more deeply. By adjusting their viewing angles, students can explore and observe elements in the scene more closely, which can better stimulate their thoughts. Moreover, students can observe their communities more comprehensively with virtual reality, which can foster them to better understand the context of communities and make reflections on their life.

The purpose of this study was to explore students' conceptions of ISVVR supported Chinese writing learning. Six Grade-9 students who used the ISVVR to learn Chinese writing were interviewed.

1.2 ISVVR-supported Chinese Writing Learning Program

This study is a part of an ISVVR-supported Chinese writing project. In the project, junior high school students use ISVVR to learn how to write landscape literature in Chinese. Landscape in literature refers to the texts about a specific place that has been conferred special meaning by the writers. This is an established form of Chinese literature and it usually includes nostalgia with landscapes as a means to cherish memories.

ISVVR can provide students with the platform for viewing the landscapes so as to foster and sharpen their understanding of texts. Some landscapes highlighted in texts still exist but teachers might not conduct field trips or site visits for students due to limiting factors (i.e. lesson time and spatial distribution). Virtual reality can instead project the scenarios of the texts. Some landscapes mentioned in texts have disappeared with time. Virtual reality can reflect the historical progress contrasting today's development to provide a new reading experience for students. Figure 1 shows a landscape of Hong Kong in ISVVR.

In this project, there were five stages in the teaching process: learning basic knowledge, learning famous works of this landscape, observing the landscape with ISVVR, writing compositions on related topics, and evaluation and feedback. The teaching cycle lasted for three weeks.

Figure 1. Views of ISVVR

2. Method

2.1 Participants

A total of six students from a junior high school in the ISVVR-supported Chinese writing project were interviewed. There are three girls and three boys. By maximizing the variation among the participants, it is expected that the range of meanings derived from this study could be representative of the range of meanings within the target population (Åkerlind, 2005). All the participants were assigned the letter "S" and a number (e.g., "S1"), allowing their identity to remain anonymous when reporting the results.

2.2 Data Collection

Data were collected through semi-structured interviews. In other words, a list of predetermined open questions that focused on the students' ideas and experiences about ISVVR-supported Chinese writing learning was used to prompt students' reflection on Chinese writing learning. Some examples of the guiding questions used to probe the students' ideas about Chinese writing with ISVVR are as follows:
1. Do you enjoy Chinese writing? If yes, in which aspects do you enjoy Chinese wiring?
2. Do you see Chinese writing as an important skill to develop?
3. How do you feel about using ISVVR to learn Chinese writing?
4. After this round of study, have you become more interested in learning Chinese writing?
Additionally, follow-up questions such as "Could you give me an example?" and "What do you mean by that?" were used to invite students to elaborate on their ideas. Students were interviewed in

Mandarin Chinese or Cantonese by a trained researcher. The interview time ranged from approximately 40 to 60 minutes. All the interviews were audio-recorded and transcribed word for word.

2.3 Data Analysis

The purpose of this study was to explore students' conceptions of ISVVR-supported Chinese writing learning and to find variations in their experience. To this end, the phenomenographic approach (Marton, 1981) was employed to analyze the student interview transcripts. The transcripts were analyzed iteratively. The data analysis process started with reading through the transcripts as a whole for several times to gain familiarity with the students' ideas. Next, the key meanings expressed in the transcripts were highlighted and marked with some keywords that best describe the students' views regarding Chinese writing and using the ISVVR to learn Chinese writing. The key meanings were then compared and contrasted to identify similarities and differences between them. Then, structural relationships that related or distinguished the key meanings were examined.

3. Results

3.1 Purpose of Learning Chinese Writing

Six different categories of students' conceptions of the purpose of learning Chinese writing were identified through the phenomenographic analysis, as follows and a sample of students' answer is given for each category:
1) Seek new information. In this category, Chinese writing was described as a means of knowing new things.
S6: I felt like I was getting a lot of information out of writing that I hadn't heard of before.
2) Express their feelings. In this category, Chinese writing was described as a way to express their feelings towards people, things and events.
S3: I write because I want to write about my feelings. For example, when I see a very new coffee shop in Sham Shui Po (an old block in Hong Kong), I am surprised because it doesn't fit in with the surrounding environment.
3) Write their own opinions. In this category, participating students emphasized writing down their own opinions and ideas which are different from others'.
S2: It can be written from our perspectives. Sometimes we may have different opinions on some things, such as our feelings, angles, and moods.
4) Influence what other people think. In this category, participating students considered Chinese writing as an opportunity to influence others.
S2: By writing, we can let people know what we think, and what we think can influence what they think.
5) Enjoy a sense of accomplishment. In this category, participating students thought completing a Chinese composition would bring them a sense of achievement.
S5: I think when I put my heart into writing and finish the process, I will feel satisfied.
Have a joy of creation. In this category, participating students used their imagination when they were writing Chinese composition, and viewed this as a creative process.
S4: Actually, I prefer to write. I think we can enjoy the process of writing. It's like creating something.

3.2 Use of ISVVR in Improving Chinese Writing

Six different categories of students' conceptions of the using ISVVR to learn Chinese writing were identified through the phenomenographic analysis. These six categories form a hierarchy, from the surface to sophisticated. The participating students thought through ISVVR, they can :
1) Have more time to observe the landscape, community, and people in the ISVVR.
S2: Usually, we don't look at things very carefully. It's just like giving a hurried and cursory glance. If we use VR in class, we will look at things more carefully.
2) Accumulate more writing materials, and then to rich the composition's content.

S4: Just like him, I have written down what I saw in the VR. From the VR film, I can see the night in Sham Shui Po. It's really busy.

3) Use more descriptive techniques and multi-angle description.

S1: I think with VR, I can have more things to write, and then I can use more descriptive techniques, and I can write from different angles.

4) Write more details, so their writing is more concrete and vivid.

S3: When I used to describe a place which has a lot of people, I would write "there are a lot of people". I would not describe the faces nor action manner of those people in detail. VR let me see more details, so now I write as "people jostle each other in a crowd and they are shoulder to shoulder".

5) Obtain new perspectives. They thought ISVVR provide views and perspectives which are different from what they used to see.

S5: Usually, I don't pay special attention to the places, but when I use VR, I see that the place is different from what I thought.

6) Get inspiration. In this category, students had a deeper understanding of the landscape through teachers' explanation of histories and views, so that they can get inspiration and find a theme to write.

S6: ...and there's a chain restaurant, and this is the segment that impressed me most because it reflects the changes of times, and some things are replaced, and this is the feeling it brings to me.

3.3 The Motivation of Using ISVVR to Learn Chinese Writing

Six different categories of students' motivation to using ISVVR to learn Chinese writing were identified through the phenomenographic analysis. These six categories form a hierarchy, from surface to sophisticated:

1) Students won't become interested in Chinese writing only because of the use of ISVVR.

S1: In fact, I would not become interested in Chinese writing because of the study of this unit or the use of VR.

2) Parents' pressure and teachers' encouragement. In this category, students' motivation for Chinese writing is external.

S2: There is also pressure from my parents. If I fail in writing, my parents will confiscate a lot of things from me, so I will try my best to improve my performance.

3) Have a feeling of freshness. In this category, participant students enjoyed using ISVVR to learn Chinese writing because they like to try something new.

S5: VR is such a high-tech thing that I don't get much exposure to, and then the process is like playing, and I can see a lot of new things.

4) The class is more active and engaging. Participating students felt the ISVVR class was more interesting compared with a traditional writing class.

S3: It's just that I don't have to listen to the teacher all the time and the class is more interesting.

5) Observe in a comfort zone. In this category, participating students considered it's a comfortable way to observe the landscape compared with the traditional field observation.

S4: I can observe in a comfortable environment without embarrassment or inconvenience.

6) More confidence leads to more motivation. In this category, participant students showed their interest in learning Chines writing by ISVVR because they got higher scores in the writing examination, and they felt more confident about Chinese writing.

S3: This time, my score is higher, and my composition can be better, so I want to continue using VR.

4. Conclusion

We have reported the students' conceptions of ISVVR supported Chinese writing learning unfolded from our study. Three different themes were revealed: 1) purpose of learning Chinese writing, 2) use of ISVVR in improving Chinese writing, and 3) motivation of using ISVVR to learn Chinese writing. We also find that different conception categories of these themes form hierarchies and show a trajectory moving from learner-oriented to author-oriented conceptions. Students' conception reflects how they learn Chinese writing and how they see themselves as a writer. Hounsell (1987) suggested that students and teachers must share an understanding of the assumptions underlying the advice given before it can be effective. This study offers a reference for teachers and researchers to have a closer look at students'

conceptions of Chinese writing and ISVVR supported Chinese writing. In the future, we will further study how teachers reflect on the pedagogy design based on students' conceptions of ISVVR supported Chinese writing.

Acknowledgments

References

Åkerlind, G. S. (2005). Academic growth and development - how do university academics experience it? *Higher Education, 50,* 1-32. http://doi.org/10.108003075070601099416.

Geng, J., Chai, C. S., Jong, M. S. Y., & Luk, E. T. H. (2019). Understanding the pedagogical potential of Interactive Spherical Video-based Virtual Reality from the teachers' perspective through the ACE framework. *Interactive Learning Environments*, 1-16.

Gordon, N. (2014). *Flexible Pedagogies: technology-enhanced learning.* The Higher Education Academy, UK.

Hong Kong Examination and Assessment Authority (2018). *Hong Kong diploma of secondary education (HKDSE) examiners' report.* Received August 10, 2019, from: http://www.hkeaa.edu.hk/tc/HKDSE/assessment/subject_information/category_a_subjects/chi_lang/or/bs2 018.html

Hounsell, D. (1987). Essay writing and the quality of feedback. *Student learning: Research in education and cognitive psychology*, 109-119.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* Cambridge university press.

Marton, F. (1981). Phenomenography - describing conceptions of the world around us. *Instructional Science, 10,* 177-200. http://doi.org/10.1007/BF00132516. Received August 10, 2019, from: https://www.heacademy.ac.uk/system/files/resources/tel_report_0.pdf

Development of Augmented Reality-Based Learning Package for Learning Network Topology via STAD Process

Totsaporn NAKA[a] and Nadh DITCHAROEN[b*]
[a]Major in Science Education (Computer), Faculty of Science, Ubon Ratchathani University, Thailand
[b]Department of Mathematics, Statistics and Computer, Faculty of Science,
Ubon Ratchathani University, Thailand
*nadh.d@ubu.ac.th

Abstract: The aims of this study were 1) to develop the learning package for learning network topology by using augmented reality (AR) technology, 2) to investigate students' learning achievement on network topology through the AR-based learning package in conjunction with student team achievement division (STAD) learning process, and 3) to investigate students' satisfaction toward the AR-based learning package with STAD. The participants were 27 grade 10 students. They were divided into three groups: low-achieving group, medium-achieving group and high-achieving group. The experimental instruments consisted of AR application and concrete manipulative board kit. The pre-achievement test, post-achievement test, and satisfaction questionnaires were used for collecting both quantitative and qualitative data. The results revealed that the learning activity was effective for enhancing students' understanding in basic devices of network and topology. After students conducted the activities, we found that the average of posttest score was statistically higher than that of the pretest. The average of students' progress in class was 64.84 percent. In addition, students were satisfied toward this learning activity at the high level.

Keywords: learning package, augmented reality, computer network, topology, concrete manipulative

1. Introduction

Network topology is the shape or design structure of a network representing device nodes and cables. The topology also means how to transfer or exchange information between computers within the network. The secondary schools in Thailand require students to learn the basic of computer network systems such as format of network connection (network topology) and devices used in the network system. However, the network topology is difficult to understand in terms of information exchange between networks. Therefore, teaching topology can be challenging for many teachers to manage learning activity for learners.

However, in real practicing environment of teaching network topology for high school, teachers face many problems in which the most notable one is lack of up-to-date instructional media. Regarding teacher cannot procure genuine equipment to support learning managing due to some devices have high cost and the school has no enough budget for purchasing. The restrictive educational resources including lacking the laboratory room or authentic computer network devices could cause insufficient delivery knowledge and affect students' learning significantly (Chumpagul, 2017). The traditional teaching methods in teaching network topology need to go back to study by looking example 2D pictures in the textbook and the media is often used in learning of topology network such as using of Microsoft PowerPoint but these technologies only put student as a passive element in the learning process (Irwansyah et al., 2018). Moreover, in managing learning activity as a teacher-centered who is a lecturer and students are responsible for receiving information from teachers. From a psychological perspective, the traditional teacher-centered learning activity also

often perceived as monotonous and boring, which may reduce the motivation and attachment of students to the learning activity and the student learning outcomes (Faisal, 2017).

To solve the lack of instruction media in high school, teaching topology network which lead to lecturer-centered traditional pedagogical that make student unable to get real understanding in knowledge, using educational technology and learning activity design may encourage students to learn and attend in lesson. The creating of learning package would redress many of the educational deficiencies in the way to increase students' understanding by providing the instructional technology and appropriate learning methodology (Oates & Russell, 1998).

Currently, many educational organization use the benefits of technology in classroom. These trends are making headlines in education because the ways they impacted student learning. Educational technology has been succeeding for making collaborative and interactive learning. Augmented reality (AR) –a technology that merge 3D virtual objects on real-world through digital camera, webcam or smart device which display at real time, has been the most transformative educational technology that enhance teacher instruction while simultaneously creating immersive fun and engaging lessons. Moreover, AR can also "enhance learning motivation", "help students to easily understand contents", "enhance positive attitude", "enhance learning satisfaction", and "assist students in constructing students' knowledge in a natural science course" (Karaçöp, 2016; Wu et al., 2019). In several educational fields, using AR-based learning to support learning management was helpful and appropriate; it was used to help manage learning activity which was more effective at teaching media compared to other media such as books or videos (Iilian, 2012).

In recent years, the cooperative learning is one kind of student-centered approach for managing learning activity considered to increase successfulness of students. Student Team Achievement Divisions (STAD) is one of the cooperative learning approach widely used in 21st century education in which students will be divided into small groups with the different of learning achievement level. The key factors to success of STAD are students working together, and students who have higher level helping members in their group to reach the shared learning goals, where the teacher presents the lessons and the group works together and make sure that all members understand the topic (Pandiangan, 2019). In addition, many studies of learning management based on STAD learning approach indicated that using STAD in managing learning activity was able to help students in collaborative learning such as learning together, sharing idea, communicating inner team, and helping each other. It was able in improving students learning achievement and developing students' knowledge.

In order to overcome the lack of instructional media and to present an alternative learning network topology method, we propose an AR-based learning package for learning computer network topology via STAD method to encourage effective instruction and promote collaborative skills of learner accorded learning in 21st century education. While using AR technology to stimulate student's learning motivation, simultaneously, this learning package uses the manipulative tool to assist in deepening student's understanding of concepts in technology and in increasing student's achieving. The concrete manipulative was proved to be helpful for enhancing students to engage natural interaction in the physical world (Jamhari, 2016). There are three objectives in this study including (1) to develop an AR-based learning package for learning network topology, (2) to investigate students' learning achievement regarding network topology using the AR-based learning package, and (3) to investigate students' satisfaction toward the AR-based learning package.

2. Methodology

This research contributes based on quantitative research: one group pretest-posttest design. The flowchart of this study is shown in Figure 1. Before intervention, students begin with taking the pretest on the learning management system called STADLMS (detail in section 2.4). Students are divided into small group with different levels of pretest score, then they are assigned into 4 or 5 member learning group which each groups consist of students with different levels of pre-test score. Whereas, the learning activity, students will be taught by using AR-based learning package according to STAD process. After conducting learning activity, students will be receiving the individual posttest to investigate post-understanding in network topology concept. Moreover, students will be given the questionnaire to assess satisfaction toward the learning by using AR-based learning package.
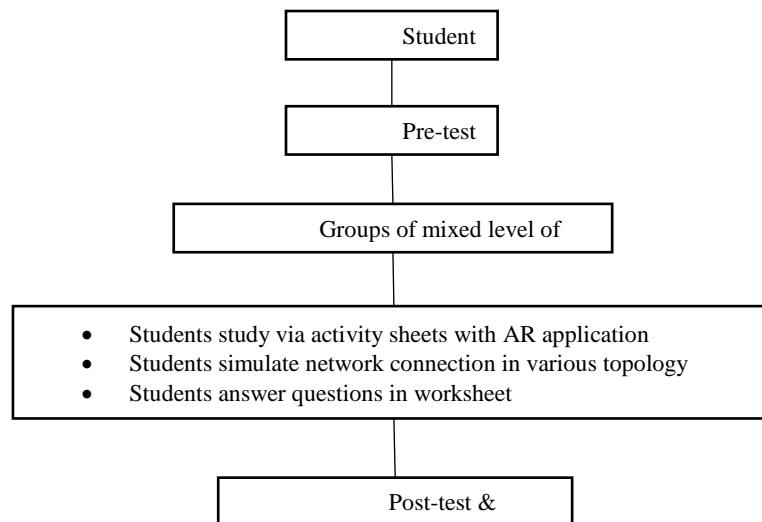
Figure 1. The research flowchart of this study

2.1 Participants

The participants of this research were 10th grade students in the high school at Ubon Ratchathani, Thailand. They were 27 students studying on science classroom program in the first semester of academic year 2019. The experiment was conducted at Ubon Ratchathani University, Ubon Ratchathani, Thailand.

2.2 Development of AR-based Learning Package for Learning Network Topology

Since the AR-based learning package was designed for 10th grade students which was based on the occupations and technology standard curriculum of Thailand core curriculum, there were two main parts of contents consisting of learning basic devices that used in network connection, and learning network topology. The learning package included AR application running on Android and the designed concrete manipulative board. We designed the AR-based learning package according to the pedagogical theory of John Dewey's philosophy –learning by doing, students are able to observe new knowledge or various contents by themselves through real or virtual environment (Krupatom, 2019).

2.2.1 Concrete Manipulative Board Kit for Learning Topology

A concrete manipulative is defined as an object that can be handled and moved. The concrete manipulative board kit was designed and developed to assist students in translating abstract concepts into concrete, practical concepts. This kit was aimed to enable students to deepen their understanding of concepts of the network connection. The kit was consisted of a quadrilateral board, rubber bands, AR markers, and pins, as shown in Figure 2. The quadrilateral board was used as a foundation, which was made from crate boxes. The rubber bands were used in place of the communication mediums. AR markers were used to connect pins and rubber bands, which simulated the network connection in various topology.
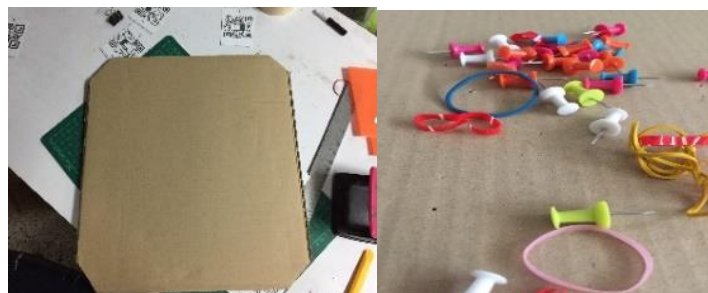
Figure 2. The concrete manipulative board kit

The AR application called 3D Topology was developed to run on an android device. It was developed by using Maya and Unity in form of 3D animations, which was divided into two main parts –devices learning and topology learning. Students can learn the basic network devices through 3D animation models in the device learning section while they are able to study the shape of topology connection and data transfer among nodes in each topology in the topology section. Moreover, students are able to interact with models by sending data from one device to another, and by setting which device is broken.
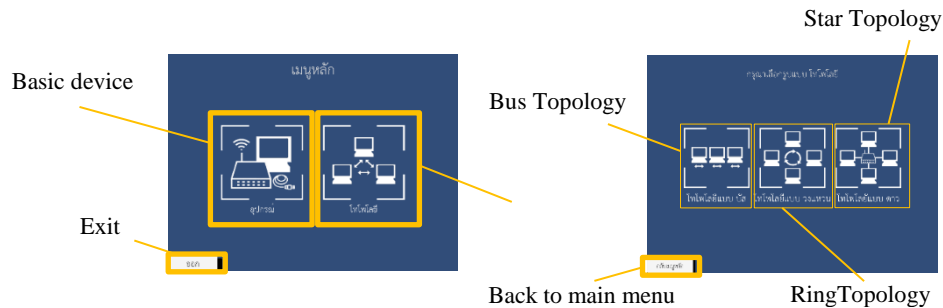
Figure 3. Main menu (left) and topology menu (right)

As shown in the Figure 3, when the AR application was started, the main menu (Figure 3 (left)) will be shown. There are two sub menus including basic devices and network topology. If the basic device menu is selected, the built-in camera will be activated (AR mode). The student can learn the network device through 3D models by using AR markers (example illustrated in Figure 4 (a)). If the student select the topology menu (Figure 3 (left)), there will be three sub menus appeared on the screen consisting of Bus topology menu, Ring topology menu, and Star topology menu (Figure 3 (right)). Once the student selects the sub menu, the AR mode will be activated. The student will use markers with the board to create the topology and interact with them as shown in Figure 4 (b).

| (a) | (b) |

Figure 4. The examples of AR application screenshot

2.3 Data collection tools

The pre-achievement test, post-achievement test, and satisfaction questionnaires were used for collecting both quantitative and qualitative data. Pre- and post- tests were designed in terms of an objective test and multiple-choice items. There are 10 questions which were divided into 2 different sets (pre- and post- tests). There were 10 items in questionnaires used for examine students' attitude toward the AR-based learning package. It was developed according to 5-point Likert scale including strongly disagree = 1, disagree = 2, neither agree nor disagree = 3, agree = 4, strongly agree = 5.

2.4 Implementation

The preliminary study was conducted to investigate the possibilities on the use of the developed AR-based learning package in conjunction with STAD learning process to enhance students' understanding on network topology. We used STAD learning management system (STADLMS), proposed by Kumseang (2016), to facilitate teacher to manage examination and learning activity.

STADLMS is an online learning management system in form of web application to support student teams' achievement division learning process. The system provides teachers to create courses and to manage their lessons so that students are able to learn via the system. Students were also able to do group activities and pretest-posttest created by the teacher. The tests were simultaneously checked and graded, then the system automatically generates student groups based on their pretest scores. Figure 5 shows the screenshot of STADLMS for learning network topology which includes 5 sections: teaching plan, overall testing score, pre-post tests, group assignment, and team recognition and rewards.

Figure 5. Example of STADLMS screenshot

As illustrated in Figure 1, once the pretest and group division have been done via STADLMS, students were assigned the group assignment. It consisted of worksheet, knowledge sheet, AR application, and concrete manipulative board kit. They worked in group as shown in Figure 6.

(a)   (b)   (c)
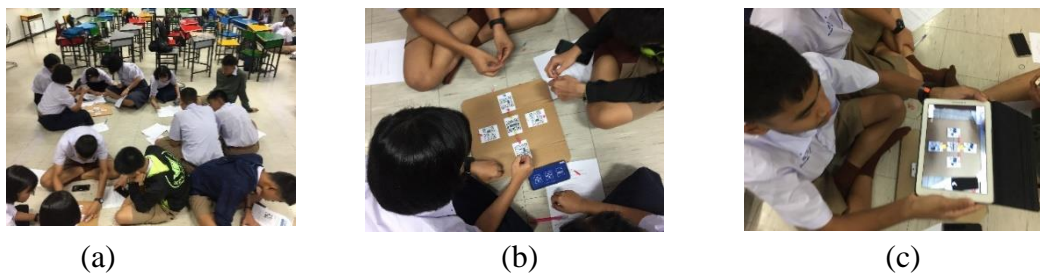
Figure 6. Learning activity (a) study of network devices (b) simulate network connection with the board kit (c) use 3D topology app and interact with the model

3. Results

3.1 Learning Achievement

Students' learning achievement after conducting the learning activity was investigated by the test consisted of 10 items of 4 multiple-choice. The pass criteria was 5 scores. We analyzed the data by mean and percentage. The results showed that (illustrated in Figure 7):

- All posttest scores were higher than pretest scores.
- The average of posttest was 85.19% while that of pretest was 52.22%.
- The average of posttest of low-achieving group was increased from 34.55% to 83.64%.
- The average of posttest of medium-achieving group was increased from 52.50% to 82.50%.
- The average of posttest of high-achieving group was increased from 76.25% to 90.00%.
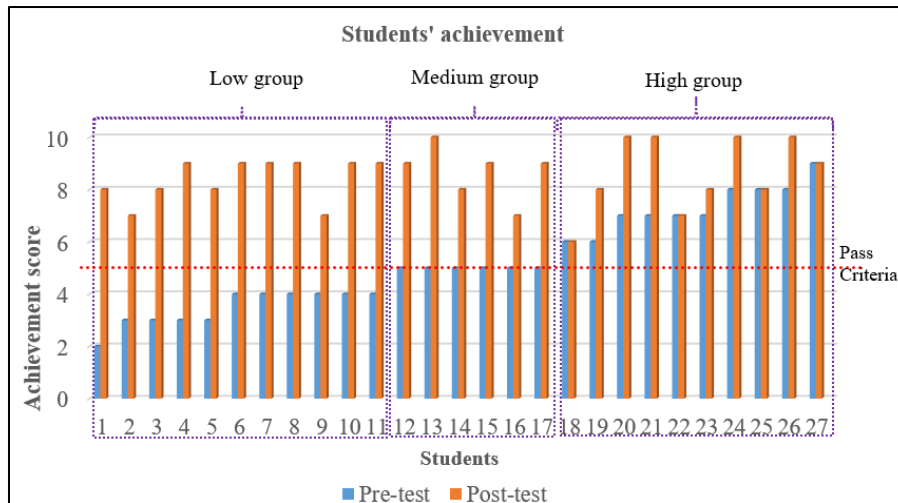
Figure 7. Learning achievement

3.2 Students' Learning Gain

The normalized gain <g>, introduced by Hake (Bao, 2006), was used to analyze pre- and post- tests in order to investigate students learning progress after learning through our developed learning package. The average <g> can be calculated using either the average scores of the class or individual student's scores detailed as follows.

3.2.1 Individuals' Learning Gain
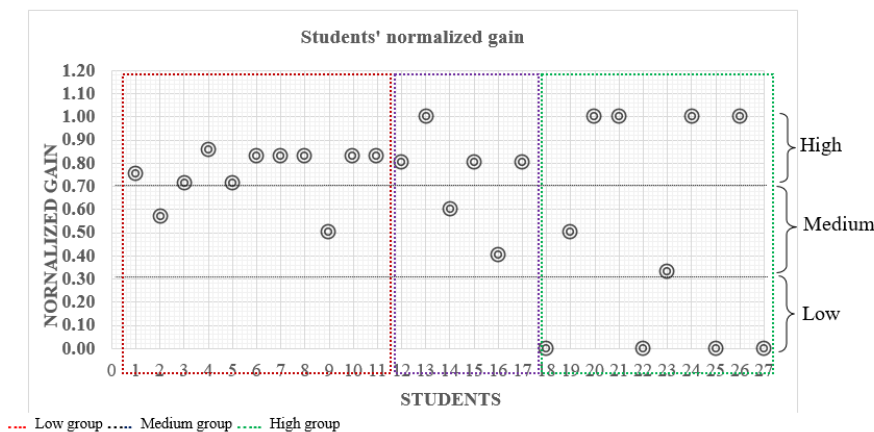
Figure 8. Individual students' normalized gain

The learning progress of students after they learned through this learning activity was analyzed by normalized gain shown in Figure 8. The results showed that 17 students have increasable learning progress that <g> value was between 0.70 and 1.00 which were classified into the high group (high gain) that was 62.97 percent all of students. There were 6 students having <g> value between 0.30 and 0.69 which were classified into medium gain group that was 22.22 percent all of students. Moreover, 4 students were classified into low gain group having <g> values lower than 0.30 that was 14.81 percent. From our analysis, we found that the low gain group was in the high group. They had their pre-achievement score as high as post-achievement score, thus the normalized gain was 0.

609

3.2.2 Learning Gain Classified by Achievement Group (Low, Medium, and High)
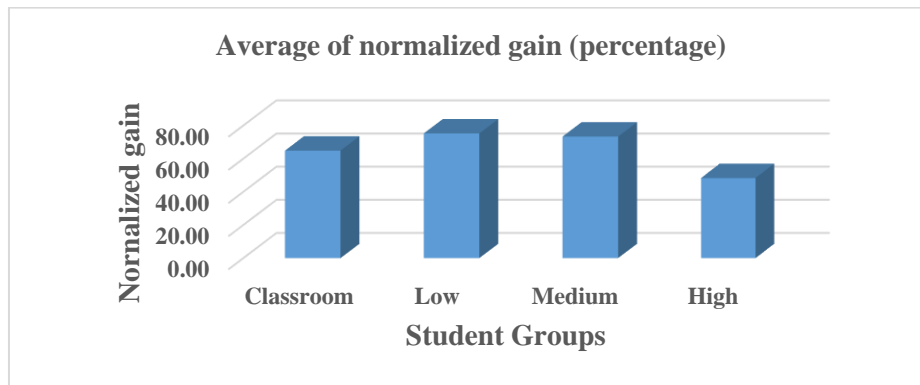
Figure 9. The percentage of achievement group normalized gain

The students' learning gain was calculated among group and classroom. The results were shown in Figure 9. It found that the highest of normalized gain was in the low group. This might be concluded that our developed AR learning package can promote students' understanding.

3.3 Students' Satisfaction

Table 1
Results of Students' Satisfaction toward AR-based Learning Package

Questions	Mean	S.D.	Level
Learning activities encourage students to exchange knowledge and ideas.	4.52	0.70	Highest
Learning activities help students helping each other.	4.56	0.57	Highest
Learning activity allows students to freely do activities.	4.48	0.75	High
The environment of the learning set makes students responsible for themselves and the group.	4.52	0.70	Highest
Learning activities give students the opportunity to express opinions.	4.44	0.75	High
The environment of learning activity gets fun and enjoy.	4.56	0.75	Highest
Learning activities make students want to learn more.	4.44	0.80	High
Learning activity makes content easy to understand.	4.40	0.75	High
Learning activity makes students able to remember the content longer.	4.48	0.81	High
The level of satisfaction toward the learning activities.	4.60	0.57	Highest
Overall	4.50	0.62	Highest

Table 1 shows that the average of students' satisfaction was at the highest level (Mean = 4.50, S.D. = 0.62). From the results, we found that the highest satisfaction were *learning activities help students helping each other* and *the environment of learning activity gets fun and enjoy* which were the same mean of 4.56 but different standard deviation.

4. Discussion and Conclusion

The AR-based learning package was well-received among the students. With the combination of the AR application and the concrete manipulative kit, students were able to understand not only the concepts of topology themselves, but also their application to the practical settings. As a result, students were much more engaged in the activities and motivated to learn.

The experimental results revealed that this AR-based learning package was able to increase students' learning achievement. From the results of normalized gain, we found that the learning activity

had more effectiveness with students who were in low-achieving group and medium-achieving group than students who were in high-achieving group.

Moreover, the leaning management based on STAD learning approach helps enhance student to develop their communication skills and teamwork skills, which is one of needed in 21st century skills. STAD is good interaction among students and helps them to improve their positive attitude through subjects which consistent with Tuncharoen et al (2018) stated that the STAD learning method promoted many aspects of students' performance, and also made students had better achievement, and interaction in themselves and working together.

In conclusion, this study discussed the development of the AR-based learning package for topology for the secondary-level students in Ubon Ratchathani, Thailand. Students learned not only the subject, its concepts, and its practicality, but also skills of necessity in life to advance their lives. In the future, this study may be expanded to different levels of schools in Thailand and compared with students in control group who learn by using other learning methods.

Acknowledgements

References

Bao, L. (2006). Theoretical comparisons of average normalized gain calculations. *American Journal of Physics*, 74(10), 917-922.

Chumpagul, C. (2017) Classroom research report: the development of internet-based lessons on data communication and computer networks for Mathayomsuksa 2 in Satri Samutprakarn School, Samutprakarn, Thailand.

Faisal, S. (2017) Gamification of foreign-language vocabulary learning using mobile augmented reality. School of Electrical Engineering and Informatics Institute Teknologi Bandung Bandung, Indonesia

Iilian, R. (2012). Why should my students use AR? a comparative review of the educational impacts of augmented-reality. In *2012 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, 313-314

Irwansyah, F. S., Yusuf, Y. M., Farida, I., Ramdhani, M. A. (2018). Augmented reality (AR) technology on the android operating system in chemistry learning. In *IOP Conference series: materials science and engineering*, 233-237.

Jamhari, (2016). The concrete manipulative-and-technology-based learning cycle unit for learning angle properties in a circle. Institute for innovative learning, Mahidol University.

Karaçöp, A. (2016). Effects of student teams-achievement divisions cooperative learning with models on students' understanding of electrochemical cells. In *International Education Studies*, 9(11), 104-120.

Krupatom. (2019). Learning by doing practice or action. krupatom. Retrieved from www.krupatom.com/1637-2/1637/

Kumseang, B. (2016). Development of online learning management system for supporting student teams achievement division learning, Ubon Racthani University, Ubon Racthani,

Oates, J., Russell, A. (1998). Learning voice analysis using an interactive multi-media package: development and preliminary evaluation. In *Journal of Voice*, 12(4), 500-512.

Pandiangan, N. (2019). Comparative study: enhancing students' reading comprehension ability through ing ngarsa sung tuladha and student teams achievement division (stad) learning models. Acuity, 4(1), 1-9.

Tuncharoen, P., Chauvatcharin, N., Singlop, S. (2018). The effects of learning activities by using stad cooperative learning techniques to promote learning achievement and attitude on science for developing life skill in the topic "ecosystems" of diploma level students. In *Journal of Industrial Education*, 17(2), 188-196.

Wu, P.-H., Hwang, G.-J., Yang, M.-L, Chen, C.-H. (2018). Impacts of integrating the repertory grid into an augmented reality-based learning design on students' learning achievements, cognitive load and degree of satisfaction. In *Interactive Learning Environments*, 26(2), 221–234.

Designing an IoT-Based 3D Pop-Up Book to Engage Children in English Vocabulary Learning

Huai-Hsuan HUANG[a], Vivien LIN[a, b, c*], Yu-Fen YANG[c], & Nian-Shing CHEN[c]
[a]*Research Center for Smart Learning, National Yunlin University of Science and Technology, Taiwan R.O.C.*
[b]*Bachelor Program in Interdisciplinary Studies, College of Future, National Yunlin University of Science and Technology, Taiwan, R.O.C.*
[c]*Department of Applied Foreign Languages, National Yunlin University of Science and Technology, Taiwan R.O.C.*
*vivienster@gmail.com

Abstract: The purpose of this study was to use the Internet of Things (IoT) technology to engage elementary school children in English vocabulary learning through a pet-care game. An IoT system consisting of a three-dimensional (3D) pop-up book, a toy character, an educational robot, and a near-field communication wire network was developed. Based on this proposed IoT-based language learning environment, interactions among individual learners, an educational robot (accompanied by a tablet), and the 3D pop-up book augmented by a sensor network were induced. Two fourth graders followed the English robotic prompts, which were simple sentence structures embedded with target vocabulary, to interact with the 3D pop-up book so that each learner carried out daily life tasks under robotic guidance and human facilitation. A video analysis revealed that the IoT-augmented 3D pop-up book game effectively provided a learning environment for behavioral, cognitive, and emotional engagement. It is thus concluded that creating an IoT-based game environment for young learners and engaging them in interactions can enhance their performance in English vocabulary learning. Instructional designers may find the outcomes of this study useful for creating language learning opportunities with the support of IoT-based technology.

Keywords: Engagement, gamification, IoT-based learning, robotic guidance, 3D pop-up books

1. Introduction

Alternative instructional modes with the support of technology can effectively facilitate language learning. As English continues to be the lingua franca in the world, Taiwan has also joined the move toward a bilingual nation in English and Chinese (Ministry of Education, 2019). This language policy has resulted in an early start of English learning. In primary education, vocabulary acquisition and sentence formation serve as the main learning content in the English subject. As such, how to effectively facilitate language development among young learners becomes a crucial task for English practitioners in this context. With the advancement of sensor technology (Wang, Lin, Hwang, & Liu, 2019), educational robots (Cheng, Sun, & Chen, 2018), and the Internet of Things (IoT; Gomez, Huete, Hoyos, Perez, & Grigori, 2013), more possibilities in language education arise. The affordances of IoT and sensor technology allow for sensory-based interactive learning, which provides opportunities for practitioners to experiment with well-crafted learning networks.

Vocabulary development for English as a foreign or second language learners requires time, but young learners often perceive it to be a boring process that demands them to attend to lexical meanings (Nation, 2001). Unsatisfactory outcomes thus often result due to insufficient contact with target words and memory loss over time (Zou, Huang, & Xie, 2019). Despite previous efforts with digital game-based learning designs for vocabulary learning (e.g., Chen, Liu, & Huang, 2019), a new learning environment utilizing interactive pop-up books, educational robots, and IoT technology remains absent. This study intends to create embodied cognition (Chao, Huang, Fang, & Chen, 2013) via a multimedia environment. It is expected that through physical movement and stimulus materials enabled by the IoT-based pop-up book, meaningful English vocabulary learning will occur. The authors seek to

understand how children learn and what they need to learn via *design for learning*, which is a branch in instructional design that conceptualizes learning as 'engagement, transformational processes, sign making, and meaning making' (Selander, 2008, p. 148). By integrating new forms of technology based on the concept of *design for learning*, problems concerning boredom with vocabulary learning and difficulty with memory retention might be solved. This paper therefore presents the design of an instructional mode with the support of technology to effectively engage Taiwanese children in English vocabulary learning.

Vocabulary learning is important for young learners. Recent years have witnessed increasing popularity of digital game-based learning for second language vocabulary acquisition (Tsai & Tsai, 2018). The design of digital game-based learning can be divided into two main types — drill- and task-based games (Chen, Tseng, & Hsiao, 2018). Drill-based games offer repetitive practice opportunities to learners on target words through games such as matching, while tasked-based games lead to real outcomes through goal-oriented activities (Willis, 1996). Task-based games further provide critical thinking and problem-solving skill training through role-play, strategy application, and adventures, all of which place an emphasis on meaning over form (Homer, Plass, Raffaele, Ober, & Ali, 2018; Vahdat & Behbahani, 2013). In addition, the importance of noticing and retrieval was addressed. Noticing refers to repeated exposures, retrieval, and generative use that lead to successful vocabulary acquisition (Schmitt, 2008). According to noticing, learners can become aware of different nuances of a word's meaning as they pay attention to the word form or any cues associated with its meaning (Schmidt, 2010). Retrieval, on the other hand, is the process by which learners access stored information and connect the associative cues to the retrieved knowledge, leading to better vocabulary retention (Nation, 2001).

The Internet of Things (IoT), when applied in educational settings, makes use of network computing, sensors, online platforms, and even artificial intelligence for transforming real-world objects into intelligent ones to facilitate learning (Abdell-Basset, Manogaran, Mohamed, & Rushdy, 2019). IoT technologies combine physical, digital, and biological spheres in people's daily lives (Schwabs, 2015), and is one of the forces that shape the future of education. In an IoT-based setting, educational aids such as toys, educational robots, and sensor technology can be applied to foster cognitive development is enhanced by motor and sensory exploration (Dauch et al., 2018). Toys, for one, bear features that can lead to growth in cognition, social skills, and motor skills among children. They also bear cultural beliefs and add to children's play experience (Trawick-Smith, Wolff, Koschel, & Vallarelli, 2015). In addition, Bikowski and Casal (2018) on non-native English speaking undergraduates studying in the U.S. reported that as learners engaged in using an interactive digital textbook on iPads, measures on their engagement levels categorized them into emergent and proficient learners. Example engagement behaviors included putting efforts into assignments, taking good notes, thinking about course materials outside class, and desiring to learn course materials. The proficient learners were the ones that displayed more engagement behaviors and conscious use of strategies to help them benefit from the new way of learning with the use of the digital textbook.

The purpose of this study was to engage elementary school children in English vocabulary learning through a pet-care game in an IoT system consisting of a three-dimensional (3D) pop-up book, toy character, educational robot, and near-field communication wire network. The research questions were therefore formulated as follows:

RQ 1. How was an Internet of Things (IoT) system consisting of a three-dimensional (3D) pop-up book, a toy character, an educational robot accompanied by a tablet, and a near-field communication wire network developed?
RQ 2. How can the designed learning activity of an IoT-based 3D pop-up book effectively engage Taiwanese two fourth graders in English vocabulary learning?

2. Method
2.1 Augmenting the Three-Dimensional Pop-Up Book with IoT Technology

In the proposed IoT-based system network, circular near-field communication (NFC) tags, a touch sensor, a NFC reader, and a Raspberry Pie were embedded in a commercial pop-up book in order to create a sensory-motor environment for English vocabulary learning. The IoT-based game consisted of the pop-up book, an educational robot, a tablet PC, and a rabbit doll. The robot's features included two

flexible hands and wheel legs that instructed learners with vivid gestures. Beside the robot, a 9.7-inch tablet PC was used to help learners with visual cues for task completion. Both the pop-up book, the robot, and the tablet PC were scripted in English. As for visual effects that increased learner appeal and motivation, the colorful pop-up book, along with a well-dressed male rabbit doll, was able to attract learners' attention and enhance their learning desire. The rabbit doll was connected to a NFC reader. On the 3D pop-up book, 12 circular stickers could be found. These were embedded NFC tags that provided audio feedback when a learner tried to perform a task. The NFC tags were connected wirelessly to a Raspberry Pie hidden at the bottom of the pop-up book, while the NFC reader on the rabbit doll was connected to the Raspberry Pie with wires in the IoT augmentation of the pop-up book.

2.2 IoT-Based Interaction Framework

The authors proposed an IoT-based interaction framework whereby three main entities interacted with each other in the process of language learning. The three entities were the learner, the educational robot aided by a tablet, and the 3D pop-up book. The learner is a child who is engaged in a sensory-motor learning activity in the IoT-augmented environment in the form of a 3D pop-up book consisting of a house with tangible objects and toy-like living space. The robot and the tablet serve as one entity that provided instructional aids. Figure 1 illustrates the framework components and their main functions. The design of the learning activity, the pet-care game, is based on the postulations that (a) with tangible playable objects, the learner will be highly engaged in receiving language input under appropriate instructional guidance; and (b) as learners receive feedback from the robot and tablet, they will be able to go reach the correct target object through trial and error, and ultimately learn the target vocabulary in authentic play context.
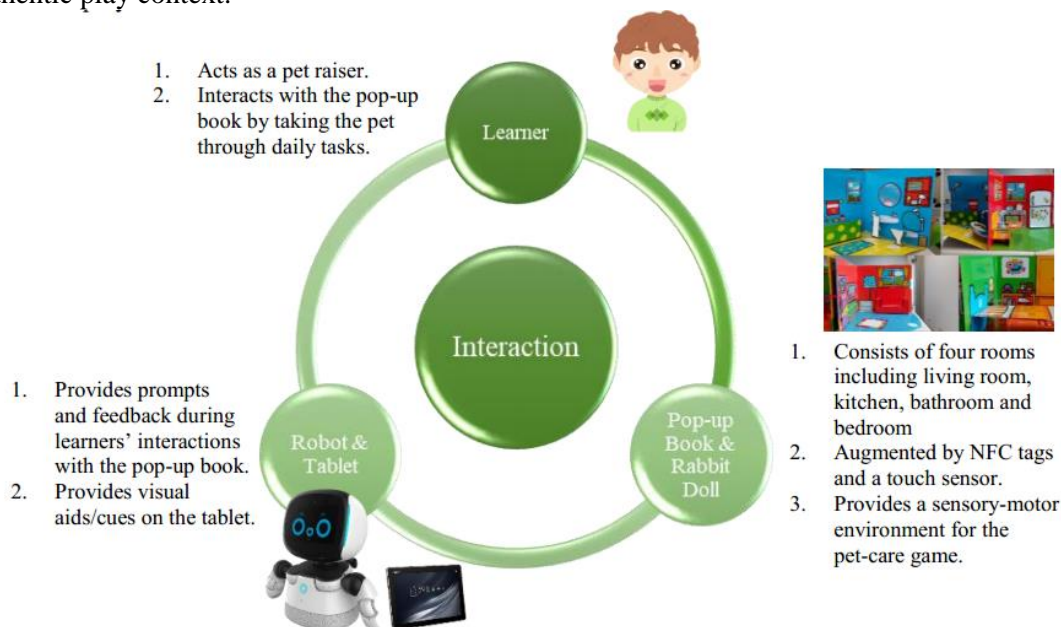
Figure 1. IoT-Based Interaction Framework for Language Learning

2.3 Game-Based Design of the IoT 3D Pop-Up Book

It is challenging for children to learn new English vocabulary in daily life settings. Previous research (Lenhart, 2019) shows that based on the instructional sequence of say-tell-do-play (STDP), guided play enhances learners' word awareness. To help children learn English vocabulary in a fun way, sociodramatic play, a common practice among children's daily play, was adopted for the design of the IoT-based learning in this study. Children, along with their parents and siblings, live in their own house where as the most familiar environment to learn vocabulary in early childhood development. This echoed the digital game design concept of relating the learning content to daily life situations (Shi & Hsu, 2016). The selected commercial 3D pop-up book was therefore connected to the learning content with a domestic theme in the game environment. The central theme of the game involved pet-care, as pets are children's favorite company. Moreover, some children have experience playing pet-care games. Therefore, the rabbit doll served the pet role to engage target learners in pet-raising as a process

for them to learn vocabulary in the familiar environment resembling their own home. It was expected that the design of the IoT-based pet-care game would strengthen their listening competence as they carried out tasks following the robotic instruction in English. Figure 2 presents the set-up of the IoT-based system with the augmented components.
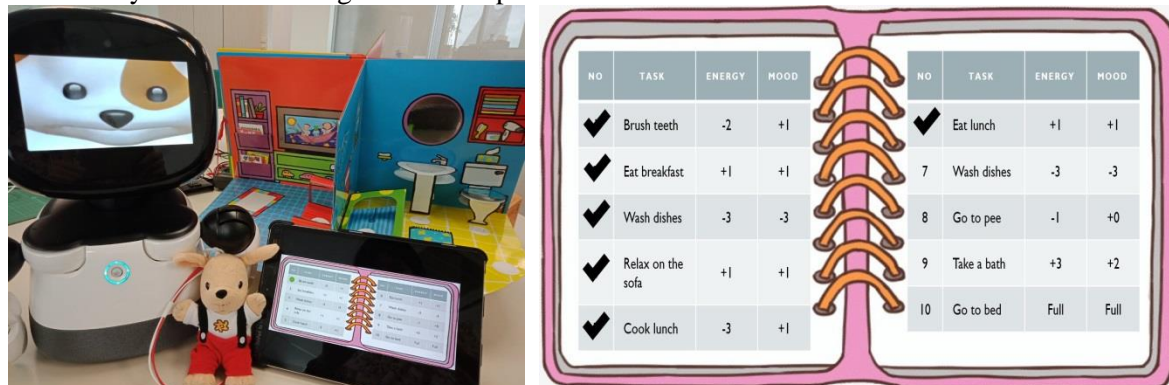
Figure 2. The Set-Up of the IoT-Augmented 3D Pop-Up book and an Example Guidebook Page

2.4 The Pet-Care Learning Game

The pet-care game required each learner to engage in role-play. To fulfill the task-based game design, the pop-up book, which was a 3D house equipped with four rooms (a living room, kitchen, bathroom and bedroom), was embedded with IoT components (a Raspberry Pie, a NFC wire network, and a touch sensor on the guidebook). A rabbit character served as a token for children to navigate through each room, taking the rabbit to touch different objects. Moreover, an educational robot and a tablet PC served as educational aids in the game-based learning environment. When a learner touches the guidebook, the tablet will display a Guidebook page to show them which tasks they are on, as shown in Figure 2. In terms of the learning content, vocabulary items related to different rooms in a house were used. Table 1 presents a task list developed for the pet-care game as well as the target words to be introduced and learned. required the learner to act as a pet raiser by following robotic instructions to tend to the daily needs of the pet, the rabbit doll. To guide learners through this role-play,

Table1. *Task List for the Pet-Care Game*

TASK NUMBER	TASK	TASK NUMBER	TASK
1	Brush teeth* (*sink, *brush, *teeth)	6	Eat lunch (*eat, *lunch, *yummy)
2	Eat breakfast (*eat, *breakfast, *full)	7	Go to the bathroom (*bathroom)
3	Wash dishes (*wash, *dish, *cook)	8	Go to pee (*pee, *feel, *better)
4	Relax on the sofa (*relax, *comfortable)	9	Take a bath (*take, *bath)
5	Cook lunch (*cook, *lunch, *smells)	10	Go to sleep (*sleep, *bed, *night)

NOTE: An asterisk (*) indicates a target vocabulary in the learning module

Under robotic instruction and visual aids on the tablet, each learner was expected to complete the game autonomously. An example page of the Guidebook is shown in Figure 2. The pet-care game consisted of four stage. The first stage, the Warm-Up, involved the robot's greetings to the learner and introduction of the pet. The second stage, the Introduction, involved the robot's introduction of the game rules. The third stage, the Trial, provided a scaffold for the learner to complete an initial task. In the last stage, the Exploration, the learner must explore the pop-up book by carrying out the tasks in the pet-care game. Figure 3 shows the game flow for the Trial and Exploration sessions.

The robotic guidance was entirely scripted in English and the guiding mechanisms were divided into three types, each serving a specific function. The first type of guidance introduced the learners to the game (e.g. "Hi, my friend is traveling. She has a pet. Can you help take care of it?"). The second type of guidance prompted the learner to take action (e.g. "Please go to the bathroom. Find the Guidebook and touch it."). The third type of guidance provided feedback on each learner response to the prompt during an interaction with the pop-up house. If the learner responded correctly, a reward was provided (e.g. "Wow! Good job! Let me give you a star. You can get stars if you do a good job. Stars are good. You can upgrade each room with stars."). On the other hand, if the learner's response was

incorrect, the robot would instruct the learner to turn to his/her attention to the tablet (e.g. "Check the Guidebook again.").
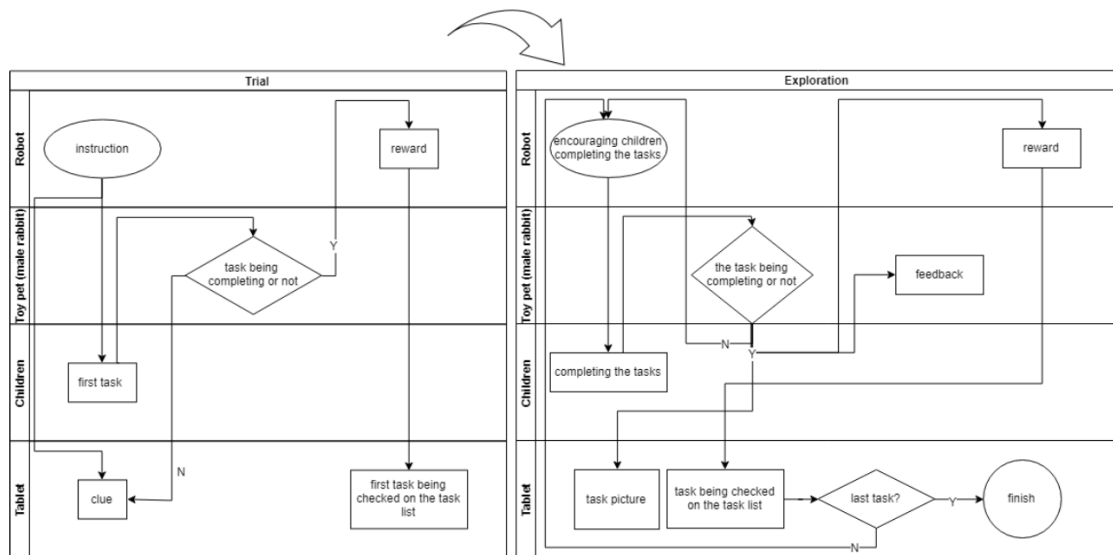
Figure 3. Flow Chart for the Trial and Exploration Stages

2.5 Participants

Two male fourth graders who attended public elementary schools in central Taiwan were recruited to each participate in a role-play game session using the proposed IoT pop-up book. The two participants underwent similar English curriculum at school, which expected them to own a vocabulary of 100 to 200 words. Based on the General English Proficiency Test for Kids, both learners reported an equivalent proficiency of A1 on the Common European Framework of Reference Test. Specifically, Learner A achieved 72%, while Learner B achieved 100% in the Listening Section; and for the Reading and Writing Section, Learner A achieved 48%, which was higher than Learner B's performance (28%). It was likely that Learner B's weekly verbal interactions with a native English-speaking tutor and daily interactions with his Mandarin-English bilingual mother allowed him to perform better in listening. On the other hand, Learner A received intensive reading instruction at school and from a tutor with a degree in Applied Foreign Languages. Both learners frequently used multimedia tools (e.g., computers and iPads) to play games or watch videos. Learner A completed the session in his own home, while the other (Learner B) in a playroom at a Research Center for Smart Learning. One author served as a facilitator during the two game sessions. Figure 4 provides photographs of both learners' engagement in play sessions.

Figure 4. Learner A (left) Checking the Guidebook & Learner B (right) Checking with the Facilitator

2.6 Instruments and Analyses

This study mainly employed a video analysis (Debski, 2019) to examine learner engagement in the IoT-based pet-care game. The recording involved the participants' play sessions during all four stages of the game. Four learning trials were carried out by Learner A and two trials were undertaken by

Learner B due to system overloads caused by the learners' repeated response errors. Two of the authors viewed the two video recordings several times and discovered that both learners were intensely focused on the game sessions. Consequent investigation on specific movements as engagement patterns was therefore carried out. They classified the learners' engagement using a criteria list adapted from a previous study by Yang (2011), who examined language learners' engagement from behavioral, cognitive, and emotional perspectives (Fredrick, Blumenfeld, & Paris, 2004). As such, the two learners' physical, facial, and gestural acts (Lavelli et al., 2019; VanDerHeyden, Snyder, Sevin, & Longwell, 2005) were categorized as behavioral engagement; their reactions toward the task demands prompted by the robot (e.g. taking the rabbit doll to eat in the kitchen) were categorized as cognitive engagement; and their facial expressions were considered as emotional engagement. The time elapsed for each engagement instance was also added up and converted to percentages as part of the entire play time (excluding the system breakdown time). The total valid play time was 26 minutes and 27 seconds for Learner A and 19 minutes and 46 seconds for Learner B. Mainly, the authors examined both learners' reactions to the robotic instruction and prompts for interacting with the pop-up book, and tried to measure the proportion of time spent on each type of engagement. The classification of engagement types is shown in Table 2 in the result section. For example, an instance of behavioral engagement was touching any part of the pop-up book, the number of times the learner touched the pop-up book was recorded, then the elapsed time for all the instances of this act were converted to a percentage for assessing whether the learners spent a long time on a specific type of engagement instance. In contrast, disengagement was also observed and analyzed. However, only one instance was identified when the learner was not looking at the pop-up book, rabbit doll, the educational robot, tablet PC, or the facilitator. In summary, the video analysis included two aspects − (a) the frequency of engagement instances, and (b) the accuracy of response to robotic prompts for Learner A and Learner B.

3. Results

A preliminary video analysis led to analytical findings on engagement, including (a) frequency of cognitive, behavioral, and emotional engagement, and (b) response accuracy in the multimedia, sensory-motor learning experience facilitated by the IoT-based 3D pop-up book.

First, in terms of frequency analysis, the results show that both learners were highly engaged throughout their respective play session. Specifically, two engagement instances, *touching the pop-up book* (an instance of behavioral engagement) and *responding to robotic prompts* (an instance of cognitive engagement) were identified as the most frequent actions taken by both learners. There was only one disengagement instance (when the learner was not looking at anything in the IoT system), which occurred four times for Learner A.

Figure 5 shows graphically the frequency of major instances identified by the authors. The major instances identified belong to either behavioral or cognitive engagement. There was also an interrelationship between behavioral and cognitive engagement. When learners responded to robotic prompts, they were actually trying to use the rabbit doll to touch the correct NFC sensor, or turning the pop-up book to face the target room for task completion. It was also found that the time spent on these two behaviors (touching the pop-up book and responding to robotic prompts) occupied a relatively large proportion of the entire play session for both learners. Other engagement instances were *looking at the tablet*, *looking at any part of the pop-up book*, and *holding onto the rabbit doll*. Again, these instances show that the learners were trying to collect information using visual cues from the tablet PC in order to respond correctly to the robotic prompts.

Secondly, concerning the accuracy in responding to robotic prompts, the accuracy rate for both learners increased as time passed by over their respective game session. By the end, Learner A responded accurately to 43.6% of the prompts in the four learning trials (17 correct and 22 incorrect responses), and Learner B responded accurately to 70.3% of the prompts in the two learning trials (26 correct and 11 incorrect responses).
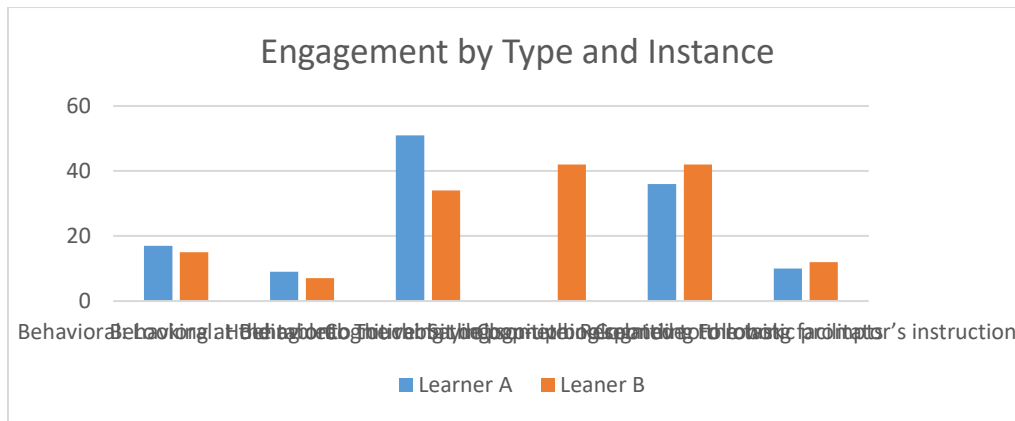
Figure 5. Behavioral and Cognitive Engagement during the Pet-Care Game

Table 2. *Frequency of Engagement Instances*

Engagement Type	Actions Taken during the Pet-Care Game	Learner A	Learner B
	Specific Instances of Engagement		
Behavioral	Holding onto the rabbit doll	9	7
	Looking at a specific part of the pop-up book	20	5
	Looking at the tablet	17	15
	Touching the pop-up book	51	34
	Looking at the facilitator	2	4
	Nodding Head (Signal: Feeling accomplished)	0	2
	Shaking head (Signal: Feeling frustrated)	0	1
	Shrugging (Signal: Seeking help from the facilitator)	0	1
Cognitive	Saying something related to the task	0	42
	Responding to robotic prompts	36	42
	Following the facilitator's instruction	10	12
Emotional	Facial expressions showing feelings of joy (+)	0	3
	Facial expressions showing feelings of surprise (+)	0	1
	Facial expressions showing feelings of accomplishment (+)	2	1
	Facial expressions showing feelings of frustration (-)	0	2
	Total Number of Engagement Incidents	**147**	**172**

Two instances of cognitive engagement, *saying something related to the task* and *following the facilitator's instruction*, yielded interesting findings. Concerning Learner B's verbal reaction of talking about the task, the authors identified his high cognitive engagement through talking in the role-play activity. Learner B would ask questions from the perspective of the pet-raiser. He was into the role and would say aloud target words that were unfamiliar to him, for example, as he took the rabbit doll into the Kitchen, he showed that he did not know the meaning of the word *cook* by asking "*Cook*? What is that [What does that mean]?" However, as he looked at the guidebook's kitchen-related visual cues, he was able to connect the target vocabulary to the actual kitchen in the 3D pop-up book. He also asked questions in Mandarin Chinese during the pet-care game procedure, such as "Which room should we go now?" when prompted to go to another room, or "Why don't you want to brush your teeth?" when the IoT system gave him feedback on touching the wrong NFC sensor for a task (Brushing Teeth). On the contrary, Learner A remained speechless throughout the play session. This finding revealed that verbal expression, was an instance of cognitive engagement, was learner-dependent. This specific kind of cognitive engagement ultimately affected task performance. As shown by Figure 6, on the accuracy of responses to robotic prompts, Learner B, who was highly engaged in *saying things related to the task,* performed better than Learner A.

With regards to *following the facilitator's instruction*, both learners benefitted greatly from the facilitator's assistance, which was an external facilitation mechanism of the IoT system. The facilitator provided verbal cues to both learners under specific circumstances such as when the learner repeatedly

used the rabbit doll to touch NFC tags but could not reach the correct sensor that matched the prompt. The facilitator would say in English (indicated by italicized text) the target vocabulary such as "*Lunch*" in a question phrased in Mandarin Chinese "Where would you eat *lunch*?" Then the learner would think about the clue and then find the right NFC sensor to complete the task accurately. For the instance on *following the facilitator's instruction*, Learner B actively asked the facilitator questions and got more cues to complete the game than Learner A. This engagement act, along with his higher listening proficiency than Learner A, might be the reason that Learner B achieved a higher accuracy rate than Learner A. This finding implies that even though the learners were highly engaged with the 3D pop-up book learning activity through role-playing and task completions, they still relied heavily on feedback from a human facilitator. One important implication concerning the design of such IoT-based pop-up books is the potential of inserting human-like questions that would guide learners through tasks as they made errors. The questioning mechanism could be added in future designs of similar game-based activities.
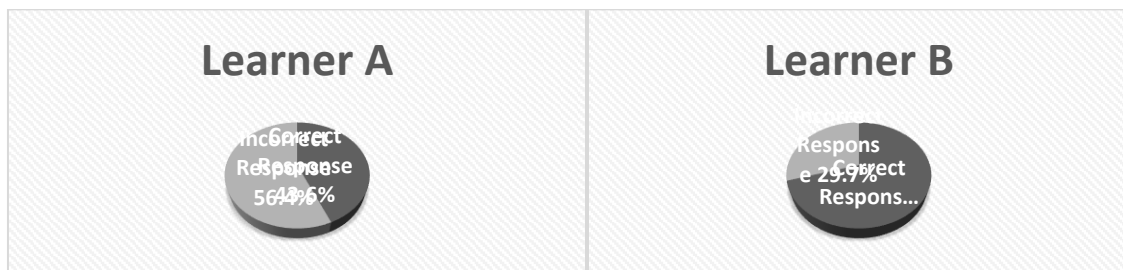
Figure 6. Accuracy of Responses to Robotic Prompts

Overall, the augmented IoT-based 3D pop-up book scripted in English provided a sensory-motor interactive learning experience that effectively engaged target fourth-graders. In particular, physical and cognitive behaviors such as touching the pop-up book and following robotic prompts to fulfill the daily life tasks engaged learners in listening to English vocabulary, testing their vocabulary knowledge by identifying the correct NFC sensor. Moreover, as the analysis on Learner B's verbal reactions demonstrated, the role-playing activity could effectively engage children in responding verbally. That is, Learner B would talk about target learning content as he tried to respond to the robotic prompts. The video-based observations therefore led to the finding that as both learners gained more experience playing the pet-care game throughout the game session, they became more capable of following the English robotic prompts and reacted more quickly and accurately toward the end of the game.

5. Discussion

The first research question investigated how English practitioners could design and develop an IoT system that included various components such as a 3D pop-up book, a toy character, educational robot, and a NFC sensor network. In response, the development of such a learning system can adopt an interaction-based learning framework that consists of three main entities — the learner, the toy, and the educational aid (e.g., a robot accompanied a tablet PC). With this game-based learning activity design, the affordances of toys and the IoT learning environment could be utilized. In the case of the pet-care game, providing a rabbit doll character allows the learner to be a pet-raiser and take the rabbit to different places of the 3D pop-up house for daily tasks. In these interactions, the learners' listening comprehension skills in vocabulary and sentences can be improved through trial and error under the robotic instruction.

The feedback mechanism from the robot gave the learners an opportunity to practice English listening in the zone of proximal development (ZPD; Vygotsky, 1978) provided by the IoT-augmented pop-up house. As put forth by Vygostky (1978), when learners engage in problem-solving tasks beyond their actual ability level, appropriate guidance such as scaffolding activities can help them achieve the task successfully, thereby increasing their knowledge or skills in the process. Developing an IoT sensor network to create a ZPD with role-play and the four progressing stages (Introduction, Warm-Up, Trial, and Exploration) was a useful strategy for engaging children in authentic listening with context-specific target vocabulary.

In addition, a common pattern identified in both play sessions revealed that the accuracy rate of responding to robotic prompts was much higher in the last trial for both learners. This implied that as the learners interacted with the IoT-augmented game environment, their English listening and responding abilities improved as they progressed through the scaffolding mechanisms. It was found that the learners gradually accepted the new mode of learning with a sensory-motor, stimulus-response manner.

The second research question probed into learning activity design for engaging the two target fourth graders in learning English vocabulary. In this regard, it was found that three types of engagement (behavioral, cognitive, and emotional) could be enhanced with an IoT-augmented game to help learners gain vocabulary about different rooms and objects in a house. Among behavioral, cognitive, and emotional engagement, cognitive engagement stood out to be the most frequent of the interactions (e.g. responding robotic prompts, following facilitator's instruction, verbal expressions), followed by behavioral, and emotional engagement. Such findings about the IoT-augmented pet-care game echo claims about the effectiveness of using play-based instruction to engage children in cognitive and social-emotional development (Cielinski, 1995). As the learners went through role-play tasks, they were also involved in social-interactional play-based learning. It has been argued that intelligence is connected to play (Piaget, 1962). Beneficial outcomes on child development have also been reported when children are engaged during play; as they interact with physical and social elements of the environment, they undergo challenging learning experiences and develop cognitively, emotionally, socially, and physically (Dauch et al., 2018). To summarize, effective design of IoT-augmented games should bear features that can lead to child play. Specifically, activity design should focus on creating scaffolding mechanisms for (a) physical interactions with toys via multimedia affordances, (b) cognitive engagement through listening to prompts and eliciting verbal learner responses, (c) stimulating social interactions, and (d) fostering positive emotions.

6. Conclusion

This study presented the design of a pet-care game on a 3D pop-up book augmented by an IoT sensor network. The participants fulfilled the role of a pet-raiser, and simultaneously listened to English instruction from the Guidebook from the IoT system. The learners' duty was to take a rabbit doll to touch various NFC tags in the 3D pop-up book. Both learners were highly engaged with cognitively and behaviorally. Findings also revealed that such an IoT-augmented role play game environment could effectively engage children in sensory-motor reactions that ultimately led to improvement in English vocabulary and listening. Surprisingly, the study also identified the importance of human facilitators in IoT-based games. Future studies can examine how learners' immersion into role-play (e.g., verbal interactions) may enhance cognitive engagement and therefore game performance and language learning outcomes in an interactive IoT environment. Finally, it will be worthwhile to investigate how instructors may serve as effective facilitators during IoT-based language learning.

References

Abdel-Basset, M., Manogaran, G., Mohamed, M., & Rushdy, E. (2018). Internet of things in smart education environment: Supportive framework in the decision-making process. *Concurrency and Computation: Practice and Experience, 31*(10), e4515.

Bikowski, D., & Casal, J.-E. (2018). Interactive digital textbooks and engagement: A learning strategies framework. *Language Learning & Technology, 22*(1), 119-136.

Chao, K.-J., Huang, H.-W., Fang, W.-C., & Chen, N.-S. (2013). Embodied play to learn: Exploring Kinect-facilitated memory performance. *British Journal of Educational Technology. 44*(5), E151-E155. doi:10.1111/bjet.12018

Chen, M. H., Tseng, W. T., & Hsiao, T. Y. (2018). The effectiveness of digital game-based vocabulary learning: A framework-based view of meta-analysis. *British Journal of Educational Technology, 49,* 69-77. doi:10.1111/bjet.12526.

Chen, C.-M., Liu, H., & Huang, H.-B. (2019). Effects of a mobile game-based English vocabulary learning app on learners' perceptions and learning performance: A case study of Taiwanese EFL learners. *ReCALL, 31*(2), 170-188. doi:10.1017/S0958344018000228

Cheng, Y.-W., Sun, P.-C., & Chen, N.-S. (2018). The essential applications of educational robot: Requirement analysis from the perspectives of experts, researchers and instructors. *Computers & Education, 126,* 399-416. doi:10.1016/j.compedu.2018.07.020

Cielinski, K.-L., Vaughn, B.-E., Seifer, R., & Contreras, J. (1995). Relations among sustained engagement during play, quality of play, and mother-child interaction in samples of children with down syndrome and normally developing toddlers. *Infant Behavior and Development, 18*, 163-176.

Dauch, C., Imwalle, M., Ocasio, B., & Metz, A. E. (2018). The influence of the number of toys in the environment on toddlers' play. *Infant Behavior Development, 50*, 78-87. doi:10.1016/j.infbeh.2017.11.005

Debski, R. (2019). Language transmission opportunities created through video recording in the family: A microanalysis. *International Journal of Bilingual Education and Bilingualism*. doi:10.1080/13670050.2017.1311835

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, *74*(1), 59–109. doi:10.3102/00346543074001059

Gómez, J., Huete, J.-F., Hoyos, O., Perez, L., & Grigori, D. (2013). Interaction system based on internet of things as support for education. *Procedia Computer Science, 21*, 132-139. doi:10.1016/j.procs.2013.09.019

Homer, B.-D., Plass, J.-L., Raffaele, C., Ober, T.-M., & Ali, A. (2018). Improving high school students' executive functions through digital game play. *Computers & Education, 117*, 50–58.

Lavelli, M., Barachetti, C., Majorano, M., Florit, E., Brotto, C., & Miottello, P. (2019). Impacts of a shared book-reading intervention for Italian-speaking children with developmental language disorder. *International Journal of Language & Communication Disorders, 54*(4), 565-579. doi:10.1111/1460-6984.12460

Lenhart, L.-A., Roskos, K.-A., Brueck, J., & Liang, X. (2019). Does play help children learn words? Analysis of a book play approach using an adapted alternating treatments design. *Journal of Research in Childhood Education, 33(*2), 290-306.

Ministry of Education. (2019, September 5). Bilingual National Policy by the Ministry of Education. Retrieved from https://www.edu.tw/News_Content.aspx?n=D33B55D537402BAA&s=FB233D7EC45FFB37

Nation, I. S. P. (2001). Learning vocabulary in another language. *Cambridge: Cambridge University Press.*

Piaget, J. (1962). *Play and imitation in childhood*. New York: Norton.

Schmidt, R.-W. (2010). Attention, awareness, and individual differences in language learning. In W. M. Chan, S. Chi, K. N. Cin, J. Istanto, M. Nagami, J. W. Sew, T. Suthiwan, & I. Walker (Eds.), *Proceedings of CLaSIC 2010* (pp. 721–737). Singapore: National University of Singapore, Centre for Language Studies.

Schmitt, N. (2008). Instructed second language vocabulary learning. *Language Teaching Research, 12*(3), 329–363. doi:10.1177/1362168808089921

Schwabs, K. (2015, January 14). The fourth industrial revolution: what it means, how to respond. Retrieved from https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/

Selander, S. (2008). Designs for learning and ludic engagement. *Digital Creativity*, *19*(3), 145-152. doi: 10.1080/14626260802312673

Shih, J.-L., & Hsu, Y.-J. (2016). Advancing adventure education using digital motion-sensing games. *Educational Technology & Society, 19*(4), 178–189.

Trawick-Smith, J., Wolff, J., Koschel, M., & Vallarelli, J. (2015). Effects of toys on the play quality of preschool children: Influence of gender, ethnicity and socioeconomic status. *Early Childhood Education Journal, 43*, 249–256.

Tsai, Y.-L., & Tsai, C.-C. (2018). Digital game-based second-language vocabulary learning and conditions of research designs: A meta-analysis study. *Computers & Education, 125*, 345-357. doi:10.1016/j.compedu.2018.06.020

Vahdat, S., & Behbahani, A.-R. (2013). The effect of video games on Iranian EFL learners' vocabulary learning. *Reading, 13*(1).

VanDerHeyden, A.-M., Snyder, P., Smith, A., Sevin, B., & Longwell, J. (2005). Effects of complete learning trials on child engagement. *Topics in Early Childhood Special Education, 25*(2), 81-94.

Vygotsky, L. S. (1978). *Mind in Society: The Development of Higher Psychological Processes*. Cambridge, MA: Harvard University Press.

Wang, H.-Y., Lin, V., Hwang, G.-J. & Liu, G.-Z. (2019). Context-aware language learning application in the green technology building: Which group can benefit the most?. *Journal of Computer Assisted Learning, 35*(3), 359-377.

Willis, J. (1996). A flexible framework for task-based learning. *Challenge and Change in Language Teaching, 52–62.*

Yang, Y. F. (2011). Engaging students in an online situated language learning environment. *Computer Assisted Language Learning, 24*(2), 181-198. doi:10.1080/09588221.2010.538700

Zou, D., Huang, Y., & Xie, H. (2019). Digital game-based vocabulary learning: Where are we and where are we going? *Computer Assisted Language Learning,* 1-27. doi:10.1080/09588221.2019.1640745

The Effect of an Immersive Virtual Reality Interactive Feedback System on University Students' Situational Interest and Learning Achievement: The Case of a Pour Over Coffee Brewing Lesson

Shih-Jou YU[a], Yu-Ling HSUEH[b], Jerry Chih-Yuan SUN[a*], & Hao-Ze LIU[b]
[a]*Institute of Education, National Chiao Tung University, Taiwan*
[b]*Department of Computer Science & Information Engineering, National Chung Cheng University, Taiwan*
*csun@nctu.edu.tw

Abstract: This study aimed to examine the effect of an immersive virtual reality interactive feedback system on university students' situational interest and learning achievement in a pour over coffee brewing lesson. A total of 103 university students participated in this experiment. They used the immersive virtual reality interactive feedback system to learn the steps of making pour over coffee. In addition, they were required to complete a prior knowledge test, a situational interest scale, and a learning achievement test. The results of this study indicate that the immersive virtual reality interactive feedback system can trigger sub-dimensions of situational interest to an average level except for the challenge dimension, while it also improves learners' learning achievement. It is suggested that teachers can use an immersive virtual reality interactive feedback system to teach learners multiple-step lessons or trigger learners' learning motivation.

Keywords: Virtual reality, situational interest, learning achievement, coffee

1. Introduction

Virtual reality (VR) has been recognized and is accepted by an increasing number of people as a learning technology. It utilizes computer simulation to produce a three-dimensional virtual world and provides users with visual, voice as well as other sensory simulations (Mealy, 2018). The VR environment can be designed in different ways, including desktop VR, immersive VR, spherical video-based VR, CAVE-like VR (Ye, Liu, Lee, Zhang, & Chiu, in press), and video-capture VR (Yang, Chen, & Jeng, 2010). Past research has compared different VR systems and the results indicated that immersive VR improved learners' achievements in engineering education because it can bring more immersive experience (Alhalabi, 2016). In addition, learners can observe object from different angles and distances in an immersive virtual environment, which helps them to calibrate between the real object and virtual object in their mind (Blascovich & Bailenson, 2005). In brief, if the virtual environment resembles the authentic environment more closely, people can easily transfer their knowledge or skills to the real world. Their manipulative ability can also be enhanced by the immersive virtual space, and the learners' attention, motivation and imagination will affect their manipulative ability (Loomis, Blascovich, & Beall, 1999).

Pour over coffee emphasizes the manipulative ability to keep the high quality flavor of coffee. The maker needs to control the extraction pressure, time, and water-to-coffee ratios to make pour over coffee (Folmer, 2017). Nowadays, the ratio of 18-24 year-olds who drink coffee every day has increased to 50% in U.S. (FONA, 2017) and 79% of coffee lovers prepare their coffee at home (National Coffee Association, 2018). Therefore, since the 18-24 year-old group includes university students, they may have the demand to learn how to make coffee themselves. The key point of the training was to standardize the steps of making coffee. The aim of this research was to design an

immersive VR interactive feedback system for pour over coffee training and to analyze the effect of this system on university students' situational interest and learning achievement. The following are the research questions, and the research framework is shown as Figure 1.

Research question 1: Can learners improve their learning achievement significantly after using an immersive VR interactive feedback system to learn to make pour over coffee?

Research question 2: Which sub-dimensions of situational interest were higher than average level after using the immersive VR interactive feedback system?
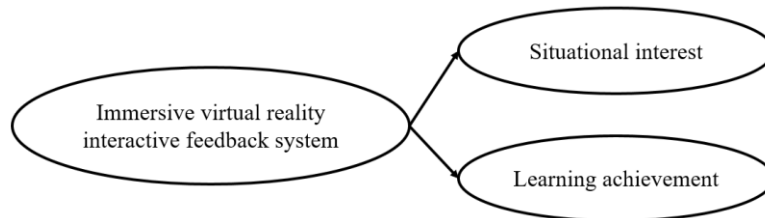
Figure 1. Research framework.

2. Related research

2.1 Situational interest

Interest is divided into two concepts: Situational interest and individual interest. Situational interest is defined as the affective reaction of a learner to face a specific environment, while individual interest is defined as a learner following the accumulation of time to structure stable affective reaction for a specific activity (Renninger & Hidi, 2016). Interest development is a sequential process. The four phases are "triggered situational interest," "maintained situational interest," "emerging individual interest," and "well-developed individual interest" in order (Hidi & Renninger, 2006). Situational interest plays an important role in triggering learners' interest and it is related to the learning environment. Chen, Darst, and Pangrazi (1999) developed a situational interest scale to analyze six sub-dimensions of situational interest. These six sub-dimensions include "exploration intention," which refers to the explorative inclination for a specific environment; "instant enjoyment," which refers to the instant feeling for activities; "novelty," which refers to the gap between new and existing information; "attention demand," which refers to the level of attraction between learners and activities; "challenge," which refers to the difficulty level based on learners' ability; and "total interest," which refers to an evaluation of overall interest of activities (Chen et al., 1999; Chen, Darst, & Pangrazi, 2001). Lin, Yu, Sun, and Jong (in press) indicated that the head mounted display (HMD) VR can significantly enhance learners' novelty and challenge dimensions of situational interest. Yu, Sun, and Chen (2019) also mentioned that university students' situational interest and remembering aspect of learning achievement was improved when they use an AR-based online wearable guide to learn museum content. Situational interest and the remembering aspect of learning achievement have a positive relationship. Therefore, the immersive VR interactive feedback system of this study may trigger learners' situational interest and its sub-dimensions. At the same time, learners' learning achievement may also improve.

2.2 Immersive VR in education

The HMD VR devices provide learners with an immersive VR experience (Ye et al., in press) and help them obtain first-hand and close-to-real perception (Kozhevnikov, Gurlitt, & Kozhevnikov, 2013). The HMD systems include HTC Vive, Oculus Rift, and so on. After undergraduate students wear the HMD VR display to learn relative motion concepts, their learning performance is significantly improved (Kozhevnikov et al., 2013). Alhalabi (2016) also mentioned that HMD VR for learning is better than other VR types. Past studies have found that immersive VR has a positive impact on learning performance in formal education. This research attempted to integrate immersive VR into standard manipulative ability training in a pour over coffee brewing lesson and to analyze the change of learning achievement.

3. Method

3.1 Participants

This study discusses the effect of a VR interactive feedback system on university learners' situational interest and learning achievement. The experiment involved 103 students over the age of 20 from two universities. The participants came from different departments. Among the 103 valid samples, 45 were males and 58 were females. There were 59 undergraduate students, 42 master's students, and 2 doctoral students. The average age of all participants was 22.41 (SD = 2.18) years old.

3.2 Experimental design

Before conducting the experiment, the participants needed to fill out a participant consent form which explained the experimental process, the experimental purpose, and that the participants had the right to leave the experiment at any time if they experienced discomfort. After they understood the content of the participant consent form and accepted it, they had to spend 5 minutes answering a prior knowledge test. Next, the participants were led to participate in the experiment. The researchers explained the operation of the immersive VR interactive feedback system and the participants tested it for approximately 5 minutes. The time of the experiment was about 35 minutes and participants used the immersive VR interactive feedback system to learn how to make pour over coffee. After the experiment, the participants completed a situational interest scale and a learning achievement test which took about 15 minutes. The experimental design chart is shown in Figure 2 and the status of participants using the immersive VR interactive feedback system is shown in Figure 3.
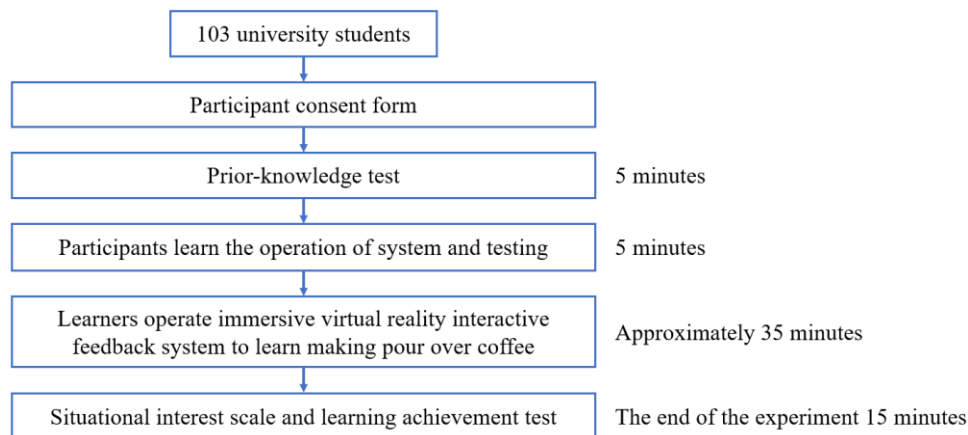
Figure 2. Experimental design chart.

Figure 3. The status of participants using the virtual reality pour over coffee system.

3.3 Instruments

3.3.1 Situational interest scale

The situational interest scale was adapted from Chen et al. (1999). The scale was divided into six dimensions: exploration intention, instant enjoyment, novelty, attention demand, challenge, and total interest. Each dimension had 4 items and the total number of items was 24. It was a 6-point Likert scale, from "1" representing *strongly disagree* to "6" representing *strongly agree*. The Cronbach's α of each dimension was .86, .90, .87, .95, .89 and .93, respectively, while the overall scale was .87.

3.3.2 Prior knowledge test and learning achievement test

The prior knowledge test and learning achievement test were the same and were based on the material of a professional barista lesson. There were 10 multiple-choice questions in the test and each question only had one answer. If the answer was correct, the participant could get one point. If the answer was false, they got zero points. All questions were verified by a professional barista, a professor of e-learning, and a professor of computer science and information engineering to achieve expert validity. After 30 university students filled out this test, the researchers analyzed the level of difficulty and item discrimination for each question. Finally, four items could be reserved, their difficulty level was within .3–.7 (Allen & Yen, 2001), and the item discrimination level was above .2 (Ebel & Frisbie, 1991).

3.3.3 The immersive virtual reality interactive feedback system

The learning topic is the step of making pour over coffee. For this study, the coffee tools 3D model for pour over coffee were downloaded from SketchUp, including the virtual coffee shop environment, swan neck kettles, electric kettles, coffee grinders, and electronic scales. On the other hand, filter cones, filter papers, coffee pots, and coffee cups were structured by 3ds max, and Unity was used to design the 3D animation production, the water flow model, and the water vapor model. Learners used HTC Vive to control the system.

This system was divided into six phases. In the first stage, the learners practiced moving and picking up objects in the VR environment. This phase helped learners to become familiar with the operation of the VR device without any narrators. When the learners understood the functions of the VR device, they could move to the second stage. In the second stage, the user interface displayed the learning steps. Learners could go through the content while trying to click the check button on a window. The third to sixth phases taught the steps of making pour over coffee. The third phase was the coffee tool introduction (Figure 4). When learners emitted a ray by the controllers to point to a coffee tool, the interactive feedback appeared above the tool. Learners could only obtain one instance of interactive feedback at a time. After all interactive feedback was shown to the learners, the next stage window would appear. The fourth phase was a making pour over coffee video which provided a professional sample to learners (Figure 5). The video showed the usage of coffee tools and used them to explain the posture of making pour over coffee and related knowledge. Learners could replay this video until they understood the content. The fifth phase was the pour over coffee unit program (Figure 6). The process of making pour over coffee was cut into three unit programs. Each unit had different interactive feedback. Interactive feedback can help learners to make pour over coffee step by step by themselves. The system can also specify to learners which part they are doing wrong and the corresponding correct procedures. They could also repeat practicing the programs until they were familiar with the process. All interactive feedback was displayed in black and red words on a window. Red words mean important keywords. The final phase was the final test which asked the learner to complete an overall process of making coffee without any interactive feedback in the VR environment. In this step, if learners did wrong operations, the system recorded the error and deducted points. The system stopped recording learning behaviors when the learner completed the whole process of brewing pour over coffee. At the end of the operations, the learner could get their final score and detailed criteria of the deducted points in order.

Figure 4. The interface of coffee tool introduction.
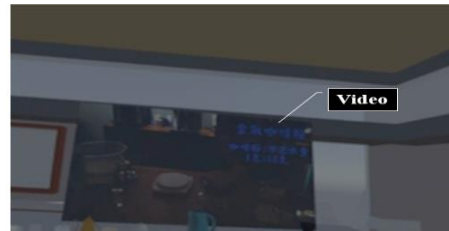
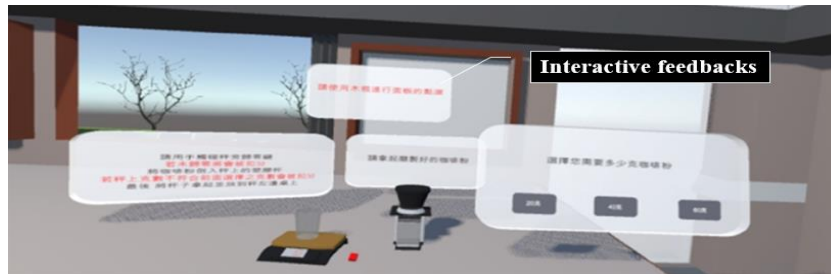*Figure 5.* The interface of making pour over coffee video.

Figure 6. Pour over coffee unit programs.

4. Result and discussion

As shown in Table 1, the result of the paired t test revealed that the average score of the post-test (M = 3.01, SD = 0.94) was significantly higher than that of the pre-test (M = 2.03, SD = 1.04), and $t(102)$ = -8.82 , $p < .001$. This finding means that learners can obtain more knowledge of pour over coffee after they use the immersive VR interactive feedback system, which conforms to the studies of Alhalabi (2016) and Kozhevnikov et al. (2013).

Table 1

The Result of the Paired t test of Learning Achievement

Variable	Pre-test		Post-test		t
	Mean	*SD*	*Mean*	*SD*	
Learning achievement	2.03	1.04	3.01	0.94	-8.82***

*** $p < .001$

       As shown in Table 2, the average score of sub-dimensions of situational interest from high to low is total interest (M = 5.12, SD = 0.75), instant enjoyment (M = 4.88, SD = 0.89), attention demand (M = 4.85, SD = 0.99), novelty (M = 4.70, SD = 0.90), exploration intention (M = 4.60, SD = 0.81), and challenge (M = 2.96, SD = 1.17). Only the challenge dimension did not achieve an average level. This result revealed that the immersive VR interactive feedback system can trigger all sub-dimensions of situational interest except for challenge. As Yu et al. (2019) suggested, a high level of challenge may cause learners to reduce their learning willingness in informal education. This research topic is informal education and so did not require learners to get high scores or set goals. The difficulty of this system may not exceed the average level of learners' ability because of the low challenge score.

Table 2

The Result of Descriptive Statistics of Situational Interest and Its Sub-dimensions

Variable	*Mean*	*SD*	Rank
Situational interest	4.52	0.52	
Exploration intention	4.60	0.81	5
Instant enjoyment	4.88	0.89	2
Novelty	4.70	0.90	4
Attention demand	4.85	0.99	3
Challenge	2.96	1.17	6
Total interest	5.12	0.75	1

5. Conclusion

This study examined the effect of an immersive VR interactive feedback system on university students' situational interest and learning achievement. The results showed that the immersive VR interactive feedback system can trigger some of the sub-dimensions of situational interest to an average level and improve learning achievement. In the future, it is suggested that teachers can use an immersive VR interactive feedback system to teach multiple-step lessons or trigger learners' learning motivation. The future works can compare different pedagogies, demographics, and feedback types to obtain deeper understanding of the effects of immersive VR interactive feedback systems.

Acknowledgements

References

Alhalabi, W. S. (2016). Virtual reality systems enhance students' achievements in engineering education. *Behaviour & Information Technology, 35*(11), 919-925. doi:10.1080/0144929X.2016.1212931

Allen, M. J., & Yen, W. M. (2001). *Introduction to measurement theory*. Long Grove, IL: Waveland Pr Inc.

Blascovich, J., & Bailenson, J. (2005). Immersive virtual environments and education simulations. In S. Cohen, K. E. Portney, D. Rehberger, & C. Thorsen (Eds.), *Virtual decisions: Digital simulations for teaching reasoning in the social sciences and humanities*. Mahwah, NJ: Lawrence Erlbaum Assoc Inc.

Chen, A., Darst, P. W., & Pangrazi, R. P. (1999). What constitutes situational interest? Validating a construct in physical education. *Measurement in Physical Education and Exercise Science, 3*(3), 157-180.

Chen, A., Darst, P. W., & Pangrazi, R. P. (2001). An examination of situational interest and its sources in physical education. *British Journal of Educational Psychology, 71*(3), 383-400.

Ebel, R. L., & Frisbie, D. A. (1991). *Essentials of educational measurement* (5th ed.). Englewood Cliffs, NJ: Prentice-Hall.

Folmer, B. (2017). *The craft and science of coffee*. London, United Kingdom: Elsevier.

FONA. (2017). Category insight report. Retrieved from http://www.fona.com/wp-content/uploads/2017/12/1217-coffee-part-1_FONA.pdf

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist, 41*(2), 111-127.

Kozhevnikov, M., Gurlitt, J., & Kozhevnikov, M. (2013). Learning relative motion concepts in immersive and non-immersive virtual environments. *Journal of Science Education and Technology, 22*(6), 952-962. doi:10.1007/s10956-013-9441-0

Lin, H. C.-S., Yu, S.-J., Sun, J. C.-Y., & Jong, M. S. Y. (in press). Engaging university students in a library guide through wearable spherical video-based virtual reality: Effects on situational interest and cognitive load. *Interactive Learning Environments*. doi:10.1080/10494820.2019.1624579

Loomis, J. M., Blascovich, J. J., & Beall, A. C. (1999). Immersive virtual environment technology as a basic research tool in psychology. *Behavior Research Methods, Instruments, & Computers, 31*(4), 557-564.

Mealy, P. (2018). *Virtual & augmented reality for dummies*. Hoboken, NJ: John wiley & Sons, Inc.

National Coffee Association. (2018). By the numbers: US coffee consumption. Retrieved from https://nationalcoffee.blog/2018/09/26/by-the-numbers-us-coffee-consumption/

Renninger, K. A., & Hidi, S. E. (2016). *The power of interest for motivation and engagement*. New York, NY: Routledge.

Yang, J. C., Chen, C. H., & Jeng, M. C. (2010). Integrating video-capture virtual reality technology into a physically interactive learning environment for English learning. *Computers & Education, 55*, 1346-1356.

Ye, X., Liu, P.-F., Lee, X.-Z., Zhang, Y.-Q., & Chiu, C.-K. (in press). Classroom misbehaviour management: An SVVR-based training system for preservice teachers. *Interactive Learning Environments*. doi:10.1080/10494820.2019.1579235

Yu, S.-J., Sun, J. C.-Y., & Chen, O. T.-C. (2019). Effect of AR-based online wearable guides on university students' situational interest and learning performance. *Universal Access in the Information Society, 18*(2), 287-299. doi:10.1007/s10209-017-0591-3

A Museum Guiding and Learning System Based on Augment Reality and Wearable Technology

Huai-Ling Chang[a] and Kai-Yi Chin[a*]
[a]*Department of Digital Humanities, Aletheia University, New Taipei City, Taiwan*
*au0292@mail.au.edu.tw

Abstract: The common ways of museum guide are manual guide and voice guide, but both ways can only make people passively absorb relevant historical knowledge, which can easily reduce people's enthusiasm for learning, and the learning effect after the guide is not good. With the rapid development of information technology, museums begin to use new technology to change the way to communicate and interact with people. In view of this, this study develops a wearable guide and learning system based on Augmented Reality (AR). Seven modules have been planned, including Teaching Material Download Module, Main Menu Module, Map Module, Object Identification Module, guide information module, test module and learning process module. Through the presentation of Smart glasses, it combines the real world with virtual information to create a new environment in which the learners can be immersed and interact with each other in real time. In addition, this study takes the monuments surrounding Tamsui District in northern Taiwan as the object, and designs five units of textbooks, and makes multimedia textbooks mainly on the historical allusions and cultural backgrounds of historical sites as well as museum collections, which extends the guide activities from single sensory stimulation to intuitionistic audio-visual experience, so as to enhance learners' willingness to learn and strengthen the effectiveness of museum guide education.

Keywords: Wearable device, Augmented reality, Museum guide, Mobile guide system

1. Introduction

Nowadays, countries around the world have been paying more and more attention to people's right to education. The scientific and technological development and the transformation of economic structure are accelerating, as a result of which, large amounts of information can be copied and spread widely and rapidly, leading to the phenomenon of "half-life of knowledge" in terms of the knowledge and technology needed in human life (Ho & Liu, 1997).As a result, increasing attentions have been paid to the view of lifelong learning. The meaning of "lifelong learning" lies in the continuous learning process in one's life and in the fact that everyone enjoys the opportunity of universal learning. Through self-pursuit and external assistance, individuals can adapt themselves to the environment and achieve their potential development and self-realization (Chung & Lee, 2000). Taiwan has been actively strengthening the promotion of lifelong education since the 1980s. In 1995, the government launched the "Education Report of the Republic of China: Towards the Vision of Education in the 21st Century", which set "establishing a lifelong education system and marching towards a lifelong learning society" as an important indicator of Taiwan's education system ucation(Lin, 1997), the most important function of museums is to provide the opportunities of lifelong learning. Therefore, in response to the national policy, the Ministry of Education issued a white paper Towards a Learning Society in 1998 (Ministry of Education, 1998), explicitly listing museums as important educational institutions for implementation of educational activities, which has become a common consensus in modern society(Lai, 2007).

At present, there are three kinds of common museum guide modes. The first one is to conduct museum guide activities by guiding the public through the commentators on the spot. The second one is to provide rental equipment to provide users with voice guide through pre-prepared introduction tapes. The last one is to place KIOSK system guide machines in museums for visitors to inquire about guide objects in the museums. However, no matter in which way, the public can only passively absorb relevant historical knowledge, and few customized interactive guide mechanism is provided in the interactive process, which may easily reduce the public enthusiasm for learning, and the learning effect

after the guide is not good either. In order to solve the above problems, researchers in related fields began to apply mobile technology to museum guide in order to improve the internal operation functions and external communication efficiency, and establish a new way of interaction with the public to provide a more friendly and convenient tool for information guide (Sung, Chang & Yu, 2006).

Among the numerous tools applying mobile technology, the use of hand-held mobile devices has been more common in recent years. For example, Lin (2017) has developed a mobile guide system using pervasive games based on AR. Taking the temple of New Taipei City as an example, visitors can hold mobile phones and understand the culture and backgrounds of the surrounding objects through pervasive games. Tung (2012) applied the mobile digital guide to the Chimei Museum. By scans the QR coded files with a camera application in the mobile device, the visitors will receive the guide screen with pictures and texts and enjoy the interactive guide experience (Tung, 2012). Most of these related research results show that, in the actual guide learning, if hand-held mobile devices are used in guide tour services, the learning effect is often higher than that with traditional guide tours. Therefore, the combination of museum guide tour service and mobile devices is in line with the expectation and development direction of modern society (Wang & Shih, 2012).

The increasingly mature mobile technology has gradually developed into wearable devices. The rise of Wearable Device has brought a new wave of technology applications. Researchers have begun to try to combine mobile guide with wearable devices in order to achieve more intuitive and amazing interactive effects. This kind of guide system is often considered to have the following advantages: 1) free the hands of learners, so that learners can take pictures and talk without holding a mobile phone; 2) free from the constraints of location and light, so that the visitors can clearly read the exhibit information; 3) virtual information can be superimposed on the real world, so that learners can receive information in a more intuitive way (Zheng & Li, 2015). However, the study of introducing wearable devices in museum guide is still in the beginning stage. The educational and application values of museum guide still have considerable potentials that deserve further exploration (Damala, Marchal & Houlier., 2007).

This research develops a wearable guide and learning system based on AR, and make development through Android platform and smart glasses Glass Enterprise Edition 2. It also plans seven modules, including Teaching Material Download Module, Main Menu Module, Map Module, Object Identification Module, guide information module, test module and learning module. Through the presentation of smart glasses, the real world is integrated with virtual information to create a new environment for learners to be immersed and interact in real time. Finally, this study takes the monuments surrounding Tamsui District in northern Taiwan as the object, and designs five units of textbooks, including Fortress San Domingo, Oxford College, Little White House (Tamsui Customs Officers' Residence), Tamsui Church, Mackay Memorial Museum. Multimedia textbooks are produced mainly on the historical allusions and cultural backgrounds of historical sites as well as museum collections including text narrative, pictures and films etc. Smart glasses with pre-camera lens can automatically detect exhibits and then directly present exhibits information on the screen. In this way, the guide can be expanded from a single sensory stimulus to a comprehensive audio-visual experience including audio and video elements, so that learners can carry out learning activities of historic site tour through the guide system provided by this study. It could not only enhance the learners' willingness to learn, but also strengthen the effectiveness of guided museum education.

2. Literature Review

2.1 Application of Wearable Devices

Wearable devices refer to the use of various perception systems to capture information from different environments or users through embedded devices, and timely feedback the information to users after fusion processing, or send the information to the cloud for further analysis and storage. Its purpose is to provide convenience, stability and portability. In most situations, hand-free operation is adopted (Huang, Lin & Chen, 2016). Wearable device has the following functions: 1) it has the sensing and networking functions, and can automatically detect, collect, display or transmit information for a long time; 2) it has the ability of data transmission on the Internet; 3) it is convenient for users to wear for a

long time without affecting their daily life and rest. Wearable device has a wide range of applications, such as criminal forensics and educational application.

For example, in the field of criminal forensics, Li (2018) integrates the concepts of "wearable device" and "forensic cloud", and designs system modules so that investigators can transmit 3D images of the scene to the crime scene command center and image database through wireless transmission by means of "wearable search equipment", and makes use of online "video conference mode" to invite experts from all fields to consult, discuss the best treatment strategy, integrate multiple resources and provide necessary assistance (Li, Fang, Lin & Huang, 2018). Swathi and Lanka (2015) also apply wearable devices to medical subjects, allowing learners to freely choose different tools (mobile phones, laptops, smart watches, smart glasses, etc.) for learning purposes. The results also show that the number of college students who are willing to use wearable devices has greatly increased compared with the past. Moreover, wearable devices can make teachers and students interact intuitively in different places, which could greatly improve the convenience and interesting of learning.

As mentioned above, wearable devices have been applied in many fields. The major application directions include medical, entertainment, sports, fitness and even some special application fields like military purposes. However, research on the introduction of wearable device into museum guides is still in the beginning stage and still has great potential for educational and application value of museum guides (Chiang, Yang & Hwang, 2014). Therefore, this research applies wearable devices to museum guide in order to provide more diversified and innovative guide modes for museums.

2.2 Application of AR

Augmented Reality (AR) is defined as a technology that combines virtual images with the real world and allows users to be immersed into it and interact in real time. AR should have three basic features: 1) combining real and virtual objects in the same interface; 2) displaying virtual objects in real environment in real time; 3) superimposing virtual objects on real environment, allowing interactions with users (Azuma, 1997). AR is not limited by time and space. It can make interactions more dramatic and stimulate sensory feelings through the integration of real scenes (Wang, 2006). With the development of information technology, the application of AR is more diversified.

In recent years, many scholars and researchers have tried to apply AR to various fields, such as medical research, education learning, military and police research, with great potential in all fields. In foreign cases, Shelton and Hedley (2002) combined nine planetary teaching experiments into the AR, so that teachers can use a small amount of teaching materials to teach and learners can construct abstract scientific concept with AR materials to improve their own understanding. In addition, Weng, Bee, Yew and Hsia (2016) used AR technology to introduce the biological sciences of Malaysian secondary schools, including cell mitosis, meiosis, respiratory function and their systematic relationships. They also used AR icons to scan the virtual stereo models and related photos to learn biology knowledge, so as to strengthen learners' memory and understanding of biological concepts. In Taiwan, many scholars have also applied AR to teaching. For example, Li (2011) built an AR guide learning system for museums, designed guide tours based on exploratory learning theory, and created interactive museum environment. Users can take guide tours and learning in museums through mobile tools, which can deepen users' impression of exhibits and enhance their learning effectiveness.

According to the above-mentioned cases, AR can integrate words and pictures to make exhibits more lively and vivid. Besides, it can also clearly and unambiguously present the subject knowledge which is difficult to express. Therefore, applying AR to many fields will have more creations and possibilities, and improve the learners' knowledge, memory and learning effectiveness. More importantly, it can foster learner's understanding of the learning content, satisfy the learner's sense of achievement in learning knowledge, and arouse the learner's enthusiasm and motivation for learning (Lin, 2009). In other words, AR has such advantages as the integration of the virtual and the reality, instant interaction, and operation in 3D environment. If applied properly, AR can communicate effectively with learners and improve learning effectiveness and interest (Kuo, 2008).

Therefore, compared with traditional guide with tour guides, this study combines AR with wearable devices. When the learners look at the exhibits, they are immediately provided with information and films about the exhibits, so that the learners can read the exhibits more intuitively, and interact directly with the exhibition information with their hands free.

3. AR-based Wearable Guide learning System

This study provides smart glasses for on-site guide of historic sites so as to assist learners in learning. In order to achieve the purpose of the study, a wearable AR guide system with a friendly man-machine interaction interface is provided to enable learners to obtain AR virtual information of observed objects in the real environment in a simple and intuitive way. It combines virtual information with reality in an accurate and real-time manner to strengthen learners' learning experience of historic sites in reality, and help learners to understand their own learning effectiveness with the help of a test system.

3.1 Hardware

Figure 1. Glass Enterprise Edition 2

Figure 1 shows the smart glasses named Glass Enterprise Edition 2, which is an optical head-mounted display introduced Google in May 2019. It uses Qualcomm Snapdragon XR1 processor to support computer vision and machine learning functions. The lens resolution can support 720p images. It displays all kinds of information in a hands-free manner similar to smart phones. It is based on the Android platform and can be applied simply by using Android system to compile apps.

3.2 Architecture and Functions of Wearable AR Tour Guide System
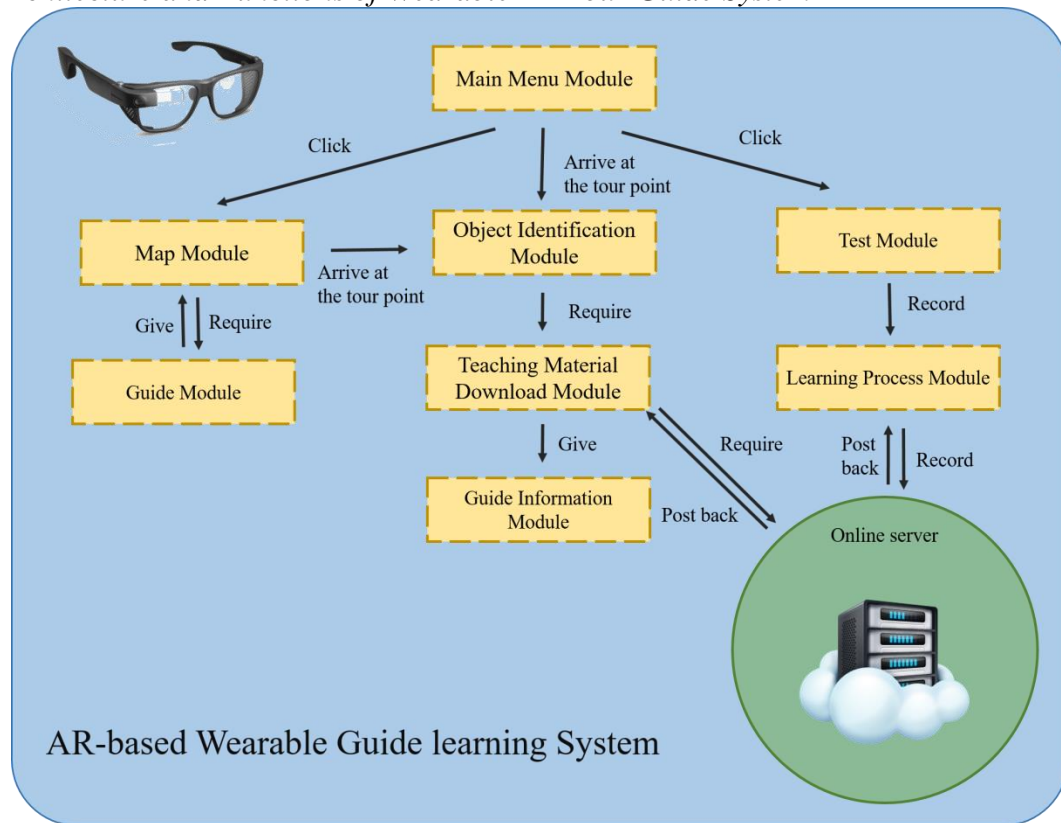
Figure 2. Architecture of AR-based Wearable Guide learning System

As shown in Figure 2, AR-based Wearable Guide learning System consists of eight modules, including Main Menu Module, Map Module, Guide Module, Object Identification Module, Teaching Material Download Module, Guide Information Module, Test Module and Learning Process Module. Firstly, the learner wears smart glasses and the image shows the Main Menu Module. When the learner chooses the Map Module, the picture will imported the Map Module interface, and automatically call the Guide Module to import the learner's historical learning record, so as to guide the learner to the required guide site. When the learner arrives at the guide site, the system will automatically require the Object Identification Module to identify the exhibits, and import the analyzed information into the Teaching Material Download Module, requiring the Teaching Material Download Module to grab the corresponding multimedia teaching materials from the online server, and pass the multimedia teaching material to the Guide Information Module for content playback. Next, when the learner completes the learning activities of a guide point, he can click the Test Module to make a test of the guide point. The test results can be imported into the Learning Process Module and stored in the online server to record learner's learning situation and allow learners to review the tested topics and learning records. The detailed module functions are as follows:

- **Main Menu Module**

The Main Menu Module mainly provides a main menu for learners to select the required module functions in order to complete the required learning work, including Map Module, Object Identification Module, Test Module and so on.

- **Map Module**

This module is mainly used through connection with the built-in Google Maps in smart glasses Glass Enterprise Edition 2. In addition to displaying the location of the surrounding attractions, the map can also locate the learner's location in time under wireless or mobile network environment, and instruct the learner to go to the surrounding guide sites.

- **Guide Module**

Record the guide sites that learners have already visited, and display the guide sites in the Map Module interface, as well as the sites that have not yet been guided, so as to guide users of the tours.

- **Object Identification Module**

It scans the exhibit objects through the upper right lens of smart glasses Glass Enterprise Edition 2 to identify the current object and locate the overlapping position in the teaching material. The information is then transmitted to the Teaching Material Download Module for downloading.

- **Teaching Material Download Module**

This module mainly obtains the information transmitted by Object Identification Module, analyses and processes such information, grabs the corresponding multimedia materials from the online server, and transmits the teaching materials to the Guide Information Module for content playback.

- **Guide Information Module**

After receiving the teaching material from the Teaching Material Download Module, projecting the teaching material on the smart glasses. The learners can read the multimedia materials of the exhibits and directly conduct the guide and learning.

- **Test Module**

The learner can take in-class test when the study at historic site has been completed. There are about 5 questions for each site, which shall be completed within specific time limits. If the learner answers the question correctly, he or she can go directly to the next question. Otherwise, he or she will have a detailed explanation on the question to deepen impression. The test results will be imported into the Learning Process Module for record.

- **Learning Process Module**

After receiving the information transmitted by Test Module, the Learning Process Module would analyze and process the information, and uploads the information to the online server. The learner can also review the tested topics or the learning process records in this module to deepen the learning impression.

3.3 System Interface
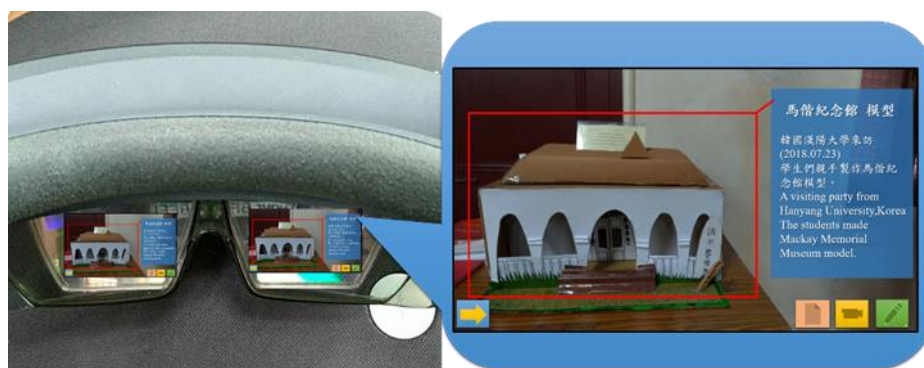
Figure 3. Display of the AR-based Wearable Guide learning System

The wearable AR guide system designed by this research provides learners with an intuitive operation interface by integrating virtual information into the real world and overlapping it on the smart glasses. In the process of using the system, learners will see corresponding learning materials popping out by looking straight at the object, which display images as shown in Figure 3. In addition, with the camera on the machine, the learners can operate to read relevant films or switch the screen. When the learner completes the guide tour, the system can put forward relevant questions to provide the learner with feedback on their learning results. When the learner has completed all the learning, he can also review his own answers to understand the learning experience.

Figure 4. Context of Use of AR-based Wearable Guide learning System

Figure 4 is a Scenario sketch for actual context of use. The learner only needs to wear the device and make the device capture the learning object. The relevant information will be displayed on the screen. The content of the information includes the history introduction, pictures, images and so on of the object, so that the learner can have a thorough understanding of the whole picture of the historical site, and can interact with the exhibits through the free hands.

4. Teaching Material Design

The teaching places of this study are five historical sites in the Tamsui area, including Fortress San Domingo, Oxford College, Little White House (Tamsui Customs Officers' Residence), Tamsui Church and Mackay Memorial Museum. The teaching materials of this study are divided into five units according to the historical sites, with each unit introducing a specific monument museum and its related historical content.

Table 1. Unit Themes

Unit Topic	Visiting Sites	Unit Teaching Objectives
Unit 1 **Mackay and Oxford College**	Oxford College	(1). To understand the historical allusions of the Oxford College. (2). To understand Mackay's story and contribution in Taiwan. (3). To understand the architecture structure and environment of Oxford College.
Unit 2 **Little White House**	Little White House (Tamsui Customs Officers' Residence)	(1). To understand the historical allusions of the Little White House (2). To understand the architecture structure and environment of Little White House (3). To understand the origins and designs of the objects in the Little White House
Unit 3 **Tamsui Church**	Tamsui Church	(1). To understand the historical allusions of the Tamsui Church. (2). To understand the architecture structure and environment of Tamsui Church. (3). To understand the origins and designs of the objects in the Tamsui Church.
Unit 4 **Mackay Memorial Museum**	Mackay Memorial Museum	(1). To understand the historical allusions of the Mackay Memorial Museum. (2). To understand the architecture structure and environment of Mackay Memorial Museum. (3). To understand the origins and designs of the objects in the Mackay Memorial Museum.
Unit 5 **Fortress San Domingo**	Fortress San Domingo	(1). To understand the historical allusions of the Fortress San Domingo. (2). To understand the stories of the Dutch coming to Taiwan. (3). To understand the architecture structure and environment of the Fortress San Domingo.

As shown in Table 1, the courses of this study are divided into five units according to five historical sites in the Tamsui area, including Fortress San Domingo, Oxford College, Little White House (Tamsui Customs Officers' Residence), Tamsui Church and Mackay Memorial Museum. The mainly objective is to enable learners to understand the historical allusions, architectural structure and geographical environment, of the historical sites. A quiz is provided after each unit has been studied. While doing the test, the learner can review the teaching content and clarify whether the knowledge has absorbed correct, so as to deepen the learner's impression of the unit's content.

5. Conclusion and Future Studies

This study constructed an AR-based Wearable Guide learning System which provides a friendly human-computer interaction interface enabling learners to acquire virtual information of exhibits in real environments in a simple and intuitive way and to have a better understanding of the museum. In addition, this study expects that the following work shall be completed in the future：

(1) Complete the integrity testing of the system

The technical development of wearable AR-based guide system proposed in this study has been constructed, and working on debugging. In the future, integrity testing will be carried out to ensure that the system can operate smoothly.

(2) Planning of experimental activities

Experiments on a regular teaching activity should be conducted. During the experiment, the wearable AR-based guide system is introduced into the actual teaching activities with the expectation to collect experimental data with equal emphasis on quality and quantity so as to evaluate the learning effectiveness and motivation and obtain substantial proof of effectiveness.

(3)Formal introduction of the system into museums to support tour guides

It is hoped that the wearable AR-based guide system proposed in this study will be introduced into the museums' guide and learning activities in the future to ease the shortage of guides for historic sites around Tamsui and make the museums' guide activities more attractive.

ACKNOWLEDGMENT

References

Azuma, R. T. (1997). A survey of augmented reality. *Teleoperators and Virtual Environments. 6*(4), 355-385.

Chiang, T. H., Yang, S. J., & Hwang, G. J. (2014). Students' online interactive patterns in augmented reality-based inquiry activities. *Computers & Education, 78*, 97-108. doi: 10.1016/j.compedu.2014.05.006

Chung, Y. P., & Lee, Y. C. (2000). Museum Lifelong Learning Concepts and System Building: Experience of England. *Museology Quarterly, 14*(2), 27-35.

Damala, A., Marchal, I., & Houlier, P. (2007, October).Merging Augmented Reality Based Features in Mobile Multimedia Museum Guides. *XXI International CIPA Symposium*, Athens, Greece.

Ho, C. J., & Liu, J. R. (1997). Lifelong Learning or Lifetime Learning? *Museology Quarterly, 11*(4), 3-5.

Huang, G. H., Lin, Y. Y., & Chen, Dong. Y. (2016, November). The Development of Wearable Augmented Reality Cooking Systems. *2016 Taiwan Academic Network Conference*. National Dong Hwa University, Taitung, Taiwan.

Kuo, S. W. (2008). Preliminary Study on the Application of Augmented Reality in Museum Exhibition. *Technology Museum Review, 12*(4), 25-37. doi： 10.6432/TMR.200812.0025

Lai, C. J. (2007). Museum and the Promotion of the Life-long Learning: A Case Study of Opening the Library at the National Museum of Natural Science. *Technology Museum Review, 11*(3), 97-106.

Li, C. L., Fang, Y., Lin, C. Y., & Huang, L. W. (2018, November). *The Application of Wearable Device with Smart Technology in Crime Scene Investigation.* 2018 Taiwan Academic NETwork conference, National Central University, Taoyuan City, Taiwan. doi： 10.6861/TANET.201810.0068

Li, H. I. (2011).*Building interactive learning environment by augmented reality technology-The case of National Taiwan Science Education Center* (M.S. thesis). Department of Technology Application and Human Resource Development, National Taiwan Normal University.

Lin, S. H. (2009). *The Influence of Infusing Augmented Reality into Mobile Learning on Elementary School Students' Learning Motivation and Achievement in Science and Technology*(M.S. thesis). Department of Information and Learning Technology, National University of Tainan.

Lin, S. Y. (1997).Services of Museum and Lifelong Learning of People. *Museology Quarterly, 11*(4), 7-11.

Lin, Y. H. (2017). *The Study on the Application in the Combination of Pervasive Gaming and Augmented Reality in the Temple Tour between Users with Different Cognitive Styles* (M.S. thesis). Department of Information and Learning Technology, National University of Tainan.

Ministry of Education. (1998). *The white paper of towards a learning society*. Taipei. Retrieved from https://ws.moe.edu.tw/001/Upload/3/RelFile/6315/6938/87.03%E9%82%81%E5%90%91%E5%AD%B8 %E7%BF%92%E7%A4%BE%E6%9C%83%E7%99%BD%E7%9A%AE%E6%9B%B8.pdf.

Shelton, B.E., & Hedley, N.R. (2002, February).*Using augmented reality for teaching Earth-Sun relationships to undergraduate geography students*. Paper presented at The First IEEE International Augmented Reality Toolkit Workshop, Darmstadt, Germany.

Sung, Y. T., Chang, K. E., & Yu W. J. (2006). Usage of Mobile Devices in Museums: Promotion of Human-Computer-Situation Interactive Design. *Museology Quarterly, 20*(1), 17-34.

Swathi, T. N., & Lanka, S. (2015). Wearable technology a new paradigm in Educational Universities. *International Journal on Computer Science and Engineering, 7*(4), 48-52.

Tung T. M. (2012). *Interactive and Mobile Feature applied to Museum Audio-Visual Navigation System* (M.S. thesis). Department of Digital Living Technology, Kun Shan University.

Wang, Y. C. (2006). Discussion on the Innovation of E-Learning based on the concept of Augmented Reality. *Distance Education Essays, 20*, 40-63.

Wang,Y. P., & Shih, N. Y. (2012,June). *Applying QR Code in Cloud Mobile Tour System －Taking The Mobile Tour System of Changhua Confucius Temple as an Example*. 2012 International Conference on Electronics Engineering and Technology Symposium conducted at the meeting of National Taipei University of Education, Taipei, Taiwan.

Weng, N. G., Bee, O. Y., Yew, L. H., & Hsia, T.E. (2016). An augmented reality system for biology science education in Malaysia. *International Journal of Innovative Computing, 6*(2), 8-3.

Zheng, Y. G., & Li, L. C. (2015). *A Study of User Experience Research for Technological Museum Guide* (M.S. thesis). Department of Interaction Design, National Taipei University of Technology.

EXTENDED SUMMARIES

Comparison between Self-awareness of Academic Procrastination and Actual Learning Activity

Yuna ISHII [a*], Izumi HORIKOSHI[a] & Yasuhisa TAMURA[b]
[a] *Graduate School of Science and Technology,*
Sophia University, Japan
[b] *Dept. Information and Communication Sciences,*
Sophia University, Japan
*y-ishii-9nw@eagle.sophia.ac.jp

Abstract: This paper focused on academic procrastination by comparing students' self-awareness of academic procrastination with their actual learning activity. We used questionnaires to measure students' self-awareness of academic procrastination and LMS (Learning Management System) learning histories to measure their actual learning activities. The results from these comparisons indicate that the participants who do not recognize their procrastination habits tend to actually postpone beginning assigned tasks.

Keywords: Procrastination, self-awareness, actual learning activity, LMS

1. Introduction

Previous research has reported that university students often engage in academic procrastination (Ellis & Knaus, 1977), which means that "learners don't begin the task immediately and don't submit the task by the deadline" (Lay, 1986). There is a substantial amount of existing research on this topic, and such studies use questionnaires or learning histories to measure academic procrastination. In the former, academic procrastination is measured based on students' answers to questions about beginning and submitting tasks. In the latter, LMS (Learning Management System) etc. are used to collect students' learning histories to measure academic procrastination. Previous studies have used either questionnaires (e.g., Fujita, 2005; Klassen et al., 2008) or LMS learning histories (e.g., Cerezo et al., 2017) to measure procrastination, but not both.

However, using only either questionnaires or learning histories does not allow researchers to identify the difference between students' self-awareness of academic procrastination and their actual learning activities. This is because questionnaires are subjective while learning histories are objective measurements.

We therefore hypothesized that there is a difference between students' self-awareness of academic procrastination and their actual learning activities. To test this hypothesis, we propose using both measurements and comparing the results (Figure 1).

If there is a difference between the two measurement results, we will discover the specific tendencies via further analyses. For example—
- The learning tendencies of the students who recognize their academic procrastination.
- The learning tendencies of the students who do not recognize their academic procrastination.

If we do find that specific tendencies exist, teachers will be able to predict their students' behavior by understanding their self-awareness of academic procrastination. Teachers will subsequently be able to set tasks and manage students based on their predictions. Our hope is that lesson designs will be improved.
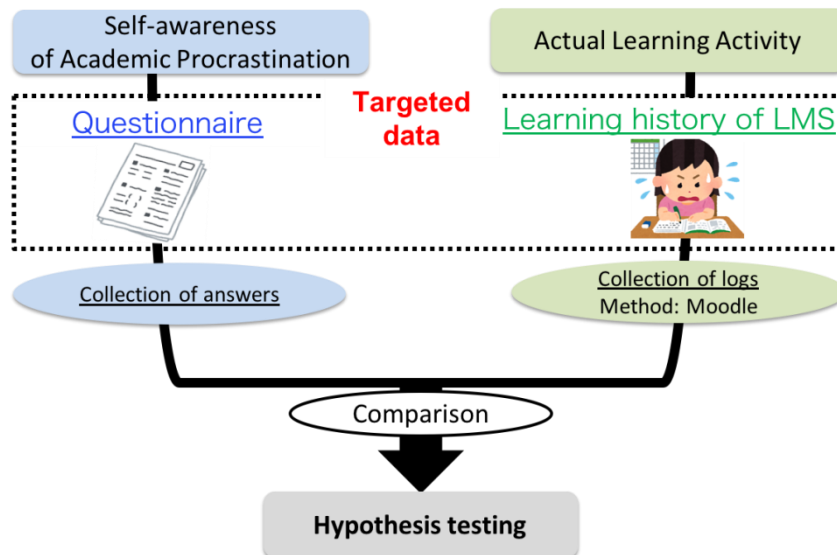
Figure 1. Proposal of this research

2. Method

2.1 Targeted Data

- *Self-awareness of Academic Procrastination*

We created a nine-item questionnaire based on Fujita (2005) and Aitken (1983), with responses measured on a five-point scale from "strongly agree" (1) to "strongly disagree" (5). We collected the respondents' questionnaire answers.

- *Actual Learning Activity*

We used "Moodle" to collect learning histories on the students' progress on a task. For example— log 1: browsing history of the task description pages; log 2: download history of the task; log 3: date the task was submitted.

2.2 Experiment

First, the participants answered the questionnaire items. Second, the participants worked on a task (creating presentation materials) and we collected learning histories on their progress. As noted in Section 2.1, the collected log items ranged from log1 to log3. The task was divided into four subtasks—

- Subtask 1: Decide on the presentation theme
- Subtask 2: Collect reference materials on the theme
- Subtask 3: Create a figure to be cited in the presentation
- Subtask 4: Create the presentation

These subtasks were set usage limits which the participants could not work on the next subtask until they finished the previous subtask. For that reason, the participants worked on these subtasks from Subtask 1 in order. Then, we compared these learning histories to the participants' questionnaire answers and measured whether there was a difference between their self-awareness of academic procrastination and actual learning activity.

We conducted an experiment to verify our hypothesis, using students in an Information Literacy course at Sophia University in 2018. The experimental period was from December 10 to December 17, 2018. 47 out of 82 students agreed to participate in this research.

3. Analysis

We analyzed the responses to the following questionnaire item—"Do you postpone working on things to the last minute?". This questionnaire item is related to the beginning the task. For that reason, we calculated the Subtask 1 submission rate. The analytical methods are displayed below.

- Analysis 1: We set the questionnaire responses as students' *degree of procrastination,* which captures the degree of procrastination that the participants recognize (self-awareness).
- Analysis 2: We grouped the participants by their *degree of procrastination* (self-awareness). Then, we calculated each group's Subtask 1 submission rate and used them to understand the participants' progress on the task. Figure 2 shows each group's Subtask 1 submission rate transition.
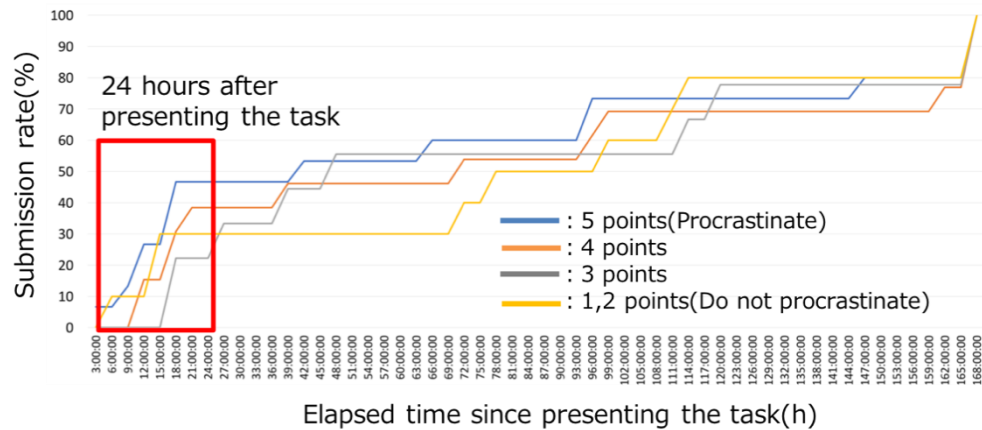
Figure 2. Transition of submission rates

- Analysis 3: We set *degree of procrastination* (actual learning activity) which demonstrates how much the participants had postponed the task actually. The setting methods are explained below. We focused on the submission rate 24 hours after presenting the task to students. Then, we ranked the groups in descending order based on their submission rates. We used this ranking to score their progress on the task (1st place [1 point] to 5th place [5 points]) and their *degree of procrastination* (actual learning activity).

- Analysis 4: We compared each group's *degree of procrastination* (self-awareness) and their *degree of procrastination* (actual learning activity) to verify the hypothesis.

4. Results

- **Questionnaire item "Do you postpone working on things to the last minute?"**

In Analysis 1 and Analysis 3, we set the two *degrees of procrastination.* Table 1 shows the results.

Table 1

Results of degree of procrastination self-awareness and actual learning activity

Degree of procrastination	Degree of procrastination (self-awareness)	Score(progress on the task) =Degree of procrastination (actual learning activity)
Procrastinate / Procrastinated	5 points (15people)	1 point
	4 points (13people)	2 points
	3 points (9people)	4 points
Do not procrastinate / Did not procrastinate	1,2 points (10people)	5 points

The results of Table 1 are illustrated in Figure 3.
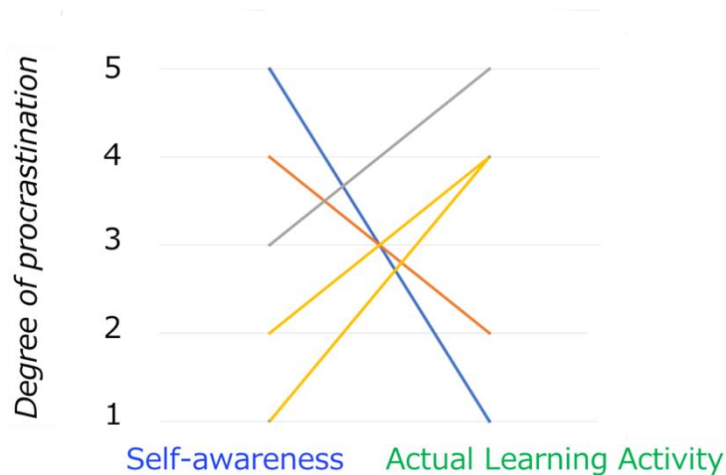
Figure 3. comparison of *degree of procrastination* between self-awareness and actual learning activity
(In Figure 3, the two *degrees of procrastination* are five-step evaluations
from "do not procrastinate" (1 point) to "procrastinate" (5 points).)

- Result A: The group with lower *degree of procrastination* (self-awareness) scores received higher *degree of procrastination* (actual learning activity) scores. We therefore found that these two procrastination measurement scores conflicted.

Receiving Result A, we made a correlation analysis of the *degree of procrastination* between self-awareness and actual learning activity. Figure 4 shows the result.
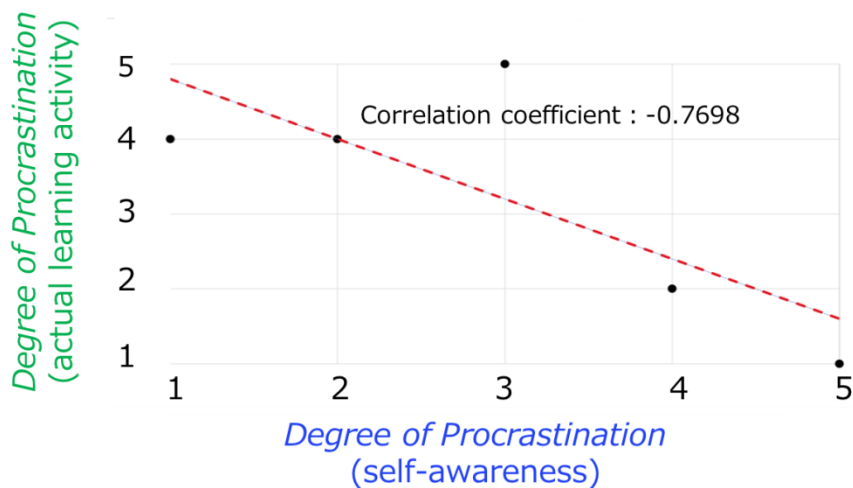
Figure 4. Correlation analysis of *degree of procrastination* between self-awareness and actual learning activity (In Figure 4, the two *degrees of procrastination* are five-step evaluations from "do not procrastinate" (1 point) to "procrastinate" (5 points).)

- Result B: The above results indicate that there is a negative correlation between degree of procrastination (self-awareness) and degree of procrastination (actual learning activity) (r =-.770, ns). In other words, the participants who did not recognize their procrastination habit tended to actually postpone their beginning of the task (hereinafter, referred to as "Procrastinator"). Thus, there was a clear difference between students' self-awareness of academic procrastination and their actual learning activities.

5. Discussion

Result B clearly indicates that there were procrastinators. We expect that the result might be affected by the student's self-strictness. For example, if the participants are easy on themselves (Figure 5), we expect that they gently evaluate themselves. Therefore, such participants might have evaluated themselves as procrastinators. While we expect that they would set easy learning goals for themselves. Therefore, such participants might not have immediately began the task. In other words, they procrastinated. Based on this discussion, we think that there were procrastinators.
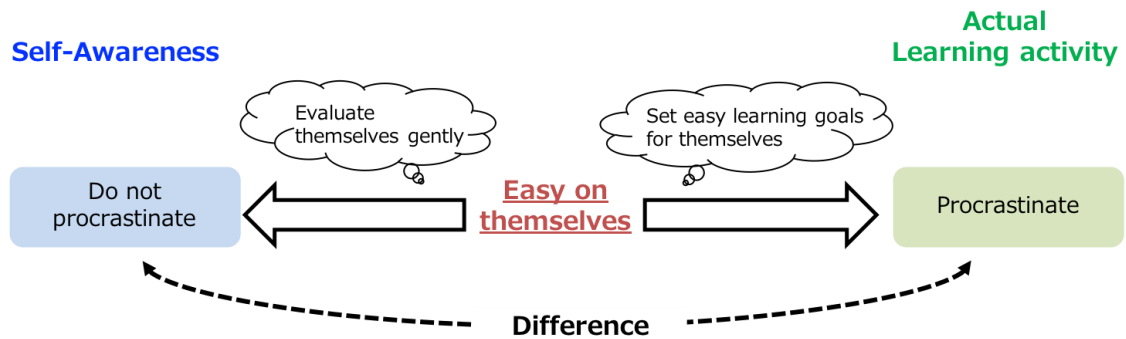
Figure 5. Conceptual Framework for Discussion

6. Conclusion and Future Work

In this study, we verified our hypothesis that there would be a difference between students' self-awareness of academic procrastination and their actual learning activities. Result B clearly indicated that there were procrastinators. The results also demonstrate that there was a clear difference between students' self-awareness of academic procrastination and their actual learning activities. In addition, we expect that the results might be affected students' self-strictness.

Also, we were unable to analyze all questionnaire items. It is important that we use our future work to analyze these items to better understand self-awareness of academic procrastination and actual learning activity.

References

Aitken, M. E. (1983). A personality profile of the college student procrastinator. *Dissertation Abstracts International, 43*(3-A), 722-723.

Cerezo, R., Esteban, M., Sanchez-Santillan M., & Nunez, J. C. (2017). Procrastinating behavior in computer-based learning environments to predict performance: A case study in Moodle. *Frontiers in Psychology*, *8*(1403), 1-22.

Ellis, A., & Knaus, W. J. (1977). *Overcoming Procrastination: Or How to Think and Act Rationally in Spite of Life's Inevitable Hassles.* New York, NY: Institute for Rational Living, 207-216.

Fujita, T. (2005). A student of the relation of procrastination behavior and error behavior. *Bulletin of the Integrated Center for Education Research and Training*, *14,* 43-46 (in Japanese.)

Klassen, R. M., Krawchuk, L. L., & Rajani, S. (2008). Academic procrastination of undergraduates: Low self-efficacy to self-regulate predicts higher levels of procrastination. *Contemporary Educational Psychology*, *33*(4), 915-931.

Lay, C. H. (1986). At last, my research article on procrastination. *Journal of Research in Personality*, *20*(4), 474-495.

Visualizing the language of teamwork

Elizabeth KOH[a*], Simon YANG[a], Dhivya SURESH[a], Yi Huan TEE[a] & Claire LEE[a]
[a]*National Institute of Education, Nanyang Technological University, Singapore*
*elizabeth.koh@nie.edu.sg

Abstract: As 21st Century problems require increasingly complex and creative solutions that are achieved through collaboration, the ability to work effectively in teams has become more important over time. To help students collaborate better, a digital formative assessment tool, My Groupwork Buddy, was developed to build teamwork competency using analytics. The scope of this paper focuses on the recent development of teamwork chatlog visualizations. This paper describes the building of the teamwork text classification system, system flow and two visualizations. Work is underway to evaluate the system, and future work includes refinements to integrate these new visualizations in the system to enable a more holistic formative assessment.

Keywords: Teamwork, discourse analytics, visualization, formative assessment

1. Introduction

As 21st Century problems require increasingly complex and creative solutions that are achieved through collaboration, the ability to work effectively in teams has become more important over time. Formative assessment is one key means to help students develop their teamwork. Utilizing the power of learning analytics, a digital formative assessment tool, My Groupwork Buddy (MGB), was developed. In MGB, four teamwork competency dimensions are focused on to help students during the process of collaborating in a team - coordination (COD), mutual performance monitoring (MPM), constructive conflict (CCF), and team emotional support (TES). These teamwork dimensions, based on extant literature on what good teamwork skills are, have been assessed using self and peer ratings and a visual dashboard from disposition analytics shown to trigger students' awareness and sensemaking (Koh, Hong, & Tan, 2018). A concurrent and more tedious development has been the assessment of teamwork competency dialogue from a chatlog (Suresh, Lek, & Koh, 2018). In this paper, we detail our most recent endeavor to visualize chatlog text in real-time of the four dimensions. The use of discourse analytics will complement the existing disposition analytics and provide a more holistic understanding of students' teamwork processes.

The next section explains the teamwork text classification system (TTCS). This is followed by an elaboration of the discourse (chatlog) analytics visualization process on MGB. A brief discussion concludes the paper.

2. Establishing the Teamwork Text Classification System

In order to generate a model that will automatically classify student chat data into the four teamwork dimensions, NLP techniques such as Named Entity Recognition (NER) and feature engineering were carried out followed by a multi-label classification. The TTCS has been developed using Python 3.7.x and the process is as follows.

First, data pre-processing is performed to handle the irregularities in the chat text. This includes emotions and punctuation tagging, chat abbreviation expansion, local terms replacement, and replacement of names in the text. The names were identified using Stanford NER model and then replaced with a generic {{NAME}} tag, thereby grouping similar features together, resulting in a better predicting classifier. The feature engineering process follows this; ten new features were created with context-sensitive rules using indicative terms dictionary, POS tagging and regular expressions. Next, using a tf-idf vectorizer from sci-kit learn, the messages are vectorized. All features extracted including the ten new features are passed to a classifier to carry out the multi-label classification (See Suresh, Lek,

& Koh, 2018). The classifier for our TTCS has been trained extensively and has the following benchmark metrics - precision: .855, recall: .651, accuracy: .701.

Through this development, TTCS has undergone revisions to enhance its reliability and execution time. In earlier versions, each step was designed as an independent module but in order to automate the process, all the modules were integrated. Also, an earlier version included a spelling correction module but this code was incompatible with 64-bit operating systems. This module was excluded and further edits were made to account for the exclusion. Additionally, the NER was a bottleneck due to the tagger.tag method. Therefore, revisions were made to reduce the execution time of this code.

3. Creating Chatlog Analytics Visualizations of Teamwork Competency

The MGB platform is built on NodeJS with VueJS as the framework. To create the chatlog analytics visualizations, two additional node packages were utilized - python-shell and highcharts packages. Figure 1 illustrates the flowchart of how MGB visualizes teamwork competency dimensions from chatlog dialogue.
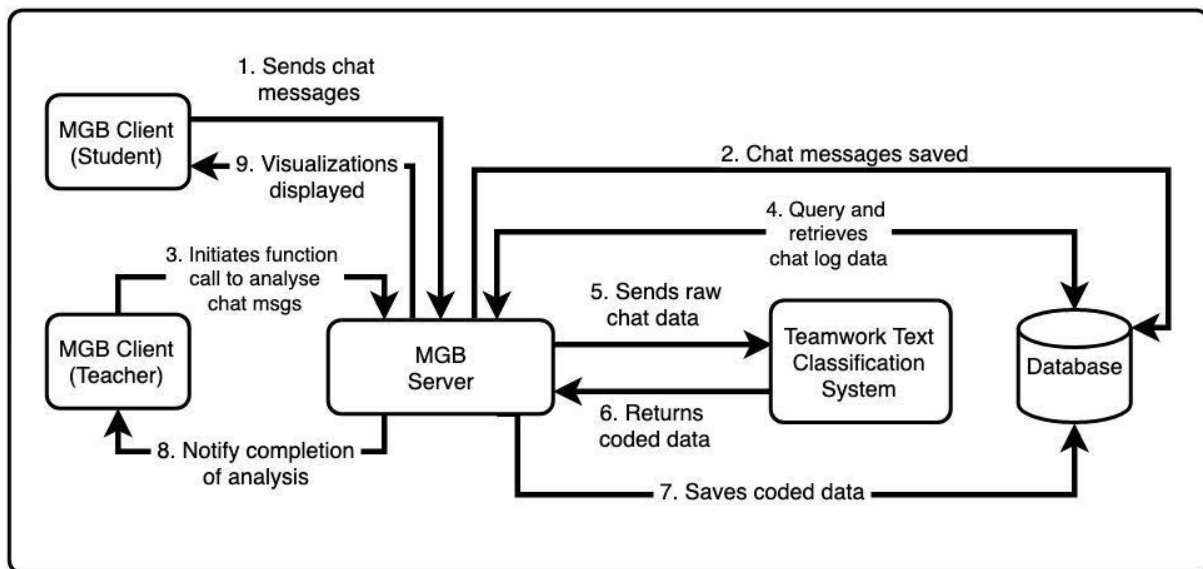
Figure 1. Flowchart of chatlog analytics visualizations

The process begins as students start chatting on the team chat on MGB. All chat messages are saved into the database as raw chat log data. To enable the display of the visualizations, the teacher performs a function call from a designated page in MGB. This enables the raw chat log data to be retrieved, formatted into a proper JSON format, and sent over to TTCS. Only uncoded chat messages will be sent while those coded, not coded again. The idea behind having a teacher to manually trigger the analysis process is to achieve better system performance and reduce the running of multiple calls to the python script.

TTCS will process the raw chat data as described in the earlier section. After all chat data are processed, each row of chat data will be coded into one or more dimensions, or none at all. The returned result consisting the chat message, the dimensions breakdown, the userid, the message timestamp and the coding timestamp will be formatted and sent back to the MGB server as a JSON string. The coded dataset is then saved in the database and the teacher notified of the completion of the analysis process.

Once coded datasets are available in the database, students are able to access a dashboard in MGB to view the visualizations. Two variations of visualizations have been designed: bar chart with slider (Figure 2) and streamgraph (Figure 3). For the former, the data is displayed with four bars, each bar representing a teamwork dimension from the student's chat text. The slider at the bottom is positioned from the earliest timestamp up till the latest timestamp of all the chat messages sent by the student. Depending on where the slider position is located, it shows the accumulated count of the teamwork dimensions up till that point in time.

For the streamgraph, the data is plotted against a timeline from the timestamp of the earliest to the latest sent messages. Each segment of the graph between two timepoints indicate the presence and count of the dimensions that are detected for the chat messages, as well as total messages count that falls within that time frame.
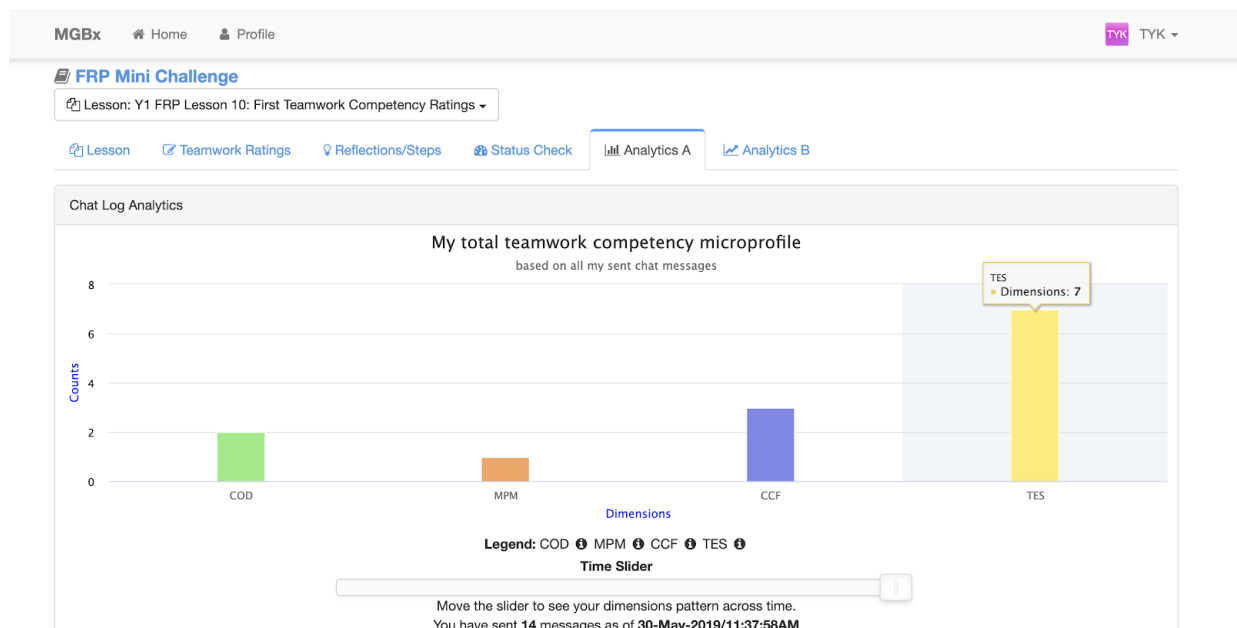
Figure 2. Bar chart with time slider
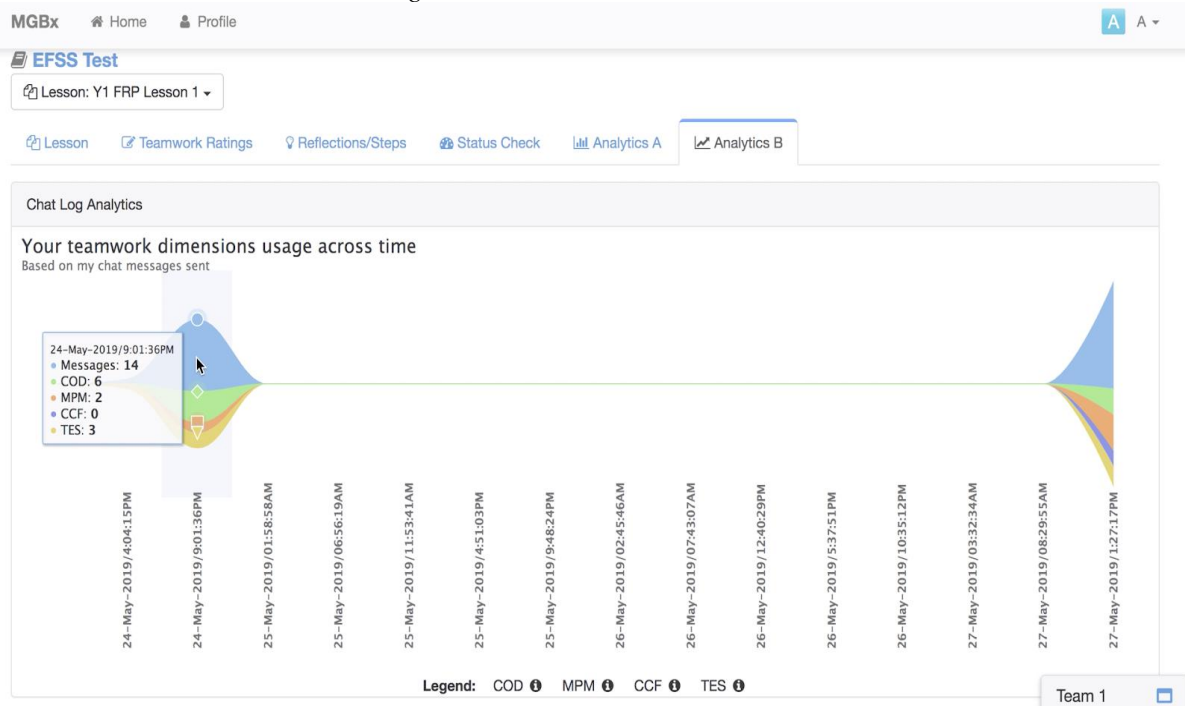
Figure 3. Streamgraph

These two visualizations were designed as they well represent the coded chat dataset of students' teamwork dimensions over time. The bar chart cleanly and clearly shows the cumulative counts for each dimension at one time-point, with the slider allowing for viewing of different time-points. On the other hand, the streamgraph shows more of the flow of chat messages, their dimensions over time and provides an overview of the intensity of the sent chat messages. The visualizations allow various interpretations of students' teamwork competency to trigger further reflections.

4. **Discussion and Conclusion**

This paper has made visible the language of teamwork as a means of formatively assessing students' teamwork competency. We have developed a classification system, process flow and two visualizations in order for students to learn teamwork skills based on the representations of their discourse on MGB. Students' are then made more aware of how their discourse contributes to working in a team and can learn to communicate better. An evaluation is currently underway to gather students' feedback to provide easy sensemaking and actionable steps for them. There is also need to investigate the degree to which each dimension is important, which could vary according to the tasks required of the team. While there is much future work (e.g., integrating the visualizations and other enhancements based on the evaluation), this study has successfully built chatlog analytics visualizations of teamwork competency making the digital formative assessment tool of MGB more holistic and timely. This design uses learning analytics and has broken new ground in teamwork assessment, which will add to research and practice in the assessment of 21CCs.

Acknowledgements

References

Suresh, D., Lek, H. H., & Koh, E. (2018). Identifying teamwork indicators in an online collaborative problem-solving task: A text-mining approach. In Yang, J. C. et al. (Eds.), *Proceedings of the 26th International Conference on Computers in Education* (pp. 39-48). Philippines: Asia-Pacific Society for Computers in Education.

Koh, E., Hong, H., & Tan, J. P. L. (2018). Formatively assessing teamwork in technology-enabled twenty-first century classrooms: Exploratory findings of a teamwork awareness programme in Singapore. *Asia Pacific Journal of Education*, *38*(1), 129-144.

A Preliminary Usability Evaluation for Online Annotation and Student Clustering System

Miao-Han CHANG[a], Rita KUO[b*], Fathi ESSALMI[c], Maiga CHANG[a], Vive KUMAR[a], & Hsu-Yang KUNG[d]

[a]*School of Computing and Information System, Athabasca University, Canada*
[b]*Department of Computer Science and Engineering, New Mexico Institute of Mining and Technology, USA*
[c]*Research Unit of Technologies of Information and Communication, University of Kairouan, Tunisia*
[d]*Department of Management Information System, National Pingtung University of Science and Technology, Taiwan*
*rita.mcsl@gmail.com

Abstract: This research evaluated an annotation recommendation system – GRACE (General Rapid Annotation Clustering Enhancement) – which gives suggestions of what annotations might be missing when students were reading the teaching materials. A pilot is done in two computer science classes in a college in Tunisia. The results show that system's usability is acceptable for students doing online reading activities on GRACE.

Keywords: Annotation, bio-inspired approach, clustering, usability, diffusion of innovation

1. Introduction

When students read learning materials like textbook, they usually take notes and highlight important words/sentences on it (Hoff, Wehling, & Rothkugel, 2009; Chen & Chen, 2014). Students have different annotation preferences while reading; for instance, they may annotate words in different ways (e.g., underlining, highlighting, or double underlining). However, they may intend to not annotate some important keywords or simply overlook those words while reading an article. When they review the annotated texts for preparing exams and doing homework, they might skip those un-annotated content on the texts as they believe that all important content have been well annotated by them earlier.

2. Online Annotation Systems

The research team has developed GRACE (General Rapid Annotation Clustering Enhancement) platform that can group students based on their annotations and provide annotation suggestions for them on the missing content. After teachers created reading activities, students can find these activities on the GRACE. Figure 1 shows the interface for reading activity on GRACE. At the top panel, students can choose the annotation styles they prefer, including highlight, underline, bold, italics, increase font size and change font color. They can also use mixed annotations, such as the use of bold face and underline at the same time for the words "England that this" (see Figure 1a).

Students can decide whether or not they would like to receive the recommendation(s) by checking and unchecking the "Hidding suggestions" check-box on the top. If the recommendation function is enabled, students will get the annotation suggestions for the paragraph when they finish annotating it. Take Figure 1a for example, the student is annotating "wheelbarrow", which is also the last word in the first paragraph. GRACE will retrieve all students' annotations and group the student with others who have similar annotation behaviours. It then finds out "chemicals and wastes" were annotated by others in the same group which this student belongs to; therefore, it reminds the student that he or she might be missed to annotate those words (see Figure 1b).
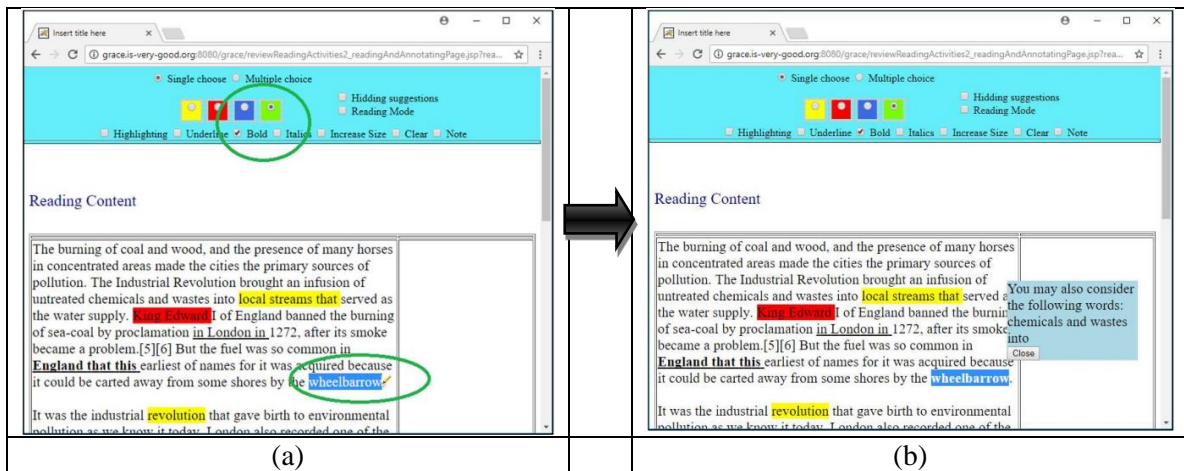
Figure 1. The interface for reading activity on GRACE.

3. Research Methods

3.1 Evaluation Process

To verify the system's usability and the influence of students' diffusion of innovation in using GRACE, this research proposed a research model (see Figure 2). The research adopts the System Usability Scale (SUS) to evaluate GRACE's usability (Brooke, 1996) and also adds a few questions from (AlQudah, 2014), (Lewis, 1995), and (Lund, 2001) as well as several self-developed items to the questionnaire. In addition, the Perceived Enjoyment (PE) factor is designed to understand how satisfy students were using GRACE. The research also investigates whether or not students' acceptance of using new technology like e-reader for reading activities will influence their overall satisfaction toward GRACE. The research uses two of the factors in Diffusion of Innovation proposed by Rogers (Rogers, 2003) and adopts the questions designed by (Park & Chen, 2007) and (Quadir, Yang, Chen, & Shih, 2017).
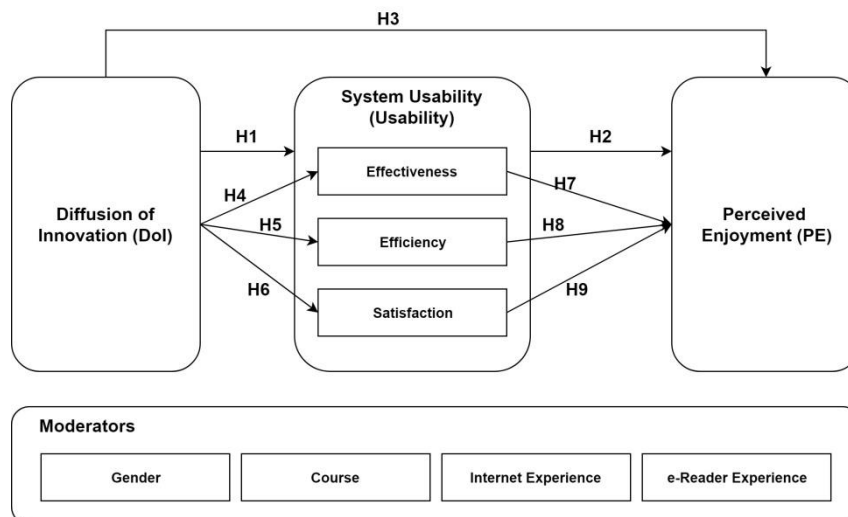
Figure 2. The research model.

To find out students' perceived usefulness toward GRACE as well as what are the influential factors, the research team has conducted a pilot in two computer science classes in a college in Tunisia with nine valid samples collected. The validity and reliability for the two major factors (Diffusion of Innovation and Perceived Enjoyment) and the three sub-factors (Effectiveness, Efficiency, Satisfaction) in the System Usability factor are in excellent ($\alpha \geq 0.9$) or good ($0.8 \leq \alpha < 0.9$) and shows the questionnaire is reliable (Georage & Mallery, 2010).

3.2 Findings

To understand whether or not the system is useful to students, we calculated the SUS value based on Brooke's study in 1996. The average value of SUS is 55.556 which shows that the system's usability is acceptable for students doing online reading activities on GRACE (Bangor, Kortum, & Miller, 2009). The research team also discovered some unexpected findings. First of all, students' perceived complexity of using any e-reader system has no significant relation with the usability score that they gave for GRACE. The finding tells us that even a student who believes an e-reader is a complex system, he or she might still believe GRACE is a useful system. Another finding shows that students' perceived ease of use toward GRACE is not affecting their intention of using the system, but students' perceived usefulness is. The finding suggests that if a system is useful for its users, even it is at the development stage and gives only fair user experience, users might still want to use the system to improve the efficiency or effectiveness of their works.

Another interesting finding is that students who like to try a new technology before officially adopt it (i.e., the triability factor in the diffusion of innovation) have higher satisfaction toward GRACE and have more intention to use it in the future. However, there is no significant relation found between the triability and perceived ease of use nor perceived good user interface design toward GRACE. This finding indicates that users treat triability is important for them to adopt new technologies and a system with triability can make users have higher intention of using it, even when it has only fair enough user interface design.

4. Conclusion

The developed bio-inspiration clustering algorithm is more stable than the previous algorithm designed by the research team. However, the precision and recall rate is still not good enough. Because the efficiency and effectiveness of GRACE highly affect students' intention of using it, giving more relevant annotation recommendations for students is extremely important. The research team will review the clustering algorithm in order to give more appropriate annotation recommendations for students.

The sample size of the study is small but is still sufficient for the Human Computer Interaction studies, which is 10±2 samples defined in Hwang and Salvendy's research in 2010. However, if the research team wants to find out more potential issues to improve the system, an evaluation with a larger sample size is required (Nielsen, 2012). On the other hand, this study only discuss students' perceived efficiency toward the system with questionnaire. To find out whether or not GRACE is really useful for students studying, pre-test and post-test should be integrated in the new evaluation plan.

References

AlQudah, A. A. (2014). Accepting Moodle by academic staff at the University of Jordan: Applying and extending TAM in technical support factors. *European scientific journal, 10*(18), 183-200.

Bangor, A., Kortum, P., and Miller, J. (2009). Determining what individual SUS scores mean: Adding an adjective rating scale. *Journal of usability studies, 4*(3), 114-123.

Brooke, J. (1996). SUS-A quick and dirty usability scale. *Usability evaluation in industry, 189*(194), 4-7.

Chen, C. M., & Chen, F. Y. (2014). Enhancing digital reading performance with a collaborative reading annotation system. *Computers & Education, 77*, 67-81.

George, D., & Mallery, P. (2010). *SPSS for windows step by step: A simple guide and reference 18.0 update* (11th ed.). Boston, MA: Allyn & Bacon.

Hoff, C., Wehling, U., & Rothkugel, S. (2009). From paper-and-pen annotations to artefact-based mobile learning. *Journal of Computer Assisted Learning, 25*(3), 219-237.

Hwang, W., & Salvendy, G. (2010). Number of people required for usability evaluation: the 10±2 rule. *Communications of the ACM, 53*(5), 130-133.

Lewis, J. R. (1995). IBM computer usability satisfaction questionnaires: psychometric evaluation and instructions for use. *International Journal of Human-Computer Interaction, 7*(1), 57-78.

Lund, A. M. (2001). Measuring usability with the USE questionnaire. *Usability Interface, 8*(2), 3–6.

Nielsen, J. (2012). How many test users in a usability study? Retrieved 21 May 2019, from https://www.nngroup.com/articles/how-many-test-users/

Park, Y., & Chen, J. V. (2007). Acceptance and adoption of the innovative use of smartphone. *Industrial Management & Data Systems, 107*(9), 1349-1365.

Quadir, B., Yang, J. C., Chen, N. S., & Shih, M. J. A. (2017). The Effects of Perceived Innovation Game Attributes by Learners on Learning Performance in a Game-Based Achievement Learning System. In *Innovations in Smart Learning* (pp. 155-164). Singapore: Springer.

Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). New York, NY: Free Press.

What are the most important predictors of Middle School Students' Online Academic Help-seeking Behaviors?

Ling CHEN[a*], Ting-Ting ZHU[b], Meng-Qi PAN[c]
[a]*School of Education and Technology, Beijing Normal University, China*
[b]*School of Education and Technology, Beijing Normal University, China*
[c]*School of Education and Technology, Beijing Normal University, China*
* chenling@bnu.edu.cn

Abstract: With the rise of online learning and counseling, exploring the influencing factors of online academic help-seeking behavior can provide more targeted intervention and support for the students' individualized help. Taking mathematics as an example, we conducted a questionnaire survey on the seventh-grade students in two districts of Beijing, China, to explore the reasons why students differ in the choice of online academic help-seeking approaches. Results show that instrumental help-seeking and executive help-seeking have a significant impact on the choice of help approaches. The purpose of instrumental help-seeking is more positively correlated with the willingness of one-on-one online tutoring, and the purpose of executive help-seeking is more positively correlated with the willingness of the Q&A center. In terms of external factors, peer influence significantly predicts the willingness of two online academic help approaches. The fact that the tool is easy to use positively affects one-on-one online tutoring while it has no significant impact on the Q&A center.

Keywords: Online Academic Help-seeking, One-on-one online tutoring, Q&A center, influencing factors

1. Literature Review

1.1 Online academic help-seeking

Online academic help-seeking is a behavior in which learners spontaneously seek help from others through the Internet. Liu divided online academic help into the real-time academic help (such as video conferencing, telephone and other real-time interactive communication) and non-real-time academic help (such as forum reply, email and other non-real-time interactive communication) (2017).The help-seeking platform mentioned here supports high quality teachers to answer questions for students after classes in Beijing.The platform supports two types of teacher-student interaction: Real-time one-on-one online tutoring (Figure1) and Non-real-time Q&A center (Figure2).Learners can get reply from both approaches.Teacher-student interaction through real-time academic help is similar to face to face communication and learners have more chances to ask questions and clarify their thoughts(Liu,2017).Learners have different choices in online academic help approaches (Cheng &Tsai, 2011,Hao, Wright& Barnes, & Branch, 2016). To provide effective guidance for students,it is significant to find out what factors influence the choice of help approaches.Based on previous studies(Aleven,Stahl, Schworm,Fischer, & Wallace,2013),we plan to explore the influencing factors from individual and external aspects.

Figure 1. The Real-time one-on-one Online Tutoring.

Figure 2. The Non-real-time Q&A Center.

1.2 The influencing factors of online academic help-seeking behavior

1.2.1 Self-efficacy of Mathematics

Mathematical self-efficacy refers to the judgment of an individual's actual ability to learn mathematics . Individuals who have high self-efficacy of mathematics tend to attach more importance to external help, and they are more likely to seek help (Marchand&Skinner,2007, Ryan&Shin,2011).

1.2.2 The Purpose of Students' Help-seeking

Nelson-Le Gall divided academic help-seeking into two categories according to help-seeking purposes: instrumental help-seeking means that the learner asks the helper for some information related to solving the problem, and hopes to use the information to solve the problem; Executive help-seeking is that the learner asks the teacher or classmate for answers without understanding (1985).

1.2.3 Value of Mathematics Homework

The value of mathematics homework refers to perceived utility and cost of doing homework in math, which affects students' learning strategies.Students who believe mathematics homework is important have more help-seeking behaviors. (Trautwein, Lüdtke, & Schnyder,2006).

1.2.4 Social Factors

Parental attention to homework refers to the level of parental involvement in student work. Parents can influence students' learning behaviors by teaching various strategies(Zhang,2010). Peers are the key factors affecting the network pleasure and curiosity for middle school students (Zhu,Wang, &Wang,2016).

1.2.5 Perceived Ease of Use

Perceived ease of use refers to the degree to which the student expects the system to be free of effort (Davis, Bagozzi, & Warshaw,1989,Chu, Hwang, Tsai, &Tseng, 2010).The ease of use is strongly related to individual's willingness to use the help-seeking platform (Liu,2017).

2. Methodology

2.1 participants

Random sample was used to select six junior high schools which were participating in the help-seeking program in Beijing. Students in the seventh grade as subjects. In July 2018, 1237 students participated in an offline survey,and 1115 questionnaires are valid .

2.2 Questionnaire

The first part is background information.The second part are factors that affect the students' online academic help-seeking.The third part is the willingness of students using two approaches. A 5-point Likert scale ranging from 1 (completely disagree) to 5 (completely agree) are used for the questionaire.

3. Research Results

3.1 Correlation Matrix

Table 1 shows all factors are positively correlated with the two approaches. Executive help-seeking is more positively correlated with the Q&A center.

Table 1

Correlation between Influencing Factors and Online Academic Help

	Self-efficacy of math	Instrumental help-seeking	Executive help-seeking	Value of math homework	Parental attention to homework	Peer influence	Ease of use
One to One	0.266***	0.618***	0.072*	0.104**	0.131***	0.479***	0.380***
Q&A	0.215***	0.526***	0.130***	0.034	0.110***	0.418***	0.296***

*p<0.05，**P<0.01，***P<0.001

3.2 Regression Analysis

We choose the one-on-one online tutoring as dependent variable. Multivariate stepwise regression results are shown in Table2. Instrumental help-seeking, peer influence, executive help-seeking, and ease of use significantly predict the choice of one-on-one online tutoring.

Table 2

Multiple Regression of factors to one-on-one online *tutoring*

Model	Non-standardized coefficient		Standardized coefficient	T	Significance
	B	S.E.	Beta		
Constant	-.752	.178		-4.219	.000
Instrumental help-seeking	.615	.033	.499	18.740	.000
Peer influence	.273	.039	.199	7.026	.000
Executive help-seeking	.185	.032	.131	5.769	.000
Ease of use	.110	.043	.070	2.543	.011
R=0.663 R^2= 0.440 Adjusted R^2= 0.438					

*p<0.05，**P<0.01，***P<0.001

Taken the willingness of using Q&A center as dependent variable. The results are shown in Table 3. The instrumental help-seeking, peer influence, and executive help-seeking in the model significantly influence the choice of Q&A center.

Table 3

Multiple Regression of factors to Q&A center

Model	Non-standardized coefficient		Standardized coefficient	T	Significance
	B	S.E.	Beta		
Constant	-1.017	.180		-5.656	.000
Instrumental help-seeking	.606	.039	.438	15.577	.000
Peer influence	.319	.043	.208	7.395	.000
Executive help-seeking	.279	.039	.175	7.174	.000
R=0.583 R²= 0.340 Adjusted R²= 0.339					

*p<0.05，**P<0.01，***P<0.001

4. Findings

Instrumental help-seeking is the most important factor for two approaches.Students with high instrumental help-seeking tendency perceive more benefits easily,which can result in more help-seeking behaviors(Keith, Babb ,& Lowry ,et al,2015).

Executive help has a greater impact on the Q&A approach.Students with strong executive help-seeking tendency are more inclined to seek answers.Q&A Center does not support students talking with teachers, which reduces the cost of help,and it induces students to directly search for superficial answers without thinking. To reduce the phenomenon,we should guide students to develop instrumental help-seeking tendency.Also,help system can add hints to support students posting questions.

Peer influence is an important factor for middle school students to seek online academic help-seeking.Adolescents' online behaviors were influenced by peers(Niu, & Han-Jen, 2013),the result imply us that we should promote the sharing of help-seeking experiences between peers.

The ease of use only significantly predicts one-on-one online tutoring.One-on-one help seeking approach is a synchronous communication method. The feedback time, network, voice and picture quality all affect teacher-student instant communication.Q&A center is an asynchronous communication tool which needs simple operation, so the ease of use does not influence the Q&A center significantly.Ease of use is directly affected by system reaction time and stability(Lin, & Hsipeng, 2000).Therefore, help-seeking system should ensure the stability. Further,the ability of the one-to-one tutoring system to respond to the student's request for help should be improved.

References

Liu, S.H. (2017). Relationship between the factors influencing online help-seeking and self-regulated learning among Taiwanese preservice teachers. *Computers in Human Behavior, 72*, 38-45.

Cheng, K. H., & Tsai, C. C. (2011). An investigation of Taiwan university students' perceptions of online academic help seeking, and their web-based learning self-efficacy. *Internet & Higher Education, 14(3)*, 150-157.

Hao, Q. , Wright, E. , Barnes, B. , & Branch, R. M. (2016). What are the most important prediction of computer science students" online help-seeking behaviors?. *Computers in Human Behavio*r, 62, 467-474.

Aleven,V., Stahl, E.,Schworm, S. , Fischer, F. , & Wallace, R . (2003). Help seeking and help design in interactive learning environments. *Review of Educational Research*, 73(3), 277-320.

Marchand, G. , & Skinner, E. A. (2007). Motivational dynamics of children's academic help-seeking and concealment. *Journal of Educational Psychology*, 99(1), 65-82.

Ryan, A. M.,& Shin,H. (2011). Help-seeking tendencies during early adolescence: an examination of motivational correlates and consequences for achievement. *Learning and Instruction*, 21(2), 0-256.

Trautwein,U.,Lüdtke,O.,Schnyder,I.,Niggli,A.(2006). Predicting homework effort: support for a domain-specific, multilevel homework model. *Journal of Educational Psychology, 98(2)*, 438-456.

Nelson-le Gall, S. (1985). Help-seeking behavior in learning. *Review of Research in Education, 12(3)*, 55-90.

Zhang Y.Q. (2010). Study on the relationship between parenting style, achievement goal orientation and academic achievement of first-year students. (*Doctoral dissertation, Northeast Normal University*).

Zhu, Z. , Wang, J. , Wang, X. , & Wan, X.(2016). Exploring factors of user's peer-influence behavior in social media on purchase intention: evidence from qq. *Computers in Human Behavior*, 63, 980-987.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: a comparison of two theoretical models. *Management Science, 35(8)*, 982-1003.

Chu, H. C. , Hwang, G. J. , Tsai, C. C. , & Tseng, J. C. R.(2010). A two-tier test approach to developing location-aware mobile learning systems for natural science courses. *Computers and Education*, 55(4), 0-1627.

Keith, M. J. , Babb, J. S. , Lowry, P. B. , Furner, C. P. , & Abdullat, A.(2015). The role of mobile-computing self-efficacy in consumer information disclosure. *Information Systems Journal*, 25(6), 637-667.

Niu, & Han-Jen. (2013). Cyber peers' influence for adolescent consumer in decision-making styles and online purchasing behavior. *Journal of Applied Social Psychology*, 43(6), 1228-1237.

LIN, J., C. C., & Hsipeng, L. U. (2000). Towards an understanding of the behavioural intention to use a web site. *International Journal of Information Management*, 20(3), 197-208.

A Case Study on How Children Develop Computational Thinking Collaboratively with Robotics Toys

Kay Yong KHOO

PT Lecturer, The University of Hong Kong, HK

kykhoo@yahoo.com

Abstract: This article reports on a case study on how robotics toys provide the affordances for developing computational thinking (henceforth abbreviated to CT) in young learners. The three key constructs of CT - coding, algorithm and decomposition - are used in the research. The study results identify how children interact with robotics toys collaboratively and acquire CT skills. Problems were presented to the children through planned non-routine and immersive collaborative group activities. The situations in which they externalized their inquiries and internalized new knowledge were observed. A detailed examination of the data collected was made to determine which robotics toys mediated the children's acquisition while seamlessly switching between individual and collaborative activities and has led to the development of a framework of the stages in CT learning designs. The article will include details and analyses of commercially available technologies for developing CT as applied with the young learners in the study.

Keywords: computational thinking, robotic toys, decomposition, algorithm, coding

1. Introduction

In an increasingly information-based society, CT is viewed as a foundation for coding (Baroutsis, White, Ferdinands, Goldsmith, & Lambert, 2019). Bers and her colleagues (Bers, Gonzalez-González, & Armas-Torres, 2019) showed that children as young as four years were able to engage in computational thinking activities using a robotics curriculum. These robotic toys hold the promise of creating direct and actionable interaction between the physical world and the electronic information and thereby representing a paradigm shift in exposing children to technology compared with screen-based human-computer interaction.

A review of the literature on the integration of robotic tools in the education of young children has mainly focused on exploring their interactions with such tools: (a) within the context of various content domains, such as maths, science, literacy and engineering (Lavigne, Orr, & Wolsky, 2018) and (b) in the context of familiarizing children with robotics concepts and computer programming (Misirli & Komis, 2014). there is no description of how teachers design young students' computational thinking lessons in the classrooms and provide robust empirical evidence of learning gains (Charoula & Nicos, 2019). The investigation of the development of young children's computational thinking through educational robotic toys remains in its infancy.

Table 1

The Constructs of CT

Constructs	Definition
Algorithm	refers to the arrangement of a step-by-step series of instructions to execute a task or solve a problem.
Abstraction	invites students to identify important information while ignoring unrelated or irrelevant details.
Pattern Recognition	involves the skill to look for similarities among and within problems.
Decomposition	involves the process of breaking down a problem into smaller manageable parts.

2. Research Design

The research was initially based on the four key constructs as in Table 1. The current study seeks to analyze informative and evidence-based findings to give an insight into how children acquire CT knowledge through collaborative activities with robotics toys. The activity theory was selected as the theoretical framework best applicable in the contexts of learning studied here (see Figure 1).
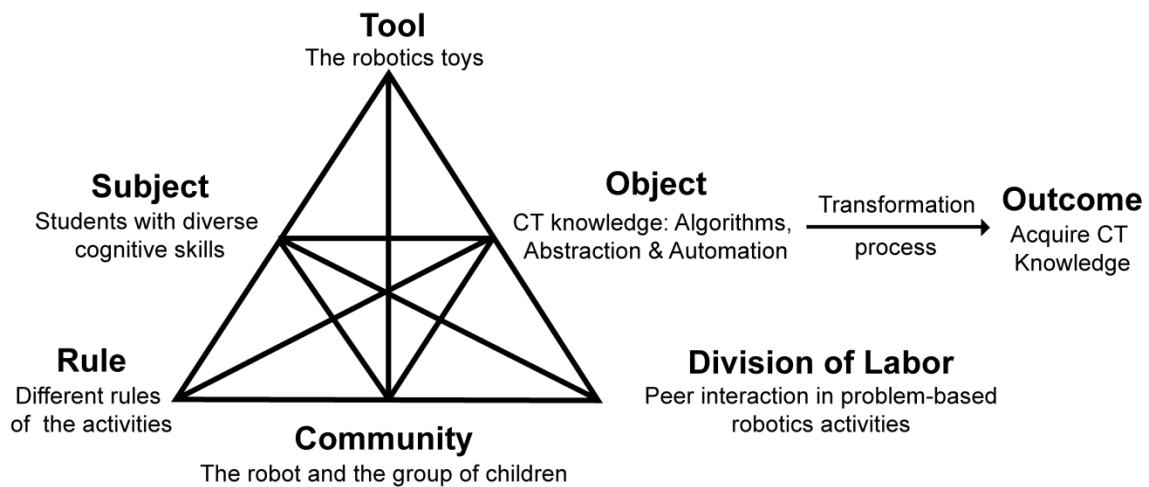

Figure 1: The research framework of the study

The study employs a qualitative research approach that is both descriptive and exploratory. Two research questions emerging from the literature reviews guided the data collection and analysis of the current study:
1. Which robots are best suited for learning various CT constructs?
2. What aspects must be considered when designing collaborative preschool classroom activities that use robots for the learning of CT?

Three types of robots - i.e., Mouse Robot, 3D Pen and OZO-bot - were selected based on their unique characteristics as claimed by the manufacturers matching the constructs in Table 1. The steps of the activities (see Table 2) were developed according to the framework of technology support for collaborative learning aimed at the learning gain of the constructs of CT.

Table 2

The steps for conducting CT activities with the robot

Step	Description
1	*12 children in the class to be divided into 4 groups of three*
2	*The teacher demonstrates how to operate the robot through referral to the worksheets (Set A).*
3	*The teacher distributes the robot and worksheets to the group (Set B).*
4	*Each group completes the worksheets with the robot.*
5	*The teacher distributes the robots and worksheets to each child (Set C).*
6	*Progression to Step 5 is allowed only when Step 4 has been correctly completed.*
7	*The teacher awards a sticker to all students who manage to correctly complete the worksheet.*
Note:	*Sets A, B & C comprise the same type of questions but vary in the details.*

Table 3A

The Educational Robotics Activity (3D Pen)
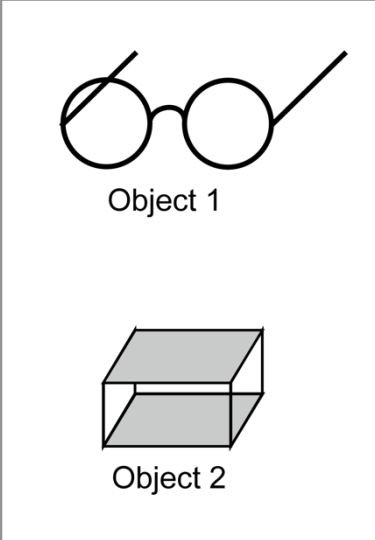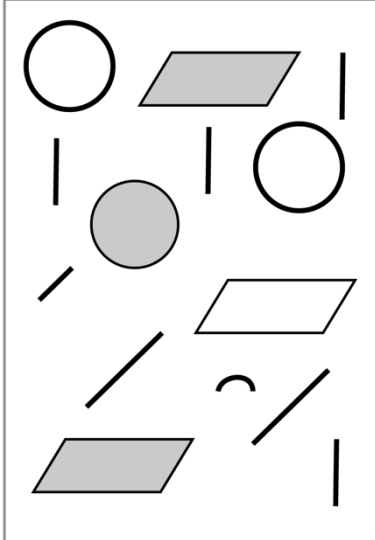
3D Pen

Worksheet P1

Worksheet P2

Object 1

Object 2

The activity: 3D Pen

Use the 3D pen to trace the items in worksheet P1. Subsequently, the participants form one of the spectacles (Object 1) using the items created. The participants only select the items necessary to form the object. Working individually, the participant then forms the next object (Object 2) (CT construct: decomposition).

Table 3B

The Educational Robotics Activity (Mouse Robot)

Mouse Robot(MR)

Worksheet M1
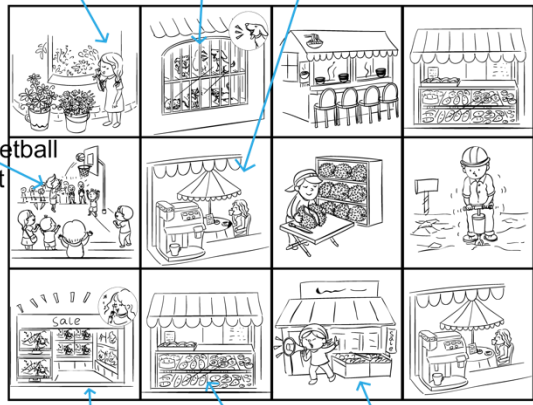
Worksheet M2

Worksheet M3

florist   Pet Shop   Cafe

Basketball Court

TV Shop   Bakery   Roadside Stall

The activity: Mouse Robot
There are directional buttons at the back of the mouse, which enable it to move forward, left, right, backward, clear, execute etc.
M1: There are 3 questions. Place the robot at 5 (or 6), code it and find out the result. Write the answer in the circle (CT construct: coding).
M2: There are 3 questions: Place the robot at 3 (or 1). Draw the arrows in the boxes. Program the robot to reach box 2 (or 6 or 4). Verify the answers and redraw (debug) the arrows until you get the answers (CT construct: algorithm).
M3: There are 3 questions: Place the robot in the box above the picture at the bottom of the first column. Draw the arrows in the boxes to enable the robot to reach the picture at the top of the same column. In the second and third columns, find two different ways to start from the same beginning point and end at the same ending point (CT constructs: efficiency and performance). Lastly, find out the least number of steps the robot can take to travel from the same beginning point to reach the ending point (CT construct: pattern recognition).
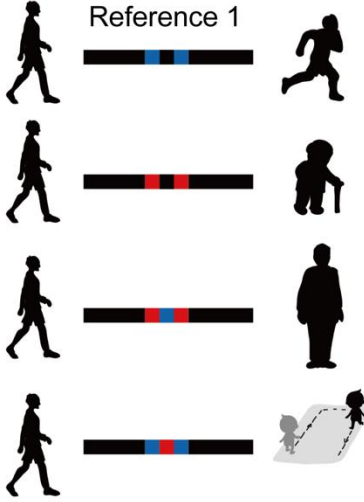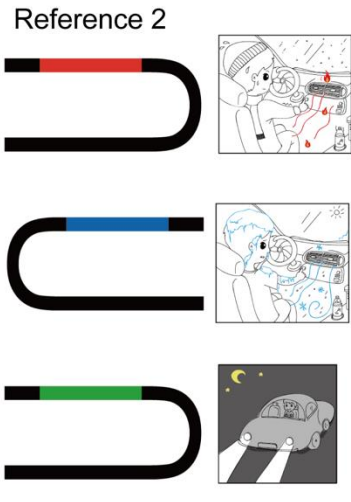
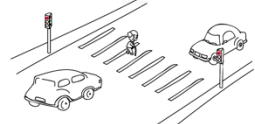Table 3C

The Educational Robotics Activity (OZOBOT)
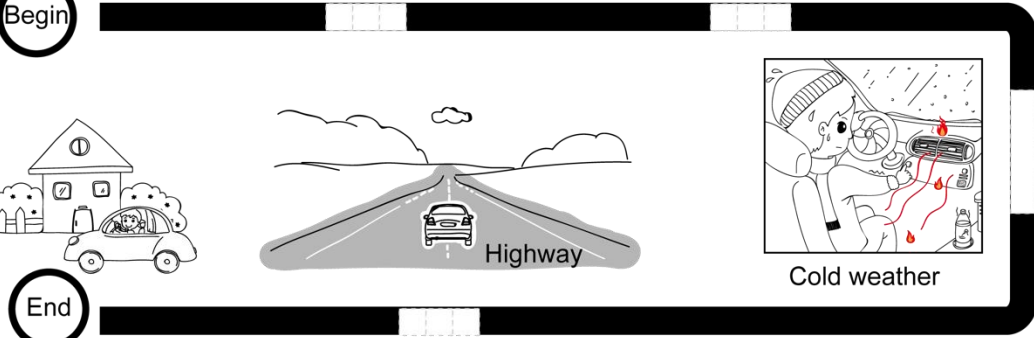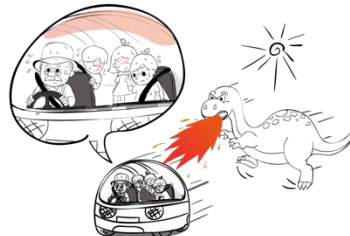
The activity: OZOBOT

There are 4 activities. The activities treat the OZOBOT as a car. The participants use different codes to set the OZOBOT as it travels.

Code references 1 & 2 in Table 3C inform the participants of the codes required in the activity; Worksheet Z1: The participants are required to apply suitable codes at different situations (CT construct: coding); Worksheet Z2: Each of the three situations presents two circumstances (it was cold and the road was dark; it was hot inside the vehicle and the occupants were being chased by a fire-breathing dinosaur; It was cold inside the car and the occupants were on the highway). The participants must choose a suitable code to be applied to each situation (CT construct: abstraction).

3. Results

This section will report the research findings as revealed by the data collected on the three participating children. The data collected based on activity theory led to the following four sub-activity triads:

Figure 2. The skills of collaboration applied in different constructs of CT
M1, M2,M3,P1,Z1,Z2 are the activities as described in Table 3.
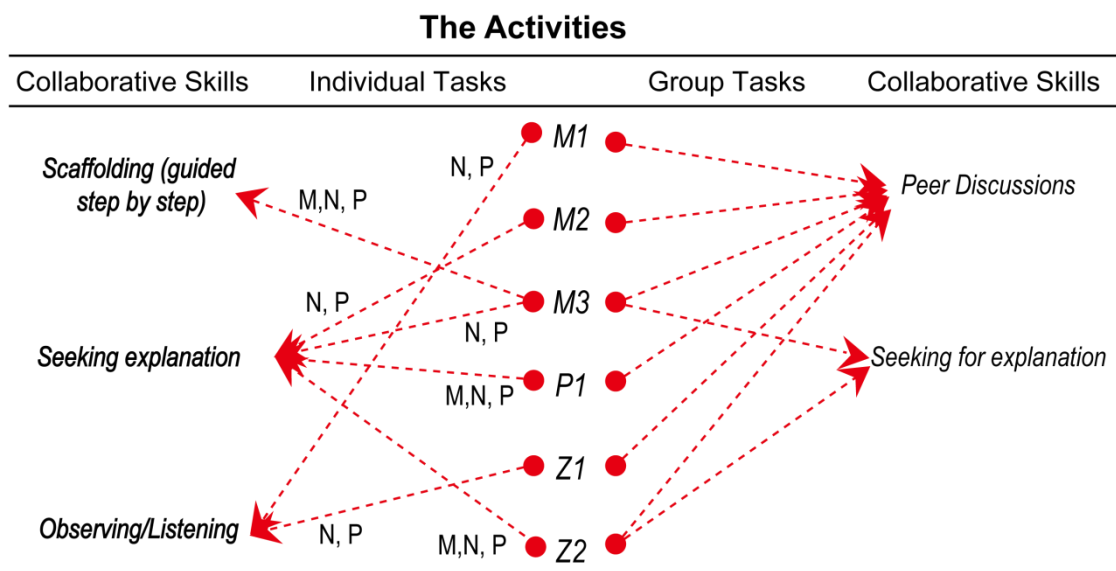
Figure 3. The skills of collaboration applied in both group and individual activities
Note: 'M' denotes Mary; 'N' denotes Nicole; 'P' denotes Peter;

Table 4

Analysis of the achievement of the participants as per Table 2

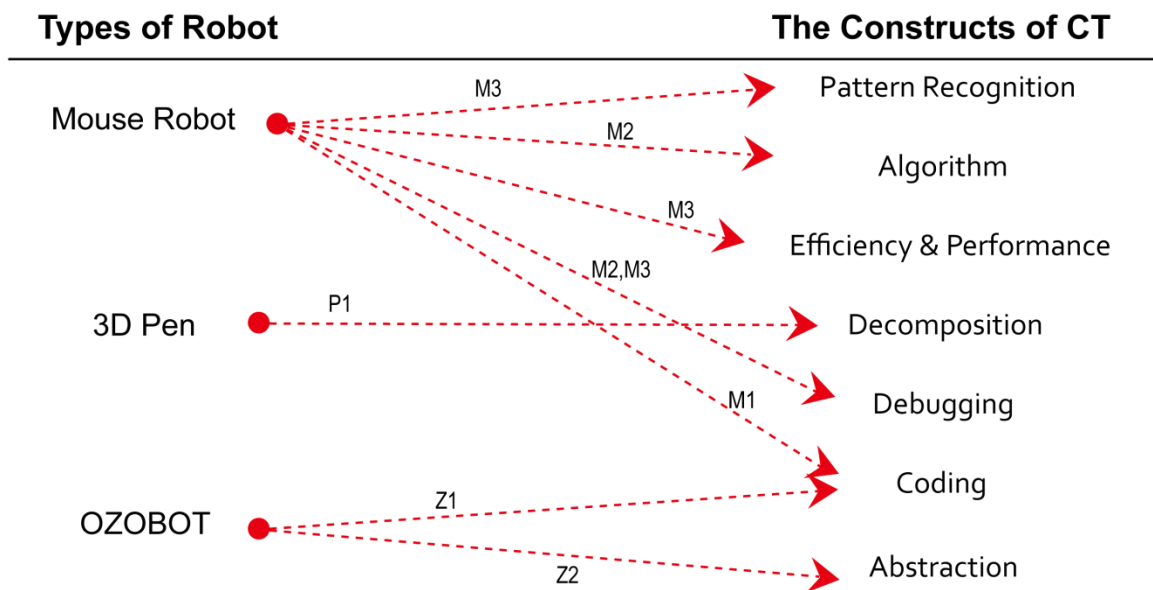| Steps/The constructs of CT	Pattern Recognition	Algorithm	Efficiency & Performance	Decomposition	Debugging	Coding	Abstraction
M1 (Group)						O (2)	
(Mary)						O (1)	
(Nicole)						O (1)	
(Peter)						O (2)	
M2 (Group)		O (2)			A		
(Mary)		O (2)			A		
(Nicole)		O (2)			A		
(Peter)		O (2)			A		
M3 (Group)	O		O (2)		A		
(Mary)	O		O (2)		A		
(Nicole)	O		O (2)		A		
(Peter)	O		X		A		
P1 (Group)				O (2)			
(Mary)				O (2)			
(Nicole)				X			
(Peter)				X			
Z1 (Group)						O (1)	
(Mary)						O (1)	
(Nicole)						O (1)	
(Peter)						O (1)	
Z2 (Group)							O (1)
(Mary)							O (1)
(Nicole)							X
(Peter)							X

Note: 'O' denotes 'the answer is correct'; 'x' denotes the answer is wrong/incomplete; the number in the parentheses denotes the number of attempts made; 'A' denotes the participant has attempted to respond with an answer.

3.1 Subject-tool-object

The participant was regarded as gaining the target skill only when their answer to the activity task was correct. The study of the 1st dimension sheds light on the first research question. Besides the four constructs of CT as determined at the beginning of the research, some additional constructs (see Figure 2) also emerged from the study - i.e., coding, efficiency & performance and debugging. Further, as observed in Figure 3, some of the interactions with the robotic toys might not have resulted in the

gaining of new knowledge in CT. This indicates that other components that might have affected the learning must be further investigated.

3.2 Subject-community-object

Detailed study of the second dimension reveals that the participants managed to complete all the group tasks correctly (see Table 4). They were also observed to apply the collaborative skills of peer discussion and seeking explanation (see Figure 3) in their group tasks. Mary managed to learn all seven constructs of the CT skills as demonstrated in her individual tasks. However, Nicole and Peter did not gain the skills of decomposition, efficiency and performance and abstraction in their individual tasks although they had applied the collaborative skills of observation, seeking explanation and scaffolding (see Figure 3 and Table 4).

3.3 Subject-division of labor-object

In the third dimension, the progressive introduction of activities of the same set of robots was studied in relation to the individual tasks. CT is a process-based skill - it happened in time, not in space. Mary and Nicole completed their individual tasks correctly for M1, M2 and M3; Peter managed to complete M1 and M2 correctly but not M3; Mary had also completed Z1 and Z2 correctly but Nicole and Peter did not manage to correctly complete the latter; none of the participants managed to complete P1 correctly (see Table 4).

3.4 Subject-rule-object

In the fourth dimension, the rules that regulate the actions and interactions of the participants were studied (see Table 2). For every activity, the class started by listening to the teacher's briefing, which was followed by the group practice; the group had to complete the activity correctly before all group members were allowed to get their robots and worksheets for the individual practice. It was observed that all participants managed to complete all the group activities correctly (see Table 4). The participant was rewarded with a sticker if he/she completed the task correctly. All participants attempted all the individual tasks. As previously mentioned, the questions of the same type were set, but with minor changes in the details. The participants' levels of achievement varied in the different questions (see Table 4).

4. Discussions

The findings of research question two are analogous to a jigsaw puzzle. Through application of the activity theory, the four dimensions of analysis served as fundamental pieces of the puzzle. Once these pieces were fitted together, research question two was answered in totality. The analysis of the dimensions is summarized as follows.
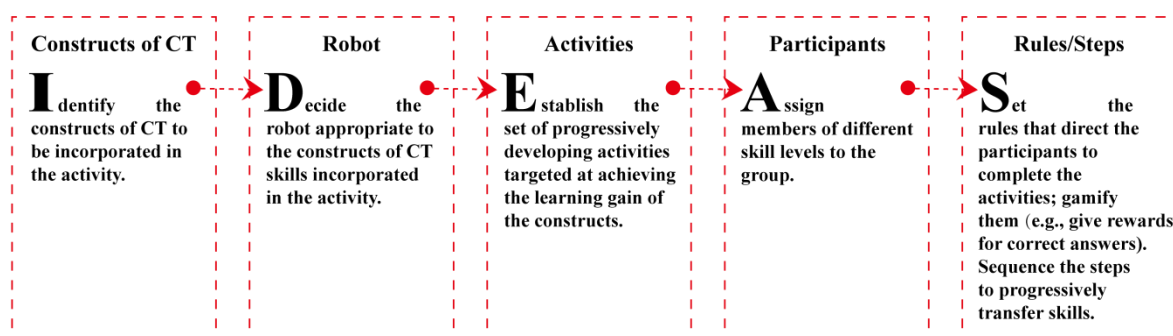

Figure 4. The Framework to Design CT Activities with Educational Robotics Toys

It is necessary to establish a more robust framework (as in Figure 4) to incorporate elements to consider in designing CT activities. The following framework emerges from the current research findings.

5. Conclusions

This paper syntheses relevant classroom activity designs in addressing CT as a general term that applies robots as the learning tools. The framework proposed here suggests aspects to be considered in appropriately designed classroom activities aimed at promoting learning gain within a constructivist model of CT skills building. Society now demands individuals have computer skills. Therefore, it is imperative that teachers find ways to integrate computational thinking into the classroom. While teachers have hesitated to pursue this because the associated terminology is unfamiliar, they can embrace the framework as suggested in the research finding for incorporating this type of thinking into their lessons.

References:

Baroutsis, A., White, S. L., Ferdinands, E., Goldsmith, W., & Lambert, E. (2019). Computational thinking as a foundation for coding: Developing student engagement and learning. *Australian Primary Mathematics Classroom, 24*(2), 10-15.

Bers, M. U., Gonzalez-González, C., & Armas-Torres, M. B. (2019). Coding as a playgrounf: Promoting positive learning experiences in childhood classrooms. *Computers & Education, 138*, 130-145.

Charoula, A., & Nicos, V. (2019). Developing young children's computational thinking with educsational robotics: An interaction effect between gender and scaffolding strategy. *Computers in Human Behavior, In Press.*

Lavigne, H., Orr, J., & Wolsky, M. (2018). *Exploring Computational Thinking in Preschool maths Learning Environments*. Paper presented at the Society for Information Technology & Teacher Education International Conference.

Misirli, A., & Komis, V. (2014). Robotics and programming concepts in early childhood education: A conceptual framework for designing educational scenarios. In *Research on e-Learning and ICT in Education* (pp. 99-118). New York: Springer.

A SySTEMic approach to Data Literacy

Jon MASON*, Khalid KHAN & Gregory SMITH
College of Education, Charles Darwin University, Australia
*jon.mason@cdu.edu.au

Abstract: We outline an emerging research agenda that brings together three distinct topics relevant to the changing requirements of school education: STEM education, inquiry learning, and data literacy. When examining current curriculum materials in Australia we find that data in the digital environment is primarily seen as something to be examined in terms of its representations, interpretations, and visualisation – all activities that can be understood as downstream from data production. We argue that in the same way that inquiry learning involves a shift from the teacher to the student as the pivotal questioner, that a comprehensive and systemic approach to understanding data in the digital environment must involve appreciation for its production as well as consumption. Teaching STEM as an integrated and interdisciplinary way to decomposing real-world problems, not just the STEM subjects, requires a systemic approach running through and across the curriculum. It also now demands data literacy.

Keywords: STEM, inquiry, questioning, questions, data literacy, curriculum

1. Introduction

A character in a 1936 story *Swadeshi Rail* by a famous Urdu writer, Shaukat Thanvi, inquires *which station is this train heading to?* He receives a response that *it depends upon the majority of passengers.* A Facebook post recently asked a similar question, *who decides what is fake?* Big data may provide a compelling new resource that potentially can be used to solve many real-world problems, but it presents similar challenging questions if we scrutinize the underpinning instruments that produce it. It would be a big mistake if the sheer volumes involved in big data led us to think such scale has equivalence to a comprehensive census.

Combining big data with algorithms enables decision-making processes to be automated; however, most people only experience algorithms as 'black boxes' and must either accept the data produced as valid or not. In practice, despite the growing public outcry regarding this issue, such data is usually attached to a service. A common example is banking, and the sources of data used to produce our credit rating. Another well-known example is the data collected via consumer loyalty cards. But what of the data collected that we don't really know about?

In previous work two of us defined proposed a definition of data literacy that extends beyond the learning of data through computational and statistical representations that also includes making sense of diverse data types, to recognise the stories that data visualizations can convey, and to acknowledge the role of the data storyteller (Khan & Mason, 2016). In our combined research agenda, we focus on the progression of understanding the nature of data from first encounters in educational activities that begin in early childhood through to senior schooling years. In doing so, we propose and advocate for a systemic approach to data literacy that aligns with a curriculum where science, technology, engineering and mathematics (STEM) is embedded, though not necessarily explicitly.

In 2018, we surveyed STEM experts from around the world attending three separate international conferences focused on computers in education. Among the findings are themes of concern that were identified in the literature a few decades ago, leaving us to conclude that systemic change of embedding of STEM in the curriculum has not yet taken place. Additionally, responses to the survey reveal that data literacy is yet to be recognised as a foundation that underpins STEM education.

2. Change of Millennium

Leading up to 2000 there was widespread public discourse concerning the school curriculum and how to prepare the next generations for a technology-transformed workplace. In Australia, the focus shifted to development of skills in cross-disciplinary, critical and creative thinking, problem-solving and digital technologies. These objectives are now central to the Australian national STEM school education strategy. It recognises the role of STEM at all levels of schooling (Education Council, 2015). In parallel, a global agenda focused on *21st century skills* has evolved (Griffin, McGaw, & Care, 2012). In the Australian Curriculum, this is embedded as 'general capabilities'. Both agendas align with a shift toward student-centred pedagogies enabling self-directed learning.

In terms of calibrating teaching and learning to meet these new challenges we question whether the core competencies of creativity, critical thinking, collaboration, and communication are beginning to look too general? What about problem-design and data literacy? And, while computational thinking, design thinking, and systems thinking have all become embedded into the Australian curriculum, these modes of thinking are not enough in an environment where false information is prevalent and data visualization tools can be easily manipulated. Fake news and cyberwarfare are becoming increasingly sophisticated and both require a response that is acutely analytical, discerning and agile – and these abilities require questioning techniques that probe deeper than search. We need to focus curriculum on such questioning techniques and shift legacy and traditional pedagogies that focus on 'thinking in answers' to a mindset that is nurtured through the inquiry of 'thinking in questions.'

3. STEM and Data Literacy

Abundance of data now is a feature of our times. Little data collected with rulers, thermometers and stop watches has morphed into big data (Lohr, 2012). Science has moved to using big data to investigate 'big problems'; gene expression, plate tectonics, algal blooms, disease, and the fundamental particles of the universe to name a few. Science has entered a 'fourth paradigm' of data-intensive investigation (Tansley & Tolle, 2009). A key implication for inquiry is that it is now closely coupled with handling data – its production, processing, and interpretation. Thus, Earl and Katz (2006) have described data literacy as a skill that uses evidence to systematically consider an issue from a range of perspectives to explain, support and challenge established thinking (p.45).

Because data is produced in a diversity of ways across all disciplines a systemic way of dealing with it across the curriculum is needed. Table 1 illustrates how the number '5' can be inferred (as data) in various ways.

Table 1

Representations of the number five

five	5	V	⫴	2 + 3	✋	⭗⭗⭗

In primary schools, students often see the numeral five as a counting number, something to add, subtract, multiply and divide, but the meaning comes from a specific activity or context. Often the inquiry takes the fair test approach: change one variable, keep all other variables the same and measure the change. The measure skill moves from bigger-smaller to tools of measurement to discern how much bigger or smaller, so units become important. The journey of the numeral five in primary schools is again bound in the inquiry as the amount of change. The plants in the sun grow five centimeters more than those in the dark. Build a spaghetti bridge, a well-known STEM activity, one block breaks the bridge, another bridge holds five blocks, the data suggest that the bridge that held five blocks is stronger. As for the cars on the ramp: one block verses five blocks have now a measured height, a measured distance travelled, and for older primary students a speed calculated. Again, the data is generated through measurement to answer the inquiry question and visualised usually in a graph.

Secondary school brings, what Metz (2015) calls the 'Cambrian explosion of data'. However, the inquiry is often the same process: question or problem; data generated, analysed, interpreted and

visualized; more precise measurements, more variables, more data. The numeral five is again a measure of difference, yet it could be the slope of the line in a graph or the number of trials in an inquiry.

The Australian Curriculum already touches upon on issues concerning data usage though 'data production' itself is not yet explicit. Given that data can be produced automatically and intentionally within digital environments, data literacy requires attention to the full scope of data production.

We are now pursuing a core research question: *in what ways can we articulate a systemic approach to embedding data literacy within a STEM curriculum from early childhood to senior schooling?*

Acknowledgements

References

Earl, L. and Katz, S. (2006), *Leading Schools in a Data Rich World*, Thousand Oaks, California.

Education Council (2015). *National STEM school education strategy 2016-2026.* Australian Government.

Griffin, P., McGaw, B., & Care, E. (Eds.). (2012). *Assessment and Teaching of 21st Century Skills.* Springer.

Khan, K., & Mason, J. (2016). Data, the Story, the Storyteller*,* in Chen, W. et al. (Eds.) *Workshop Proceedings of the 24th International Conference on Computers*, India: Asia-Pacific Society for Computers in Education. (2016). pp. 142-144.

Lohr, S. (2012). *Big Data and Big Brother*. New York Times: New York.

Mason, J., Khan, K., &. Smith, S. (2016). *"Literate, Numerate, Discriminate – Realigning 21st Century Skills",* in Chen, W. et al. (Eds.) *Proceedings of the 24th International Conference on Computers in Education*. India: Asia-Pacific Society for Computers in Education. pp. 609-614.

Metz, S. (2015). Big Data. *The Science Teacher, 82*(5), 6.

Tansley, S., & Tolle, K. M. (2009). *The fourth paradigm: data-intensive scientific discovery* (Vol. 1). A.J. Hey (Ed.). Redmond, WA: Microsoft research.

WORK-IN-PROGRESS POSTERS

Apply Zuvio system to explore student's learning effective in the biostatistics class

Kuo-feng Wu

Assistant Professor, Department of Nurse-Midwifery and Women Health, National Taipei University of Nursing and Health Sciences

Doresses Liu PhD, RN

1.Department of Nursing, Wan Fang Hospital, Taipei Medical University, Taipei, Taiwan
2.School of Nursing, College of Nursing, Taipei Medical University, Taipei, Taiwan
3. Center for Nursing and Healthcare Research in Clinical Practice Application, Wan Fang Hospital, Taipei Medical University

Abstract: The nursing education system learning training is focus on improving technical skills. Most students directly into the workplace after graduation. For this reason, they are more interested in technical courses than basic courses. Students' learning effective reflect teachers' teaching quality and learning effective. In this research, the researcher will using the Zuvio cloud digital platform to expand the learning environment and evaluation methods. The sample of this study is all of two-year technical program student, they are less interested in the biostatistics of this research course. Researcher will through different design in teaching methods, in mid-term and final-term courses. Compare with difference teaching methods of learning effective, to showing which is better. Researchers will collect data in the biostatistics course, all students enrolled in research, not only compare teaching methods, but also through data to analysis framework about the student cost the time how to influence on the final exam results.

Keywords: learning effective, Zuvio, paired t test

1. Introduction

Recently, the popularity of smart phones and the increase in mobile, student spent time for Internet have increased. Market demand for related application software is expanding all over the world. For this reason, Student learning style is changed from traditional single classroom learning to multi-network learning. Teachers will shift from the traditional teacher-centered teaching method to the student-centered technology application teaching method.

Biostatistics is a compulsory course in the field of nursing. How to apply the knowledge learned in the classroom to the empirical curriculum and the workplace is a challenge for many students. In order to enable students to grasp the concept of the course, researchers will adopt a hybrid learning approach in the class. Teaching methods include traditional teaching methods, increasing mobile phones, lithography computers, and computer operations application in the class. Web platform interaction helps researcher to elucidate the gap between the learners' ability and the learning objectives in the class. Web platform allows the teacher proper interventions to make sure their learning needs. (Johnson CE, Keating JL, Boud DJ, et al, 2016). Zuvio has four major features, including: roll call, pre-class preparation, class interaction, and after-school tracking. This study will pre-set the questions in the Zuvio system before class. Researchers will use the Zuvio cloud digital platform to expand the learning environment and evaluation methods in the class.

Research Questions

The following research questions were proposed:

Research purpose1: After biostatistics course, students' learning effectiveness will be improved.

Research purpose2: New teaching biostatistics method that applicate literature review was more effective than traditional teaching method.

2. Literature Review

Outcome-based education is the ability that learners expect to have after completing a study or graduation (CEDEFOP, 2009; Gallavara et al., 2008), this ability-based learning was according to the core competencies of students and was defined from the education objectives for teacher's teaching and student's learning guide. The core competence of nursing student was included direct patient care, readiness for safe, reliable care provision is more critical (Hwang et al., 2016). In the past, in Korea,

there was a research that developed a 1-week classroom based patient safety coursed for second-year medical school students. They was found that the frequency of medical errors and adverse outcomes in student's awareness was changed after the course significantly. (Myung et el., 2012)

In this research, researcher will using ZUVIO online teaching and learning platform in, this platform was designed by Xue-Yue Technology. (ZUVIO, 2013).Through ZUVIO, researcher will collected the data about Problem-Based Learning, PBL Questionnaire to test five learning ability variety. Those ability include self-directed learning, team-work/collaboration, communication, problem solving, critical thinking, (Al-kloub, et al., 2013; Terry 2010; Wells 2009). Through pre-test and post-test to collate data and through paired t-test to evaluate student's learning outcomes variety.

Furthermore, researcher will compare student score between midterm exam and final exam. Further explain difference teaching methods which one have better learning outcomes.

3. Method

This study was using a total of 20 two-year technical program student participated. Students during the first year, they mainly learning about nursing basic knowledgeThey was enrolled in the Department of Nurse-Midwifery and Health student in biostatistics course. This research is comprised the quasi-experimental group (n=20); those with similar characteristics to the group (age, gender, and year).

Firstly, in the first biostatistics course, researcher will using Problem-Based Learning, PBL Questionnaire to test five learning ability variety.Through paired t-test to evaluate student's learning outcomes variety.The five-learning purpose was designed from National Survey of Student Engagement (NSSE) and College Senior Survey in UCLA.

Before midterm exam, adopting traditional teaching method and strengthening calculation ability in Biostatistics course. Between the tenth week and the seventeenth week. Adopting student to read literature review learning the concept of biostatistics.The final exam will through by reading the statistical reports from nurse field article and student will write their perceptions about biostatistics knowledge, evaluating student's final exam outcome to determine the student's learning quality. During the tenth week to the seventeenth week, student not only learning biostatistics calculate but also principle. The researcher will assign a definition and corresponding score to each paragraph of text. In the same time, converting qualitative text results into quantified scores.Finally, through comparing result about the differences between the two points from midterm exam and final exam. Further explain which teaching methods have better learning outcomes.

4. Expected results

Through the combination of information technology and biostatistics teaching, this study expects to get the following two results:

Through the paired t test, the student's learning performance has growth significantly.

Comparing traditional teaching methods and applications Zuvio in the literature review teaching method in biostatistics class, the latter teaching method is better than former.

References

Barrett, Terry (2010). The problem-based learning process as finding and being in flow. Innovations in Education and Teaching International. 47 (2), 165–174.

CEDEFOP (European Centre for the Development of Vocational Training) (2009).\The shift to learning outcomes: Conceptual, political and practical developments in Europe. Luxembourg: Office for official publications of the European Communities.

Gallavara, G., Hreinsson, E., Kajaste, M., Lindesjöö, E., Sølvhjelm, C., Sørskår, A. K., & Zadeh, M. S. (2008). Learning outcomes: Common framework-different approaches to evaluation learning outcomes in the Nordic countries.

Hwang, J.I., Yoon, T.Y., Jin, H.J., Park, Y., Park, J.Y., Lee, B.J., 2016. Patient safety competence for final-year health professional students: perceptions of effectiveness of an interprofessional education course. J. Interprof. Care 30 (6), 732–738.

Johnson, C. E., Keating, J. L., Boud,D. J.,Dalton,M. ,Kiegaldie, D., Hay,M., McGrath,B., McKenzie,W. A., Nair, K. B. R., Nestel,D., Palermo, C. & Molloy, E. K., Identifying educator behaviours for high quality verbal feedback in health professions education: literature review and expert refinement. BMC Med Educ 2016;16:96. doi:10.1186/s12909-016-0613-5.

Myung, S.J., Shin, J.S., Kim, J.H., Roh, H., Kim, Y., Kim, J., ... Kim, S.W., 2012. The patient safety curriculum for undergraduate medical students as a first step toward improving patient safety. J. Surg. Educ. 69 (5), 659–664.

ZUVIO. (2013, October 15). ZUVIO. Retrieved from http://www.zuvio.tw/.

Identifying Determining Factors of EFL Learners' Stage of the Acquisition on English Prepositions

Takumi MUROI[a]*, Yuichi ONO[b]

[a]*Master′s Program in Education, University of Tsukuba, Japan*
[b]*Faculty of Humanities and Social Sciences, University of Tsukuba, Japan*
*s1920080@s.tsukuba.ac.jp

Abstract: In the instruction of English prepositions, the unidirectionality hypothesis which derives from cognitive linguistics has been widely assumed. However, there are few researches about the validity of this assumption from the viewpoint of data-based or knowledge-based methodology. This paper conducts the survey on the knowledge of various uses of preposition *over* and analyze the results by employing the decision tree to identify the crucial factors to predict the score which determine Japanese EFL learners' proficiency levels of an English preposition *over*. The results of our analysis show that there are three important question items which predict participants' scores on the acquisition of *over*, and the usages of *over* in these items do not follow the unidirectionality hypothesis as is assumed in the literature. This suggests that any instructional method to enhance Japanese EFL learners' knowledge of prepositions assuming the unidirectionality hypothesis needs to be reconsidered in terms of acquisitional order.

Keywords: Knowledge-Based Approach, Decision Tree, English Prepositional Acquisition, Japanese EFL learners

1. Introduction

It is generally agreed that the data-based validation is necessary to describe the learners' knowledge in order to devise an instructional design to teach grammar of a foreign language. Although the techniques for analyzing big data have transformed many areas in our lives, the use of data mining in education, particularly in language learning, has only recently emerged (Mark, Soobin, Hansol & Bindin, 2019). Learning analytic or data-driven approaches also have a big potential for enhancing learners' learning process and outcomes in Second Language (L2) learning and constructing a more personalized learning environment.

For Japanese learners of English as a Foreign Language (EFL), the accurate use of English prepositions is one of the most difficult area to acquire. Many experimental studies indicate the benefit of a cognitive linguistic approach in the instruction of English prepositions. Studies by Cho (2002) and Tyler and Vyvyan (2003) suggest that learners acquire prepositions prototypical usage first, or in the order of spatial usage, temporal and abstract. In other words, these studies crucially assume the unidirectionality hypothesis in learning English prepositions. However, Kano (2019) challenges this assumption in his qualitative research and claims that Japanese EFL learners' acquisitional order of English prepositions does not follow the process suggested by cognitive linguistics or the unidirectionality hypothesis. Beyond the hypothesis derived from cognitive linguistics, more research from the viewpoint of data-based validation is needed to identify learners' acquisitional order of English prepositions, since this should lead to the effectiveness of the instruction on English prepositions to EFL learners.

This study aims to investigate the factors which determine acquisition process on English prepositions by analyzing the data from the score of Japanese EFL learners in a multiple-choice questionnaire research and analysis by employing the decision tree analysis.

2. Research Design: Purpose and Procedure

2.1 Purpose

This research consists of the following two research questions given below.
(I) To identify the factors which determine the Japanese EFL learners' stage of improvement in acquisition of English prepositions by analyzing the data.
(II) To suggest a suitable instructional order of English prepositions to Japanese EFL learners beyond the hypothesis which derives from cognitive linguistics.

2.2 Procedure

In order to examine whether Japanese EFL leaners understand the appropriate usage of English prepositions, a multiple-choice questionnaire was conducted.

2.2.1 Participants

A total of 186 students at a national university and a private university in Ibaraki prefecture, Japan, participated in this study.

2.2.2 The questionnaire

The questionnaire consists 80 multiple-choice questions contain target English prepositions such as *over, under, above,* and *below*. 15 out of 80 questions contain other types of prepositions such as *in, on* and *for* to obtain the data on overall prepositional knowledge. To help participants, especially, participants with lower proficiency level to get a grasp of the situation described in each question item, Japanese translations were added to each of them. In each question, participants were asked to choose one most appropriate usage from the four choices.

2.2.3 Methods

The decision tree analysis with Python 3.7.3 was used to identify the question items which determine participants' level of acquisition of a target preposition *over* based on scores in the questionnaire. In the current pilot study, we picked up and analyzed 33 items out of 80.

3. Results

3.1 Results of the questionnaire

The descriptive statistics is given below in Table 1.

Table 1
Mean and Standard Deviation

	Mean	SD
over (33 items)	13.0963	6.2695
overall (80 items)	37.2043	13.8297

3.2 Results of analysis

The results of decision tree and distribution of participants in each endpoint node is shown in Figure 1. Items Q005, Q006, and Q007 are predicted as the factors which determine the participants' acquisitional level based on the scores in the questionnaire.
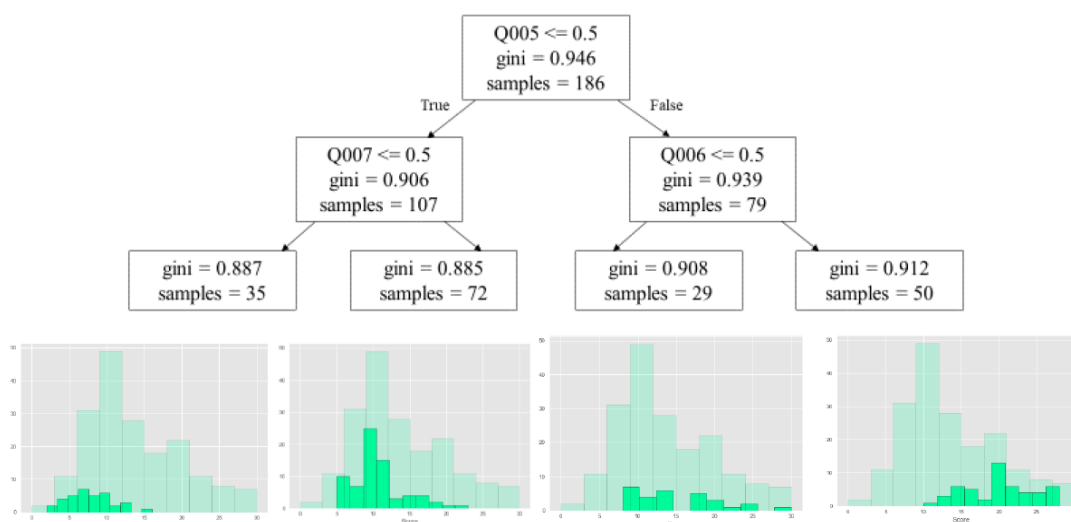
Figure 1. Decision Tree and Distribution of Participants.

Table 2
The Question Items in Each Node of Decision Tree

Question Number	Question Item	Usage
Q005	*Let's talk about it over lunch!*	*Temporal*
Q006	*Many strikes over the last few years have not ended successfully.*	*Temporal*
Q007	*People aged 65 and over can receive the service.*	*More, adv*

The usages of over are the temporal usage in Q005 and Q006, and the usage in Q007 is abstract adverbial usage which has the meaning of more.

4. Discussion and Future Research

The results of the current study show that the temporal and abstract usages can play a decisive role for predicting the stage of acquisition of the English preposition *over*. In our future research, we need to expand the number of participants, types of preposition, and uses of a particular preposition. Moreover, it is necessary to investigate the hidden factors why these uses divide proficiency levels of learners from a linguistic point of view, since this application provides a more appropriate teaching method for prepositional acquisition for Japanese EFL learners. Anyway, it is highly worthwhile to work on a knowledge-based/data-based approach to examine learners' level of proficiency.

References

Cho, K. (2002). A cognitive linguistic approach to the acquisition of English prepositions. *Jacet Bulletin*, *35*, 63-78.

Kano, T. (2019, May). Issues of image-based instruction: Focusing on errors of Japanese EFL learners. *Poster presented at ELSJ international spring forum 2019*, Tokyo.

Mark, W., Soobin, Y., Hansol, L., & Bindin, Z. (2019). Recent Contributions of Data Mining to Language Learning. *Research Annual Review of Applied Linguistics*, *39*, 93-112.

Tyler, A., & Vyvyan, E. (2003). The Semantics of English Prepositions: Spatial scenes, embodied meaning and cognition. Cambridge University Press, Cambridge.

Acquisition Order of Semantics of English Preposition by Japanese EFL Learners

Tomoki KANO[a]* & Yuichi ONO[b]
[a]*Master Program in Education, University of Tsukuba, Japan*
[b]*Faculty of Humanities and Social Sciences, University of Tsukuba, Japan*
*s1820030@s.tsukuba.ac.jp

Abstract: English preposition has been regarded as a difficult grammatical category for EFL learners to acquire. Image-based instruction is widely recognized as effective teaching methods for them, but it is pointed out that the methodology has some issues. One of them is that the previous studies on the instruction does not consider the acquisitional order of the semantics of English prepositions by EFL learners. The current study, which assumes a knowledge-driven approach, explores how the result of our survey validates the "unidirectionality hypothesis" in Japanese EFL learners' prepositional acquisition, and we conclude that they acquire meanings of English prepositions in a more irregular way than assumed in the literature.

Keywords: English prepositions, acquisition order, data-based approach, unidirectionality hypothesis

1. Introduction

English prepositions are considered to be difficult for English as Foreign Language (hereafter, EFL) learners to acquire due to their polysemous meanings and arbitrary extensions in semantics. The previous studies propose various teaching methods and "image-based instruction" is one of the popular methodologies. In this methodology, an instructor teaches English prepositions by employing some images which are derived from literature on cognitive linguistics such as Tanaka and Matsumoto (1997) and Tyler and Evans (2003). A great many of researches focus on a positive effect on the learning and suggest the "image-used" instruction is more beneficial than traditional sentence-based or translation-based instructions (Fujii, 2016; Niemeier, 2017). Kano (2018), however, points out two issues of image-based instruction. First, image-use may block learners' understanding of more extended prepositional usages. Secondly, instructors have difficulties in giving learners the feedback as to the use of image. Moreover, more importantly, the acquisition order has not been examined on the basis of empirical data. Most previous researches assume that EFL learners acquire the prototypical meaning first and other extended meanings later or that EFL learners acquire the spatial meanings first, and temporal meanings and abstract meanings later (this is what we call "unidirectionality hypothesis"). A pilot study in Kano (2019), in contrast, indicates it could not be true that Japanese EFL learners acquire a prototype or spatial meanings of English preposition earlier than the other two usages, although the study has the limited number of questions and participants. Therefore, the purpose of this paper is to examine the overall acquisitional trajectory of English prepositions, and also to observe the acquisition order of English prepositions by Japanese EFL learners in more detail with focus on various uses of *over*.

2. Survey on Acquisition Order

2.1 Procedure

In order to examine the acquisitional order of English prepositions, we conducted a survey on whether or not Japanese EFL learners acquire prepositions in a manner in which previous

675

studies predict or whether or not the unidirectionality hypothesis holds for Japanese EFL learners. Participants consists of 186 Japanese university students.

Participants answered 80 multiple-choice questions containing target prepositions such as *over, above, under* and *below*, and also dummy prepositions such as *on* and *in*. Each question was shown with Japanese translation of the English sentences. The usage of target prepositions is divided into three types; spatial, temporal and abstract. Based on its semantics, each item was further categorized such as *proto, static, -contact*. Some examples of *over* are shown below.

Table 1
Examples Used in the Study

No.	Sentences	Usage
1	He looked at himself in the mirror (　) the table.	Spatial, *proto, static, -contact.*
2	Policemen jumped (　) the wall.	Spatial, p*roto, dynamic, +obstacle, prep*
3	Many strikes (　) the last few years have not ended successfully.	Temporal
4	He's never had any influence (　) her.	Abstract, *control*
5	Think it (　) carefully before you make a decision.	Abstract, *focus of attention*

This study conducted two statistical analyses with R (R core team, 2019). As for *over*, multiple comparison test by Pearson's chi-squared test was implemented to observe sufficient differences in correct answer rates between spatial, temporal and abstract meanings. In the cases of *under*, *below* and *above*, Pearson's chi-squared test was conducted. Furthermore, to investigate the acquisition order of certain semantic usage, participants belonging to the top 25th percentile were divided into upper class and those belonging to the bottom 25th percentile were divided into lower class. Pearson's chi-square test was conducted to examine significant differences in correct answer rates between the upper class and the lower class.

2.2 Result

Table 2 shows the descriptive statistics for whole score by all participants.

Table 2
Descriptive Statistics for Whole Scores

	M	SD	95%CI
Participants (N = 186)	28.60/64.00	11.313	[27.0, 30.2]

In the case of the preposition *over*, the result of multiple comparison shows that there are not significant differences in correct answer rate between the three semantics. The result is shown below as Table 3.

Table 3
Result of Multiple Comparison by Chi-square Test

Comparisons	Chi-squared	*p*-value	Result
Spatial vs Temporal	2.04	.152	*n.s.*
Spatial vs Abstract	3.45	.063	*n.s.*
Temporal vs	0.27	.060	*n.s.*

Abstract

Note. n.s. = not significant, *p <* .0167

As for the other three target preposition, namely *under*, *above* and *below*, there is a significant difference between spatial usage and abstract usage in the cases of *below* (chi-squared = 22.90, *p <* .001) and *under* (chi-squared = 18.15, *p <* .001). Concerning *above*, no significant difference is found (chi-squared = 1.00, *p =* .316). The correct answer rate in spatial usage of *below* (39.8%) is lower than that of abstract usage (52.2%), so the results suggests abstract meanings might be acquired earlier than spatial meaning. On the contrary, the correct answer rate in spatial usage of *under* (62.4%) is higher than that of abstract usage (53.0%), so it is indicated that spatial semantics can be acquired earlier than abstract ones.

Table 4 shows the answer rates of prototypical usage of *over* by upper and lower classes.

Table 4

Correct Answer Rate of Prototypical Usage of Over and p-value of Pearson's Chi-squared Test

Usage	Upper class (%)	Lower class (%)	Chi-squared	*p*-value
Static, -contact	45/50 (90.0)	10/47 (21.3)	46.60	< .001***
Static, +contact	10/50 (20.0)	7/47 (14.9)	0.47	.508
Dynamic, +obstacle, prep	45/50 (90.0)	27/47 (57.4)	13.42	< .001***
Dynamic, -obstacle, prep	43/50 (86.0)	11/47 (23.4)	38.47	< .001***
Dynamic, -obstacle, adv	16/50 (32.0)	4/47 (8.5)	8.167	.004**

Note. * p < .05, ***p <* .01, ****p <* .001

Table 4 indicates a certain meaning such as *static, +contact* can be answered regardless of participants' proficiency levels. However, questions containing the other types of usage are not answered at the same rate by each group of learners. These facts suggest Japanese EFL learners do not acquire all of prototypical meanings in the same way. Contrary to the widely held assumption that a prototypical meaning would be acquired in the same manner, the acquisition order of English prepositions by Japanese EFL learner cannot be explained simply in term of its semantics.

2.3 Discussion

The result of this study indicates that Japanese EFL learners do not acquire semantic usage of English in the order as spatial first, temporal and abstract later. Furthermore, it is suggested that the acquisitional patterns are quite different among the target prepositions. This study also points out the acquisitional pattern cannot be predicted from the view of its meaning. Considering these findings, it is implied Japanese EFL learners, therefore, acquire the semantics of English prepositions more randomly than expected in the previous studies.

3. Conclusion

From this study, it becomes clear that the acquisition order of semantics of English prepositions could not be predicted by unidirectionality hypothesis in the literature. For the future research, we need to elaborate other factors which intervene EFL learners' learning, which affect

acquisitional pattern of English prepositions in more details. In addition, more data-based study on the acquisition is necessary to devise an alternative teaching method to enlarge the effectiveness on grammar learning.

References

Fujii, K. (2016). Exploration into the effects of the schema-based instruction: A bottom-up approach. *Journal of Pan-Pacific Association of Applied Linguistics, 20*(1), 75–94.

Kano, T. (2018). Issues on teaching English preposition to EFL learners: Focusing on the image schema of English preposition. In Y. Ono & M. Shimada (Eds.) *Data Science in Collaboration, Volume 2.* Tsukuba: General Affairs Supporting Center.

Kano, T. (2019). *Issues of image-based instruction: Focusing on errors of Japanese EFL learners.* Poster presented at ELSJ International Spring Forum 2019, Tokyo.

Niemeier, S. (2017). *Task-based grammar teaching of English: Where cognitive grammar and task-based language teaching meet.* Tübingen: Narr Francke Attempto Verlag.

R Core Team (2019) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Tanaka, S., & Matsumoto, Y. (1997). *Kukanto ido no hyogen* [Expressions about space and movement]. Tokyo: Kenkyusha.

Tyler, A., & Evans, V. (2003). *The semantics of English prepositions: Spatial scenes, embodied meaning and cognition.* Cambridge: Cambridge University Press.

Detecting Fine-Grained Syntactic Features for Predicting Japanese EFL Learners' Writing Proficiency

Takeshi KATO[a*], Yuichi ONO[b]
[a*]*Doctoral Program in Literature and Linguistics, University of Tsukuba, Japan*
[b]*Faculty of Humanities and Social Sciences, University of Tsukuba, Japan*
*takeshi.kato1994@gmail.com

Abstract: In the field of foreign language writing research, linguistic features (e.g., mean length of sentence, type-token ratio) that appear in learners' performance have been utilized to gauge learners' development. Among them, syntactic aspect of linguistic structure has prominently been investigated. While there are wide variety of features, however, it is not clear what kind of features should be implemented to improve the quality of writing assessment. This study aims at detecting fine-grained syntactic features for predicting Japanese English-as-a-foreign-language (EFL) learners' writing proficiency. In the analysis, we used 5,000 argumentative essays written by Japanese learners of English, which are assigned five proficiency levels. A total of 78 fine-grained syntactic features are computed from the essays with TAASSC (Kyle, 2016) and employed as predictors of proficiency levels in a random forest classifier. The results suggest that noun phrase elaboration, use of modal, use of passive voice, and verb based syntactic knowledge contribute to the prediction of the proficiency levels.

Keywords: automated essay scoring, syntactic feature, second language writing assessment, random forest

1. Introduction

Since the late 1990s, second language (L2) acquisition and education researchers have focused on the relationship between L2 learners' proficiency and textual features which appear in learners' written and spoken performance (e.g., Wolfe-Quintero, Inagaki, & Kim, 1998). Complexity, Accuracy, and Fluency (CAF) triad has been the most general framework for the purpose of analyzing L2 leaners' development and numerous linguistic features to gauge the three concepts have been proposed (see Housen, Kuiken, & Vedder, 2012). Among them, syntactic complexity, which is a sub-concept of Complexity, has prominently been employed in a great number of L2 writing and speaking studies.

Syntactic complexity, defined as the variety and degree of sophistication of the syntactic structures used, has been measured multidimensionally with variety of linguistic features (Norris & Ortega, 2009; Ortega 2003). Such measuring methods are supported by automated analyzers, which enable us to analyze texts by multiple syntactic levels: sentential, clausal, and phrasal levels (e.g., Biber, Gray, & Poonpon, 2011; Kyle, 2016; Lu, 2010; McNamara, Graesser, McCarthy, & Cai, 2014).

On one hand, thanks to the advance of natural language processing technique, detailed syntactic analyses with diverse linguistic features in automated essay scoring. On the other hand, it has become difficult to determine which factors among syntactic complexity contribute to the prediction of learners' proficiency, due to the proliferation of proposed diverse features as the research proceeds further. For instance, although recent studies have attempted to predict learners' proficiency or writing quality with those automated syntactic features using linear regression, many such features have been excluded from predictive models due to merely statistical problems (e.g., multiple collinearity), resulting in poor accuracy of the models (e.g., Kyle & Crossley, 2017, 2018). This treatment causes not only decrease in explanatory power of the predictive model but loss of representativeness of the construct (i.e., syntactic complexity). In order to construct a more accurate model, it is necessary to identify factors which contribute to predicting learners' proficiency level without a priori feature deletion. Working on this task can lead us to the construction of the writing support system for ESL learners.

Therefore, this study attempts to solve the above-mentioned issue. In so doing, we employ random forest algorithm (Breiman, 2001) as a prediction method and detect syntactic features that contribute to predicting learners' proficiency among all relevant features.

2. Methodology

2.1 Dataset

This study employs the essay data from a large scale standardized English proficiency test (EIKEN foundation of Japan) held in Japan. All the test takers were Japanese EFL learners and each essay was assigned one of five proficiency levels: from A1 to C1 level of CEFR. For the subsequent analysis, 1,000 essays were randomly selected from each proficiency level; the dataset contained 5,000 argumentative essays.

2.2 Automated Analyzer and Relevant Features

TAASSC (Kyle, 2016) was utilized for automated analysis of syntactic sophistication and complexity and relevant syntactic features were computed from the essays. This analyzer deals with three types of syntactic features related to syntactic complexity, which overwhelm the defects of conventional features: (i) fine-grained noun phrase complexity features, (ii) fine-grained clausal complexity features, and (iii) syntactic variation and sophistication features. The first type of features quantifies noun phrase elaboration (e.g., prepositional modification of noun phrases). The second type counts grammatical elements per clause (e.g., adverbial modifiers per clause). The third type operationalizes syntactic structural variety and sophistication utilizing Corpus of Contemporary American English (COCA) as a reference corpus. A total of 78 relevant syntactic features were selected from these types of features.

2.3 Implementation of Random Forest Algorithm

The analysis was conducted by using the statistical programming language R (R Core Team, 2019). The package randomForest (Liaw & Wiener, 2002) was used to implement the algorithm. We constructed a predictive model where 78 syntactic features as independent variables and the five proficiency levels as dependent variables. In learning, the number of independent variables subject to random sampling was set to the square root of the number of independent variables and the number of trees was set to 500.

3. Result and Discussion

As a result of cross-validation by OOB (out-of-bag), the prediction accuracy of the model was 50.34%, which largely exceeds that of previously proposed multiple linear regression models: 14.2% (Kyle & Crossley, 2017) and 20.3% (Kyle & Crossley, 2018).

Figure 1 shows the top 10 of the 78 independent variables in descending order of their contribution to classification, according to their mean decrease Gini coefficients. The first, second, third and seventh features are related to noun phrase elaboration, and in particular, noun phrase modification by prepositional phrases and adjectives contributed to the classification. The fourth through sixth features are the ones of clause level and related to the use of modal auxiliaries and passive voice. The features from the eighth to the tenth are features related to the association strength between a matrix verb and syntactic structure of a sentence, and are operationalization of knowledge related to the sentence structure based on a verb.

The high performances of the fine-grained noun phrase complexity features observed above support Biber et al.'s (2011) finding that noun phrase modification plays an important role in writing development. Additionally, clausal and syntactic structural features' contribution implies that the necessity of investigating grammatical variety and sophistication in assessment of syntactic complexity and L2 writing.

The result suggests that the proposed method is more promising than the conventional ones, but there is much room for improvement particularly in generalizing the current model. For future research, it is necessary to compare the result obtained in this study with that of other classification methods (e.g.,

boosting), and analyze different types of essays (e.g., narrative) and data by English learners whose native language is other than Japanese.
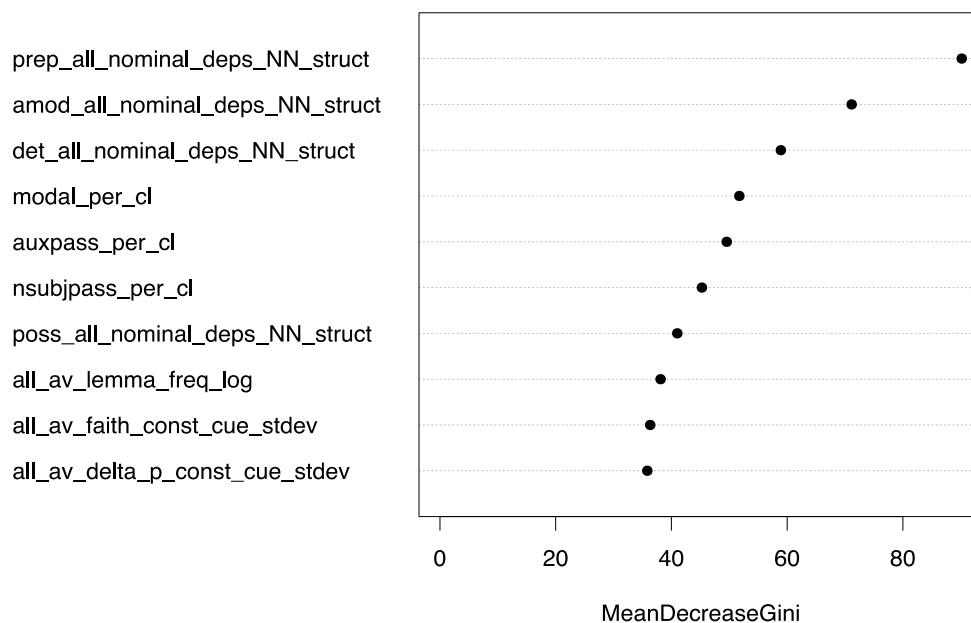
Figure 1. The top 10 contributing features.

Acknowledgements

References

Biber, D., Gray, B., & Poonpon, K. (2011). Should we use characteristics of conversation to measure grammatical complexity in L2 writing development? *TESOL Quarterly, 45,* 5–35.

Breiman, L. (2001). Random forests. *Machine Learning, 24,*123–140.

Housen, A., Kuiken, F., & Vedder, I. (2012). *Dimensions of L2 performance and proficiency: Complexity, accuracy, and fluency in SLA.* Amsterdam: John Benjamins.

Kyle, K. (2016). *Measuring syntactic development in L2 writing: Fine grained indices of syntactic complexity and usage-based indices of syntactic sophistication* (Unpublished doctoral dissertation). Georgia State University, Atlanta, GA.

Kyle, K., & Crossley, S. A. (2017). Assessing syntactic sophistication in L2 writing: A usage-based approach. *Language Testing, 34*(4), 513–535. doi:10.1177/0265532217712554

Kyle, K., & Crossley, S. A. (2018). Measuring syntactic complexity in L2 writing using Fine-Grained clausal and phrasal indices. *The Modern Language Journal, 102*(2), 333–349. doi:10.1111/modl.12468

Liaw, A., & Wiener, M. (2002). Classification and regression by randomForest. *R News, 2*(3), 18–22.

Lu, X. (2010). Automatic analysis of syntactic complexity in second language writing. *International Journal of Corpus Linguistics, 15*(4), 474–496. doi:10.1075/ijcl.15.4.02lu

McNamara, D. S., Graesser, A. C., McCarthy, P. M., & Cai, Z. (2014). *Automated evaluation of text and discourse with Coh-Metrix.* Cambridge: Cambridge University Press.

Norris, J. M., & Ortega, L. (2009). Towards an organic approach to investigating CAF in instructed SLA: The case of complexity. *Applied Linguistics, 30,* 555–578.

Ortega, L. (2003). Syntactic complexity measures and their relationship to L2 proficiency: A research synthesis of college-level L2 writing. *Applied Linguistics, 24,* 492–518.

R Core Team. (2019). *R: A language and environment for statistical computing.* Vienna, Austria: R Foundation for Statistical Computing.

Wolfe-Quintero, K., Inagaki, S., & Kim, H-Y. (1998). *Second language development in writing: Measures of fluency, accuracy, & complexity.* Honolulu: Second Language Teaching & Curriculum Center, University of Hawai'i.

Visualization of Utterance Transition in Group Discussion Using Learners' Mobile Devices

Junichi TAGUCHI[a*], Izumi HORIKOSHI[a] & Yasuhisa TAMURA[b]
[a] *Graduate School of Science and Technology, Sophia University, JAPAN*
[b] *Dept. of Information and Communication Sciences, Sophia University, JAPAN*
*j-taguchi-7ew@eagle.sophia.ac.jp

Abstract: This study proposes a method to visualize utterance transition in a face-to-face group discussion using mobile devices. In a group discussion, it is difficult for an instructor to monitor many groups simultaneously, and there have been some preceding studies on finding methods to monitor learners. However, these methods require special equipment. To avoid this, we proposed to utilize the microphones in learners' existing mobile devices to acquire sound data. Our method does not require special equipment to acquire data, as the program to acquire data runs via the learner's web browser. We conducted a preliminary experiment to visualize utterance transition in a group discussion using our programs. The result indicated that we succeeded in visualizing utterance transition. The visualization diagram indicates participants' frequency of communication with each other.

Keywords: Group discussion, Learning analytics, Visualization, Utterance

1. Introduction

Group discussion is a way of introducing active learning to a class. In a group discussion activity for a class, it is difficult for an instructor to effectively monitor many groups simultaneously. To solve this problem, some preceding studies have investigated the use of different devices for monitoring learners. Among examples of using sound information, Zancanaro, Lepri, and Pianesi (2006) classified functional roles in a group by using close-talk microphones and a voice activity detector. Tomiyama, Nihei, Nakano, and Takase (2018) segmented group discussions by using a headset microphone and an inertial motion unit attached to the participants. In our previous work, we visualized utterance transition in a group discussion based on sound source angle using Kinect (Taguchi, Horikoshi, and Tamura, 2018).

In this study, we developed a program for acquiring voice information via the web browser in learners' mobile devices such as smartphones and tablet computers. The information gathered enabled us to identify speakers, utterance transitions, and length of each utterance in a group discussion. We acquired the sound data from learners' mobile devices without having to install any special software or apps on the devices, as the program runs through the learners' web browser. The study aimed to visualize utterance transition in a group discussion by using the program in a preliminary experiment with a group of three learner participants.

2. Method

2.1 Development

To achieve our objective, we developed a set of programs to perform the following functions. Function (i) is acquiring the data. Functions (ii-vi) involve processing the data to enable visualization of the utterance transition (Figure 1).

(i) Obtain the sound volume data from the microphones in mobile devices and send it to a server using Web Audio API with the learner ID (e.g. S1, S2, S3)
(ii) Download the volume data of each learner from the server
(iii) Merge the volume data from all learners mentioned in (ii)
(iv) Judge who was speaking by analyzing which learner data was transmitted at the loudest volume at each time point, and regard volumes lower than a specified level as silence (X)
(v) Detect change of speaker at each time point and create a table including the start and end time of an utterance, and the speaker/silence (X)
(vi) Regard a period longer than two seconds without any utterance as a silence and visualize utterance sequence and transition from the table created in the function (v)
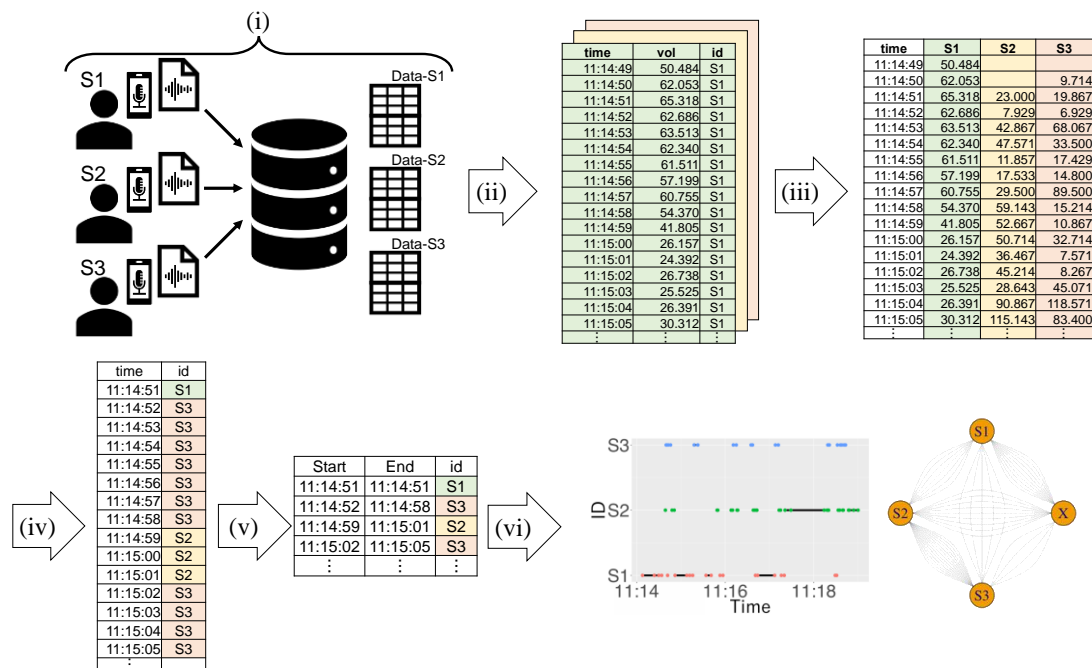
Figure 1. Data acquisition and visualization process

2.2 Preliminary Experiment

The preliminary experiment comprised three participants (a master's course student: abbreviated as M1 in figure 2 and 3, a doctoral course student: D1, and their professor: Pr.). They held a discussion for approximately fifteen minutes. The participants used the same tablet computers that the authors prepared for this experiment to avoid calibration of volume and make the experiment easier.

3. Results and Discussion

We visualized utterance sequence and transition in the first five minutes of the discussion. Figure 2 shows the utterance sequence. The horizontal axis shows the time and the vertical axis shows the participant ID (M1, D1, and Pr.). The results indicated that the utterance transition and sequence could be visualized using our system.
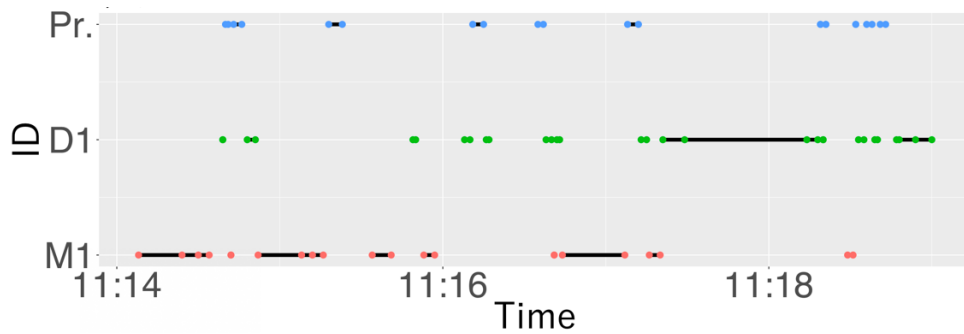
Figure 2. Utterance sequence

Figure 3 shows the utterance transition in the first 5 minutes of the discussion. For example, edges between M1 and D1 indicate that the participant M1 spoke before or after the participant D1. Note that X represents silence. In this figure, there are a relatively large number of edges between D1 and Pr. This indicates that there was a great deal of conversation between participant D1 and Pr. during the first 5 minutes. From the figure, we can identify the frequency of communication between participants.
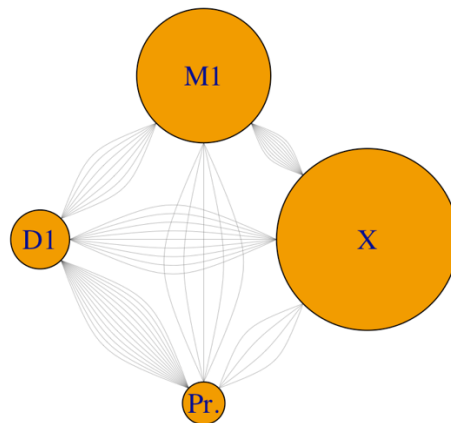
Figure 3. Utterance transition

4. Conclusion and Future Works

The purpose of this study was to visualize utterance transition in a group discussion by using our programs, which does not require special equipment to acquire data in a classroom. The results indicate that it is possible to visualize utterance transition in group discussions using mobile devices. In future work, we will verify the accuracy of the system by using video recorded during the preliminary experiment, improve the utterance detection algorithm, and conduct an experiment using learners' own devices.

References

Taguchi, J., Horikoshi, I., & Tamura, Y. (2018). Analysis and visualization of group discussion based on sound source angle obtained using Kinect. In Ogata, H. et al. (Eds.). *Extended Summary Proceedings of 26th International Conference on Computers in Education*. 11-14

Tomiyama, K., Nihei, F., Nakano, Y. I., & Takase, Y. (2018). Identifying discourse boundaries in group discussions using a multimodal embedding space, *Joint Proc. ACM IUI 2018 Workshops*.

Zancanaro, M., Lepri, B., & Pianesi, F. (2006). Automatic detection of group functional roles in face to face interactions. *Proc. 8th International Conference on Multimodal Interfaces*. 28-34. ACM.

Effects of Different Media Formats of Student-provided Explanations to Online Student-generated Questions on English Language Learning

Fu-Yun YU [a*] & Pei-Chi Wu [b]
[a] *Institute of Education, National Cheng Kung University, Taiwan*
[b] *Tainan Municipal Minde Junior High School, Taiwan*
* fuyun.ncku@gmail.com

Abstract: The main purpose of this study is to investigate the comparative effects of text-only and media-afforded student-provided explanations to online student-generated questions on English language learning. Four eighth-grade classes (n=118) participated in this study. An online learning system was adopted to support the activity. A non-equivalent pretest-posttest quasi-experimental design was used. The results of the analysis of covariance found that students in the text-only student-provided explanations group scored significantly higher than their counterparts in the media-afforded student-provided explanations group in terms of the use of learning strategies and social presence while no statistical differences were found in English language academic achievement.

Keywords: Media effects, learning effects, online learning activity, self-explanation, student-generated content, student-generated questions

1. Introduction

Under the contemporary educational paradigm, innovative approaches to teaching, learning, and assessment to cultivate deep learning have been valued by academicians and practitioners. In the same vein, student question-generation (SGQ) has been hailed as a cognitive-enhancing strategy. By requiring students to generate questions corresponding to the study material, empirical evidence on SGQ accumulated over the past decades has generally confirmed its learning effects (Yu, 2012). With the advantages of computer and networked technology, online SGQ has attracted the attention of an increasing number of scholars in this field (Yu, 2012).

Since then, different structures and types of SGQ have been proposed to increase its versatility and scalability. For instance, Stoyanova and Ellerton (1996) proposed three SGQ types: free, semi-structured and structured. Ways to scaffolding online SGQ have been suggested, and their effects on promoting learning have been substantiated (e.g., Yu & Pan, 2014; Yu, Tsai, & Wu, 2013). Recently, the ideas of students constructing tests based on SGQ (Yu & Wu, 2016) and generating explanations in correspondence to answers given to SGQ (Yu, Wu, & Huang, 2018) have been envisioned with their respective learning effects validated.

In light of the fact that nowadays learners are accustomed to media-rich learning environments (Prensky, 2001), allowing students to generate content not limited to text-based would appear desirable. The issue regarding whether such an arrangement renders additional learning gains for the learner serves as the focus of this study. On the grounds of relevant theories, including dual-coding theory (Paivio, 1990), cognitive theory of multimedia learning (Mayer, 2001), and social presence, this study aims to investigate the effects of different media formats of student-generated explanations to online SGQ on learning. Specifically, the research question under examination is: if the multimedia-afforded arrangement compared to the text-only arrangement renders additional benefits in terms of academic performance, use of learning strategies, and social presence when students engaged in explanation-generation for online SGQ.

2. Methods

A non-equivalent pretest-posttest quasi-experimental design was adopted. An online learning system supporting student-generated explanations in text-only (Figure 1) or multimedia-afforded forms (Figure 2) to be used as feedback to student answers to multiple-choice questions was adopted (Yu, 2018). The multimedia files to be included can be in any media form (e.g., texts, pictures, charts, diagrams, tables, animations, audio, video, and so on).

Figure 1. Text-only Student-provided Explanations to Online Student-generated Questions

Figure 2. Media-afforded Student-provided Explanations to Online Student-generated Questions

Four eighth-grade participating classes (*n*=118) of one junior high school in Tainan, Taiwan were randomly assigned to the two devised treatment groups — text-only student-provided explanations to online student-generated questions (i.e., Group A, the text-only student-provided explanations group) and media-afforded student-provided explanations to online student-generated questions (i.e., Group B, the media-afforded student-provided explanations group). The study took place in the context of an English course. During the study, as a routine, each week after attending five 45-minute instructional sessions on English, the participants headed to the school's computer lab for a 45-minute online activity to support English learning.

Mainly, the study consisted of two stages: the 1st training and baseline establishment stage (3 weeks) and 2nd intervention stage (8 weeks). During the 1st stage, the participants of both groups were exposed to the text-based explanations form where they were directed to generate a set of multiple-choice questions with explanations to each of the options on the English content covered in the current week (Figure 1). To equip the participants with essential knowledge and skills on question- and explanation-generation, a 45-minute training session was held at the beginning of the 1st stage for the participating students of both groups. Then, at the end of the 1st stage, students were asked to fill out a questionnaire on their use of learning strategies (40 item, 6-point Likert scale, Crobach α = .97) and social presence (14 item, 5-point Likert scale, Crobach α = .93). Student academic performance at the school-wide exam on English administered prior to this study was also collected. The collected data were used as covariates for later data analysis.

During the 2nd stage, the participants of both groups continued to engage in the online question- and explanation-generation activities as they did the previous weeks; however, the participants of Group B were introduced to the multimedia feature of the system. With all elements kept the same, the only difference between the two treatment groups was: for Group B, multimedia files are permissible (Figure 2) whereas for Group A they are not. To equip the participants of Group B with the skills of locating and uploading multimedia files as part of the explanations, at the beginning of the 2nd stage,

they were briefed on the operational procedures of accessing and including multimedia files in the adopted system, and were told that they could include any multimedia files stored in the system, or create multimedia of any type of their own. At the conclusion of the study, the participants were directed to fill out the same set of questionnaire, and their academic achievement on English content covered during the study were collected.

3. Results and Discussion

Contrary to the authors' expectations, the results of the analysis of covariance revealed that students participating in the text-only student-provided explanations group scored significantly higher than those in the media-afforded student-provided explanations group in the use of learning strategies, $F(1, 115) = 4.64$, $p < .05$ and social presence performance, $F(1, 115) = 4.07$, $p < .05$. Moreover, no statistically significant differences were found between the two groups in academic achievement, $F(1, 115) = .00$, $p > .05$.

The findings of this study did not confirm any additional benefits of having students generate explanations in media-form. Instead, students generated explanations in text-only form was found to lead to better social presence and more frequent use of learning strategies during the learning process as compared to the media-form. Even though the role and pedagogical value of multimedia in instruction is broadly known, it should be noted that existing studies were predominately conducted under the premise of 'learners as the consumer' rather than 'learners as the producer.' In the rise of the maker movement in the maker era on the basis of the findings of this study, instructors are advised to carefully assess the learning task and situation in focus so as to maximize intended learning.

Acknowledgement

References

Mayer, R. E. (2001). *Multimedia Learning*. New York: Cambridge University Press.

Paivio, A. (1990). *Mental representations: A dual coding approach*. New York: Oxford University Press.

Prensky, M. (2001). Digital natives, digital immigrants. *On the Horizon, 9*(5), 1-6.

Stoyanova, E. & Ellerton, N. F. (1996). A framework for research into students' problem posing in school mathematics. *Proceedings of the 19th annual conference of the Mathematics Education Research Group of Australasia*. June 30-July 3, the University of Melbourne.

Yu, F. Y. (2018). The learning potential of student-generated feedback with multimedia shareability for online student-generated multiple-choice questions. In Wu, Y-T., Srisawasdi, N., Banawan, M., Yang, J. C., Chang, M., Wong, L-H, & Rodrigo, Ma. M. T. (Eds.). *Workshop Proceedings of the 26th International Conference on Computers in Education* (pp. 249-251). November 26~November 30. Manila, Philippines: Asia-Pacific Society for Computers in Education

Yu, F. Y. (2012). Learner-centered pedagogy + adaptable and scaffolded learning space design—online student question-generation. Keynote speech at the *International Conference on Computers in Education*, November 26-30, Singapore.

Yu, F. Y., & Pan, K-J (2014). Effects of student question-generation with online prompts on learning. *Educational Technology and Society, 17*(3), 267-279.

Yu, F. Y., Tsai, H. C., & Wu, H-L (2013). Effects of online procedural scaffolds and the timing of scaffolding provision on elementary Taiwanese students' question-generation in a science class. *Australasian Journal of Educational Technology, 29*(3), 416-433.

Yu, F. Y., & Wu, C. P. (2016). The effects of an online student-constructed test strategy on knowledge construction. *Computers & Education, 94*, 89-101.

Yu, F. Y., Wu. W. S., & Huang, H. C. (2018). Promoting middle school students' learning motivation and academic emotions via online student-created feedback for student-created multiple-choice questions. *Asia-Pacific Education Researcher, 27*(5), 395-408.

The Effects of a Crowd-sourced Approach to Feedback-provision for Online Drill & Practice Activities

Fu-Yun YU [a*] & Chiao-Yi Chen [b]
[a] *Institute of Education, National Cheng Kung University, Taiwan*
[b] *Tainan Municipal Daciao Elementary School, Taiwan*
* fuyun.ncku@gmail.com

Abstract: The main purpose of this study was to investigate the effects of a crowd-sourced approach to feedback-provision for online drill & practice (D&P) activities. As compared to traditional teacher-designed feedback to online D&P activities, the effects of student-created feedback on academic achievement and attitudes toward the studied subject matter were the focus of this study. A non-equivalent pretest-posttest quasi-experimental research design was adopted. A total of 104 six-graders from four primary school classes participated in a weekly 20-minute online D&P exercise for six weeks. The results of the analysis of covariance indicated no statistically significant between-group differences in terms of academic achievement. However, students exposed to the student-created feedback for the online D&P activities condition exhibited a better attitude toward the subject matter as compared to the teacher-designed feedback group.

Keywords: Crowdsourcing, drill-and-practice, experts and novices, feedback, learning effects, online learning activity

1. Introduction

Engaging students in practice aligned with learning objectives and followed by timely feedback has been suggested as powerful instructional elements to facilitate learning (Dick, Carey, & Carey, 2005). Despite its well-recognized pedagogical values, questions in practice and feedback to student performance mostly come from teachers. Under the maker movement and crowdsourcing model, the idea of delegating question-generation to the larger student community is becoming increasingly popular. More recently, generating corresponding feedback to student-generated questions has been a topic of experimentation. While students have been found to benefit from the act of generating questions and feedback (Yu, Wu, & Huang, 2018), the question as to whether learners can benefit from utilizing the produced work, specifically, student-created feedback to responses to posed questions, awaits investigation.

In view of the literature on experts and novices, feedback messages created by students and teachers may lead to different learning effects. Experts and novices have been found to be distinctly different in terms of structures, types, and amount of knowledge, as well as skill level (Chi, Feltovich, & Glaser, 1981; LeFrance, 1989; Rumelhart, 1980; Voss & Post, 1988). Specifically, experts have more systematic knowledge, procedural knowledge, and a larger prior knowledge base as well as relevant experience in a specific field or domain, whereas the knowledge of novices tends to be fragmented, insufficient, and declarative in nature (Rumelhart, 1980; Voss & Post, 1988). With these distinct differences, the messages created by teachers (i.e., considered as experts in the study) and students (i.e., considered as novices in the study) to be used as feedback to questions may engender different effects on the part of student users.

To summarize, the research question of this study is to examine any differential learning effects of student-created feedback as compared to teacher-designed feedback on academic achievement and attitudes toward the subject matter.

2. Methods

For the purpose of this study, a non-equivalent pretest-posttest quasi-experimental research method was adopted. Two treatment groups were devised: Group A (the teacher-designed feedback group) and Group B (the student-created feedback group). Four sixth-grade participating classes ($n = 104$; males: 53, females: 51) from a single elementary school in Tainan City, Taiwan were randomly assigned to the two treatment groups (Group A, $n = 49$ and Group B, $n = 55$) for this 6-week study. For the teacher-designed feedback group, the feedback was designed by the implementing teacher herself. As for the student-created feedback group, the feedback was created by a selected group of 20 students (called the collaborating students) from five other non-participating sixth-grade classes in the same school. To equip the collaborating students with essential knowledge on feedback message design, a training session was arranged. For the duration of this study, the collaborating students were directed to create feedback to accompany each of the four options of the two multiple-choice questions assigned by the implementing teacher in the 30-minute morning session before their inclusion in the adopted online system for the use of Group B. Informed consent was secured from all participating and collaborative students prior to the study.

An online learning system was adopted to support the activity (Yu & Liu, 2016), and the online activity integrated was introduced to support the teaching and learning of science. Once in the D&P space, a set of multiple-choice questions was displayed individually (Figure 1), and feedback to the chosen option of the focal question was displayed right afterwards, which could be textual and media forms (Figure 2).

Figure 1. The Online D&P Space
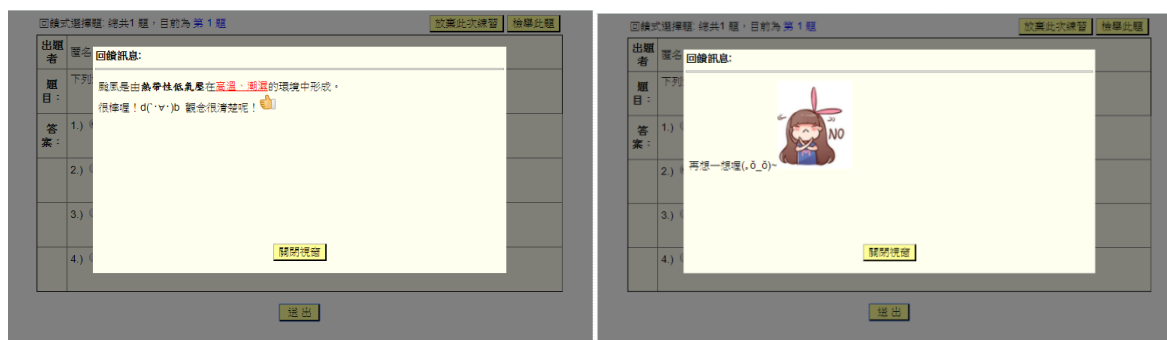
Figure 2. Feedback to Student Responses to the Posed Questions in the Textual Form (left) and Media Form (right)

Prior to the study, data on student science academic achievement on the mid-term exam administered school-wide and attitudes toward the sciences (14-item, 5-point Likert scale, Cronbach α = .93) were collected and used as covariates for later data analyses. In addition, a brief training session on accessing the D&P and learner portfolio spaces in the system was arranged. Routinely during the study, after receiving 100 minutes of teacher-led instruction and science lab activities, the participants

engaged in the 20-minute online D&P activity on the science topic covered in the previous week in the participating school computer lab. After the study, data on student academic achievement on the science content covered during the study and attitudes toward science were collected again.

3. Results and Discussion

The results of the analysis of covariance (ANCOVA) revealed that there were significant between-group differences in attitudes toward the sciences, $F(1, 100) = 13.674$, $p < .05$. However, no significant between-group differences were found in academic achievement, $F(1, 100) = 0.019$, $p > .05$. In view of the findings of this study, instructors are suggested to consider adopting a crowdsourcing approach to feedback-provision for online D&P activities as a change. As confirmed, student-created feedback to D&P questions led to improved attitudes toward the subject matter studied without sacrificing academic performance. Moreover, with the crowdsourcing approach, students at large are involved in the learning process, and participatory education are thus promoted. Furthermore, with students serving an integral part of the classroom environment and given opportunities to contribute to peers' learning, the proposed crowdsourcing model aligns well with contemporary educational paradigm.

This study examined if teacher-designed feedback and student-created feedback differed in promoting learning. As a next step, the issue regarding how and why teacher-designed feedback and student-created feedback differ can be examined. By content-analysis of feedback message designed by teachers and students, in what ways teacher-designed feedback and student-created feedback differ can be compared on multiple dimensions (e.g., style, forms, content and so on) and better understood. By in-depth interviews with a purposively selective group of participants, the activated learning process and student subjective views toward the two different approaches can be tapped on. Insights obtained can lead to the strengthening of theoretical bases and empirical evidence on student-generated content as well as expert and novice research.

Acknowledgement

References

Chi, M., Feltovich, P. J., & Glaser, R. (1981). Categorization and representation of physics problems by experts and novices. *Cognitive Science, 5*(2), 121-152.

Dick, W., Carey, L., & Carey, J. O. (2009). *The systematic design of instruction* (7th ed.). Upper Saddle River, NJ: Pearson/Merrill Publishers.

LeFrance, M. (1989). The quality of expertise: Implications of expert-novice differences for knowledge acquisition. *ACM SIGART Newsletter, 108*, 6-14.

Rumelhart, D. E. (1980). Schemata: The building blocks of cognition. In R. J. Spiro, B. C. Bruce, & W. F. Brewer (Eds.), *Theoretical issues in reading comprehension* (pp. 33-58). Hillsdale, NJ: Lawrence Erlbaum Associates.

Voss, J. F. & Post, T. A. (1988). On the solving of ill-structured problems In M. T. H. Chi, R. Glaser & M. J. Farr (Eds.). *The Nature of Expertise*. Hillsdale, NJ: Erlbaum

Yu, F. Y. & Liu, Y. H. (2016). Development and evaluation of student-generated feedback in an online student-generated multiple-choice questions learning space. *Workshop Proceedings of the 24th International Conference on Computers in Education* (pp. 413~418). IIT Bombay, Mumbai, India, November 28-December 2.

Yu, F. Y., Wu. W. S., & Huang, H. C. (2018). Promoting middle school students' learning motivation and academic emotions via online student-created feedback for student-created multiple-choice questions. *Asia-Pacific Education Researcher, 27*(5), 395-408.

Utilizing online community-based flipped learning approach for oral presentation

Yi Chun LIU [a*], Cheng-Hsuan Lan [a], & Chun-Wang Wei [b]
[a] Dept. of Applied Foreign Languages, Chia Nan University of Pharmacy & Science, Taiwan
[a] Dept. of Applied Geoinformatics, Chia Nan University of Pharmacy & Science, Taiwan
[b] Dept. of Healthcare Administration & Medical Informatics, Kaohsiung Medical University, Taiwan
*ycliu715@gm.cnu.edu.tw

Abstract: This work-in-progress study used online community-based flipped learning platform to explore college students' learning motivation in the oral presentation. A sample of 95 college students studying English as a foreign language (EFL) was assigned into control and experimental groups, with 40 and 55 students in each group based on a pre-test. Both groups were further divided into groups of two or three students for their oral presentation. Data collection consisted of pre- and post-tests and evaluations of group project presentations. Both groups uploaded their group projects with images to the online learning platform, and then gave a brief presentation of their final project. Students' group projects were evaluated by three teachers. The difference between control and experimental groups is the latter group recorded the video-mediated oral feedback to provide comments for other teams' oral presentation besides recording their oral presentation videos with written feedback. The results of this study indicated that the students in the experimental group perceived their learning process in oral presentation positively and performed better than those of the students in the control group. They provided positive and immediate feedback to their peers and clearly perceived peers' annotations which enhanced oral presentation in terms of pronunciation, fluency, comprehension, and relevance of the content. This study suggests EFL college students to use online community-based flipping learning to raise their learning motivation for the oral presentation.

Keywords: English as a foreign language, flipped learning, technology-enhanced language learning

1. Introduction

The English-speaking ability of students at technical colleges need support to develop their English skills since their English level is relatively poor. The contribution of this study is to embed online community-based flipping learning into English oral training courses, cultivating their ability to use simple English to introduce their hometown in comparison with other foreign cultures. Based on Lin & Hwang (2018), the research sought to explore factors affecting EFL students' oral performance in a flipped classroom and whether the online
community-based flipping learning would have a significant impact on students' learning motivation to apply technology in the process of learning English.

2. Literature Review

The flipped classroom has recently been regarded as an efficient learning approach in various courses (Hsia, Huang, & Hwang, 2016; Lin & Hwang, 2018). The adoption of flipped classrooms in English language teaching provides teachers more time to interact with each student (Lin & Hwang, 2018). Integrating technology into English learning, teachers can guide students to cultivate their language

skills through real-life scenarios and meaningful learning experiences (Angelova & Zhao, 2016; Wu, Yen, & Marek, 2011). Overall, teachers teach from familiar to unfamiliar contents step by step. We can summarize that learners rely on their established schematic knowledge and the scaffolding of new systemic knowledge in English learning.

3. Methodology

Research Question

The research question is as follows: Can the online community-based flipped learning approach enhance students' learning motivation in oral presentation compared with the conventional video-based learning?

Participants

Two intact Freshman English classes at a technological college with a total of 95 students were the subjects of this experiment. The students were formed into groups of two or three. The control group was comprised of 40 participants, while the experimental group of 55 students employed the cloud-based collaborative learning *1know* as the platform for students' online community-based flipping learning.

Collaborative learning tool

1know was used as a platform, enabling the students to: (a) view other team's presentation videos; (b) write comments; and (c) read peers' comments. Each group developed a PowerPoint presentation that contained descriptions of their hometown as the group project. Both classes spent 40 minutes per session working together for 6 weeks. Both groups discussed and edited files via google slides. After 6 weeks, participants uploaded their projects with images to e-learning and *1know* platforms respectively, and then made the oral presentation for their final project. Students' group projects were evaluated by three teachers, including two native English speakers and one non-native English speaker.

Measurement tool

Data collection consisted of pre- and post-tests, a learning motivation questionnaire, and evaluations of group project presentations. The learning motivation questionnaire was modified from the instructional materials motivation scale (IMMS) established by Keller (2009). The original IMMS includes four subscales: attention, relevance, confidence, and satisfaction (ARCS). In this study, the researcher modified and deleted some items, producing a modified IMMS with 25 items. It is hoped that the functions explored in this study can support English language learning and make learning more interesting for the participants. Results of the study may have broader implications for the use of the cloud-based collaborative learning platform *1know* as a peer review mechanism for enhancing learning experiences.

Procedure

At the beginning of the learning activity, the students took the pre-test. The purpose of the pre-test was to measure students' learning motivation concerning the online community-based flipped learning so that group members could learn from each other. Also, it examined if the two classes had similar level of learning motivation. After the pre-test, the two classes of students had learning activities that lasted 40 minutes for 6 weeks, where they learned about the basic knowledge via *1know* platform. Each group consisted of 2-3 students. The difference between the control group and experimental group is the latter group could record the video-mediated oral feedback to provide comments for other teams' oral presentation besides
recording their oral presentation videos. It means the control groups are not able to provide instant oral feedback based on other teams' oral presentation synchronously. After the designing activity was completed, the students took the post-test to measure their learning motivation.

4. Results & Conclusion

Most 55 participants from the experimental group made satisfactory progress with a significant difference (t=2.28, p=0.038). The survey items reached .78 of Cronbach's Alpha value. This preliminary work applied *1know* platform to allow students to upload group PowerPoints, record group oral presentations, and further record video-mediated oral feedback according to other teams' oral presentation. It sought to explore the support of *1know* for peer review. This work-in-progress study indicated the effectiveness of using *1know* platform. In the open-ended questions on the survey, students reported that they enjoyed using *1know* to work on their group project and interact with other groups, especially the experimental group, who applied *1know* as the peer review platform. Through the focus group interviews, students expressed positive feelings about editing the group project with peers, especially because they could give instant feedback. They thought they had good interaction while working on the group project. In addition to that, they appreciated having two foreign guest speakers to evaluate their group oral presentations, so that they could be sure that the foreign teachers understood their content and communicate with them. The result was that technology could be integrated into the oral training activity, allowing students to learn with each other from their own perspectives compared with other foreign cultures.

References

Angelova, M., & Zhao, Y. (2016). Using an online collaborative project between American and Chinese students to develop ESL teaching skills, cross-cultural awareness and language skills. *Computer Assisted Language Learning, 29*(1), 167-185.

Hsia, L.-H., Huang, I., & Hwang, G.-J. (2016). Effects of different online peer-feedback approaches on students' performance skills, motivation and self-efficacy in a dance course. *Computers & Education*, *96*, 55-71.

Keller, J. M. (2009). A significant contributor to the field of educational psychology. *Educational Technology*, 49(3), 43-45.

Lin, C.-J., & Hwang, G.-J. (2018). A learning analytics approach to investigating factors affecting EFL students' oral performance in a flipped classroom. *Educational Technology & Society, 21*(2), 205–219.

Liu, Y. C., & Huang, Y. M. (2015). Using the UTAUT model to examine the acceptance behavior of synchronous collaboration to support peer translation. *JALT CALL Journal, 11*(1), 77-91.

Oxford, R. L. (1990). *Language learning strategies: What every teacher should know*. New York: Newbury House/Harper & Row.

Wu, W. V., Yen, L. L., & Marek, M. (2011). Using online EFL interaction to increase confidence, motivation, and ability. *Educational Technology & Society, 14*(3), 118–129.

Practice on a Workshop Utilizing Web-based Investigation System for Teachers' Judgments on Students' Performance

Kae NAKAYA[a]*, Yuri UESAKA[b], Hidekazu KAMINISHI[c], Tatsushi FUKAYA[d], Kazuhiro YAMAGUCHI[e,f] & Masanori NAKAGAWA[g]
[a]*Initiative in Information Studies, The University of Tokyo, Japan*
[b]*Center for Research and Development on Transition from Secondary to Higher Education, The University of Tokyo, Japan*
[c]*Center for Information & Communication Technology, Dokkyo Medical University, Japan*
[d]*Graduate School of Education, Hiroshima University, Japan*
[e]*JSPS Research Fellow, Hosei University, Japan*
[f]*College of Education, The University of Iowa, USA*
[g]*Institute of Human Culture Studies, Otsuma Women's University, Japan*
*knakaya@iii.u-tokyo.ac.jp

Abstract: In this research, we developed and evaluated a workshop utilizing Web-based Investigation System for Teachers' Judgments on Students' Performance (Wits). The aim was to facilitate teachers to reflect on their teaching methods and consider how to improve them based on the analysis results of Wits. When a user inputs the data of students' actual performances of examinations or tasks along with the data of teachers' predictions, Wits automatically calculates the accuracy of teachers' predictions based on a statistical model. We designed and conducted a workshop for teachers to use Wits and to hold a group discussion on the results shown by Wits and how to improve their teaching methods. The results of a questionnaire and recorded discussion implied that through the activities of the workshop, the participants were able to recognize students' learning impasses that they had not expected. In addition, we need to add other activities that support teachers in their endeavor to consider students' essential learning impasses and how they should deal with it.

Keywords: Teachers' judgment, teacher education, students' impasses, web application, workshop

1. Introduction

It is important for teachers to acquire the skills to predict their students' performances accurately in order to provide suitable instructions. The authors have developed a web application named Web-based Investigation System for Teachers' Judgments on Students' Performance (Wits) that enables an easy analysis of teachers' judgments of their students' performances (Nakaya et al., 2017). When a teacher inputs the data of their predictions and the students' real performances, Wits automatically calculates the accuracy of the teachers' judgments based on Uesaka et al.'s model (2017). In this model, the alpha value reflects the accuracy of teachers' predictions. An alpha value that approaches 1 indicates that the teacher's prediction matches the students' real performance. In contrast, an alpha value lower than 0 indicates that the teacher's prediction contradicts the students' real performance.

Wits aims to facilitate teachers in reflecting on their teaching methods and considering improvements based on the results of the analysis. In most cases, when a teacher's prediction is a mismatch with the students' actual performance, it is because the teacher has overestimated the students' performance. In other words, although students did not understand the teacher's explanation of the topic, the teacher is of the opinion that they did. Using the analysis result from Wits, teachers can identify these gaps and consider ways to improve their teaching methods.

In this research, we designed and conducted a workshop for teachers to try to use Wits and to hold a group discussion about the result shown by Wits and how to improve their teaching methods. This paper reports the design and discusses the results of the workshop.

2. The System Design of Wits

Wits can be accessed through a webpage (https://wits.dokkyomed.ac.jp/pre/index_en.html), so that anyone can use it for free. Users can analyze teachers' judgments by the following steps: first, a user inputs the number of teachers, names and number of tasks, names and number of categories of each task, prediction data, and students' real performance data (Table 1 shows an example of a data frame); second, Wits calculates alpha values using statistical R programs for the model; and third, the user can view the summarized data. Figure 1 shows Wits screens for data input and for the analysis result.

Table 1

An Example of a Data Frame for Wits (Average Calculation)

	Options of a Task (Categories)				
	37m	38m	39m	40m	No answer
Students' real performance	27.78 %	46.83 %	11.9 %	5.56 %	7.94 %
Teacher 1's prediction	60 %	5 %	5 %	30 %	0 %
Teacher 2's prediction	75 %	5 %	5 %	10 %	5 %
Teacher 3's prediction	40 %	10 %	10 %	10 %	30 %
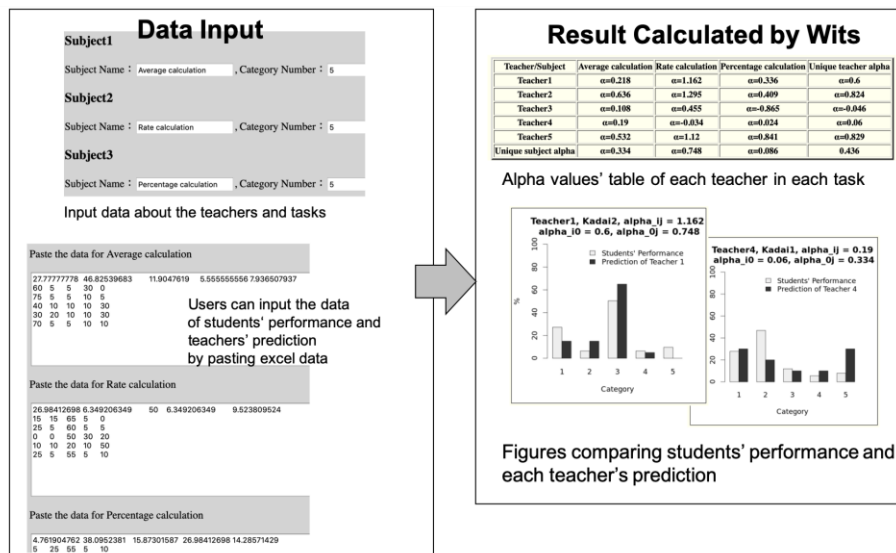
Figure 1. Wits Screen

3. Outline of the Workshop

In order to support teachers in utilizing Wits to improve their teaching methods, we designed and implemented the following workshop. Prior to the workshop, we asked participants (teachers) to conduct an examination in their classes and to predict their students' performances. The examination comprised mathematical tasks about conceptual understanding. During the workshop, one of the authors first explained the outline and aim of the workshop to participants. Second, the participants input the data of their students' performances and their predictions on Wits and analyzed their judgments. Third, focusing on the tasks of the examination for which the accuracy of their predictions were not so good, they discussed the reasons for the differences between their predictions and the students' real performances and how they could improve their teaching methods.

We conducted this workshop in February 2019 with thirteen mathematical teachers at an elementary school in Japan. We collected the following data: log data of Wits, audio and movie of the workshop, a questionnaire about the usability of Wits, and questionnaires that asked what kind of issues their students faced and ways to solve it. The questionnaire about students' problems was administered before and after the workshop.

When discussing the analysis results of Wits, the participants were split into four groups. One participant had not prepared the prediction data, therefore we excluded the data of the group to which that teacher belonged and analyzed the data of the ten teachers belonging to the remaining three groups.

4. Results and Discussion

We concluded that the teachers could recognize students' learning impasses about conceptual understanding and why the impasses occurred. According to recorded discussion data, all the participants mentioned that they had not expected their students to have learning impasses with certain tasks until the Wits results showed the inaccuracy of their predictions. For example, one of the tasks for elementary school students in the sixth grade was as follows: "The average of Tom's three-time softball throw was 36m. When he threw a ball again, the score was 40m. What is his average score of all the throws?" The options given for the mathematical task were 37m, 38m, 39m, and 40m. All the teachers predicted that percentage of students who chose "37m" would be more than the percentage of students who chose "38m," but in fact it was completely opposite. About a half of the students chose "38m" and only 27% of the students chose "37m." The teachers expressed surprise on realizing the gap between their predictions and the actual result. Moreover, they inferred from the analysis results that the students remained in shallow understanding and did not deeply understand the concept of "average" so that they calculated as follows: $(36 + 40)/2$.

In contrast, few of the participants were able to consider improved their teaching methods based on students' essential learning impasses. During the group discussion, some teachers mentioned ways in which they could improve their teaching methods for a specific task. In terms of the example on the average calculation task, a teacher said that it would be better to facilitate students in writing down a score table and plotting the average scores to be calculated. However, regarding the questionnaire about a general question asking the teachers to write down improved teaching methods, they could not apply the improvement to other situations. Therefore, we need to add other activities that support teachers by enabling them to consider students' essential learning impasses and how to deal with them.

In terms of the usability of Wits, eight teachers agreed that they could use the application easily. They could input the data and understand the summarized results. The log data of Wits also corroborated that they could use Wits smoothly because it took less than five minutes for all the participants to use Wits from the first page to the analysis result page. In contrast, two of the participants conveyed that they were able to use Wits because of our instructions, so they wanted improvements to be made to the interface. Moreover, the participants responded in the questionnaire that it could be hard for them to prepare the data. Therefore, one solution is to develop Web-based tests and incorporate these into Wits so that teachers only have to input their prediction data.

Acknowledgements

References

Nakaya, K., Yamaguchi, K., Kaminishi, H., Fukaya, T., Uesaka, Y., & Nakagawa, M. (2017). Development of Web-based Investigation System for Teachers' Judgements on Students' Performance, Proceedings of the 17th Biennial EARLI Conference for Research on earning and Instruction, pp. 298-299.
Uesaka, Y., Nakagawa, M., Yamaguchi, K., Kaminishi, H., Nakaya, K., & Fukaya, T. (2017). New Mathematical Model for Analyzing Accuracy of Teachers' Predictions About Student Competencies, Proceedings of the 17th Biennial EARLI Conference for Research on earning and Instruction, p. 456.

Video-based Competence Development in Chemistry Vocational Training

Melanie ERKENS[a]*, Sven MANSKE[b], Daniel BODEMER[a], H. Ulrich HOPPE[b], Angela LANGNER-THIELE[c]
[a]*Media-based Knowledge Construction, University of Duisburg-Essen, Germany*
[b]*COLLIDE Research Group, University of Duisburg-Essen, Germany*
[c]*Evonik Digital GmbH, Evonik Industries AG, Germany*
*melanie.erkens@uni-due.de

Abstract: Digitization in vocational education and training (VET) offers new opportunities for integrating work processes and background knowledge through interactive media. This involves the design, testing and evaluation of innovative means of didactic and technical support. In the project "Digitized support for competence development in the workplace", this task is approached from a combined psychological and computer science perspective. This paper reports on one usage scenario from the first year of the project examining how to embed learning videos in VET. The results include new findings on video-based learning, and inform the design and implementation of a prototypical online learning platform.

Keywords: VET, video-based learning, scientific discovery learning, group awareness support

1. Introduction

Competence development in the workplace requires that trainees not only acquire knowledge at a theoretical level, but are also capable of applying it self-organized in practice. Digitization offers a multitude of possibilities for supporting these processes, but at the same time increases the need to design, test and evaluate the didactic and technical support. The interdisciplinary project "Digitized support for competence development in the workplace" addresses these needs by transferring instructional design principles to VET and applying them with new technologies at Evonik Industries, a globally operating specialty chemicals company with more than 600 apprentices in Germany every year. VET in Germany is "dual" in the sense that it is distributed between two types of training venues, workplaces and vocational schools. This dual system requires trainees to independently integrate learning content across learning locations. For trainers, this means to support the trainees in self-regulated learning (Schwendimann, Kappeler, Mauroux, & Gurtner, 2018). To this purpose, the educational psychology and the computer science team involved in the project, examine support measures from different perspectives.

2. Video-based learning in VET from an educational psychology perspective

From the psychology and instructional design perspective, the aim is to develop and investigate measures for competence development that are linked to the interaction with learning contents or peers. In the first year of the project, this task involved designing and testing the didactic support of video-based learning including the following goals: (1) Embedding learning videos accurately into the VET curriculum, (2) evaluating didactic measures designed for the interaction with learning videos, and (3) evaluating the measures designed for video-based collaborative learning. Regarding (1), it was essential to consider the trainees' motivation of using learning videos in different VET scenarios. To this purpose, a guide was created on how learning videos should be designed, extended by didactic measures and embedded in different scenarios (demonstration by instructors, use by trainees in laboratory activities or in self-learning scenarios). This guide was presented to trainers and trainees to discuss the situational and didactic options in focus groups (study 1). Considering (2), the principles of

scientific discovery learning (SDL) were transferred from computer simulations to learning videos. SDL is characterized by learners actively using strategies such as generating hypotheses, testing them via experiments or observations, and interpreting the results, with a particular challenge in generating hypotheses (De Jong & Van Joolingen, 1998). Thus, the transfer consisted of integrating knowledge-activating questions into videos, stimulating the formation of hypotheses that can be tested in the course of the video. The effect of such *video-based discovery learning* on motivation, learning processes and learning outcomes (study 2) was tested in the field with a comparison of the experimental groups: (2a) static learning material vs. learning videos, (2b) learning videos without vs. with knowledge-activating questions. Regarding (3), the guidance principles of group awareness support were applied. Group awareness support means to inform learners about their learning partners' characteristics and therewith suggest specific modes of thinking and behaving during the collaboration (Bodemer, 2011). The effect of this *video-based collaborative learning* with group awareness support on motivation, learning processes, self-assessed competence, and learning outcomes (study 3) was also tested in the field with three different groups: (3a) individual vs. collaborative video-based learning (and group awareness support), (3b) video-based collaborative learning without vs. with trainer (see Fig. 1 for an overview).

| Guide: options for video-based learning | Study 1: focus group discussions on options | Study 2: video-based discovery learning | Study 3: video-based collaborative learning | Realization of concept |

Figure 1. Overview of empirical studies conducted in the first phase of the project.

Study 1 showed that trainers and trainees are open to video-based learning and its didactic extension, with trainees making the use of learning videos dependent on an increase in performance and having a special interest in self-learning scenarios. Study 2 illustrated that trainees achieved better learning outcomes with learning videos than with static learning material ($p < .01$), but knowledge-activating questions do not add value to learning outcomes. Furthermore, motivation and learning strategies do not mediate the effect of the treatment on learning outcomes. However, the descriptive results illustrated with regard to motivation that the questions lead to the highest "interest/enjoyment". The explorative analysis of log data further indicated that knowledge-activating questions make the trainees deal more intensively with the learning content. Finally, study 3 showed that collaborative outperformed individual video-based learning in terms of learning outcomes ($p < .01$) and "interest/enjoyment" ($p < .05$) as a dimension of motivation, but no difference was given between collaborating groups with and without trainer support. Taking into account the time points, competence has improved over time in all experimental groups, with the improvement being greater in video-based collaborative learning with trainer support than without this support ($p < .05$).

3. Video-based learning in VET from a computer science perspective

In the computer science perspective, the point is to provide well-adapted technologies to support digitization in VET (a) by enabling video-based technologies, and (b) through intelligent contextualized information access for learning. The implementation of these approaches is done in a participatory design approach with trainees and trainers who are using prototypes and creating content for the system. Supporting digitization processes requires both hardware and software solutions. Mobile devices have the potential to enhance learning by providing anytime and anywhere access to information, learning resources and learning activities. The trainees have been equipped with tablet PCs (i.e., IPads) in order to follow a mobile-first digitization process. In addition to the requirements of the psychological perspective to embed didactical components, the design of the software targets active learning using interactive web content in augmentation of learning videos, in particular by embedding in-video quizzes or other interactive tasks. This led to a design of a software prototype for video-based learning with interactive web content using open and standard technologies such as Moodle, H5P, Learning Locker as a learning record store (LRS) and xAPI (see Harbarth et al., 2018). Figure 2 shows an architecture that

consists of the aforementioned sub-components of the software system. It contains mechanisms to capture traces of learners (xAPI and LRS) and to provide intelligent information access.
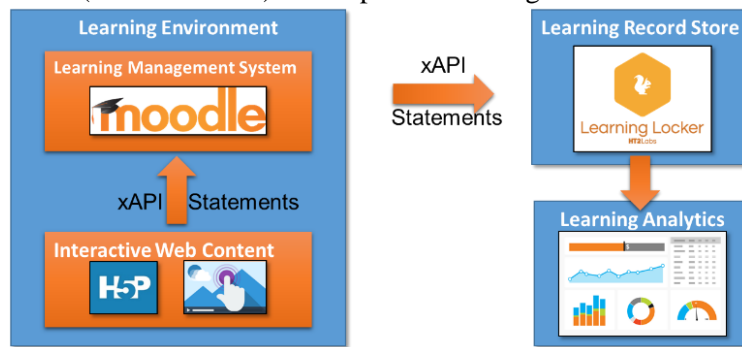
Figure 2. Architecture of the video-based learning prototype with learning analytics enabled.

Integrating new systems into already existing infrastructures is a special challenge since it potentially increases the level of fragmentation by adding new systems. Therefore, we provide access to the already existing infrastructure by linking and connecting data and sub-systems in this context. Particularly in the context of learning, this includes the recommendation and dynamic linking of learning resources based on contextualized information, such as the learning context, content, and metadata. Semantic technologies such as DBPedia Spotlight are beneficial to automatically capture characteristics of the content without a major loss of information on educational data (Manske & Hoppe, 2016).

4. Conclusion and Outlook

The resulting concept for competence development envisages using learning videos for self-learning scenarios, but also for collaborative learning in the training workplace and the classroom with strong involvement of the trainers and group awareness support. Due to a better engagement with content, also knowledge-activating questions are integrated what has to be considered in the production of videos so that hypotheses can be tested. Enabling these concepts of video-based discovery and collaborative learning on a prototypical online learning platform can be achieved using open and standard technologies that are ready for learning analytics. In the next phase of the project, the focus will be on the development of a didactic and technical concept for the use of learning journals to further support learning strategies with regard to the reflection of learning contents.

References

Bodemer, D. (2011). Tacit guidance for collaborative multimedia learning. *Computers in Human Behavior*, *27*(3), 1079–1086. https://doi.org/10.1016/j.chb.2010.05.016

De Jong, T., & Van Joolingen, W. R. (1998). Scientific discovery learning with computer simulations of conceptual domains. *Review of Educational Research*, *68*(2), 179–201. https://doi.org/10.3102/0034654 3068002179

Schwendimann, B. A., Kappeler, G., Mauroux, L., & Gurtner, J.-L. (2018). What makes an online learning journal powerful for VET? Distinguishing productive usage patterns and effective learning strategies. *Empirical Research in Vocational Education and Training, 10*(1), 1–20. https://doi.org/10.1186/s40461-018-0070-y

Harbarth, L., Delsing, S., Richtscheid, F., Yücepur, V., Feldmann, F., Akhavanfarm, M., ... & Hoppe, H. U. (2018). Learning by tagging–supporting constructive learning in video-based environment. In D. Krömker, & U. Schroeder (Eds.), *Lecture Notes in Informatics. DeLFI 2018 – Die 16. E-Learning Fachtagung Informatik* (pp. 105-116). Bonn, Germany: Gesellschaft für Informatik.

Manske, S., & Hoppe, H. U. (2016). The "Concept Cloud": Supporting collaborative knowledge construction based on semantic extraction from learner-generated artefacts. In L. O'Connor (Ed.), *2016 IEEE 16th International Conference on Advanced Learning Technologies (ICALT)* (pp. 302–306). Austin, TX: IEEE.

Grounding Support for Effective Collaborative Learning

Lydia HARBARTH[a]*, Melanie ERKENS[a] & Daniel BODEMER[a]
[a]*Media-based Knowledge Construction, University of Duisburg-Essen, Germany*
*lydia.harbarth@uni-due.de

Abstract: A common ground of knowledge is the foundation for collaborative learning. However, learners often do not know how to engage in beneficial grounding activities during collaboration, which highlights the need to support such activities and the development of grounding skills. Two prominent forms of support are collaboration scripts and cognitive group awareness tools that pursue different approaches to promoting grounding. While collaboration scripts explicitly ask learners to perform related activities to trigger the exchange of relevant information, cognitive group awareness tools directly provide relevant information about learning partners to implicitly guide learners during learning processes. The present paper examines how the two approaches differ in supporting grounding activities and to what extent they support the development of grounding skills that represent a key qualification of collaborative learning. In the next step of this research project on grounding, the question of how to support the long-term development of grounding skills will be investigated.

1. The Role of Grounding in Collaborative Learning

Communication and cognitive processes are essential for collaborative learning. Collaboration can be successful when productive interactions between learning partners take place (Dillenbourg, 1999). Such interactions can occur when learners engage in activities like asking questions, giving explanations, elaborating on utterances, or providing arguments (de Vries, Lund, & Baker, 2002), as these activities have proven beneficial building a shared understanding (Roschelle & Teasley, 1995).

For the development of a shared understanding, grounding plays a crucial role. Grounding is the process of constructing and maintaining a common ground, which means a basis of "mutual knowledge, mutual beliefs, and mutual assumptions" (Clark & Brennan, 1991, p. 222). The role of grounding in collaborative learning can be seen as two-fold. Grounding can be a requirement for collaborative learning, i.e., having a basis of shared understanding is necessary to solve the learning task, or grounding can be a part and a result of collaborative learning, i.e., constructing this basis via collaboration (Baker, Hansen, Joiner, & Traum, 1999). For building a shared understanding, learners have to make sure that they are understood by their partners, e.g., by checking for understanding and resolving misunderstandings or misconceptions. If learners do not engage in these grounding activities, collaborative learning might fail. Thus, supporting learners to engage in these activities is necessary. For enabling learners to use these grounding activities in different situations (e.g., at school, university, or work), they further need a grounding skill, i.e., knowledge of a grounding procedure, that allows them to use these activities easily and flexible in different contexts, which highlights the necessity of the development of grounding as a key qualification.

This paper presents the starting point of a research project aiming at the investigation of how grounding in computer-supported collaborative learning (CSCL) can be supported and how grounding skills can be developed. In the following, we present our first discoveries on how different forms of support, collaboration scripts (Kollar, Wecker, & Fischer, 2018) and group awareness tools (Bodemer, Janssen, & Schnaubert, 2018), can support grounding.

2. Support of Grounding

2.1 Collaboration Scripts

Collaboration scripts explicitly guide learners to perform grounding activities, which can also lead to the development of grounding skills. Collaboration scripts structure the interaction during collaborative learning explicitly by guiding learners via activities, roles, and sequences of activities (Kollar et al., 2018). For example, a script prompts learners to engage in specific activities (e.g., "explaining", "providing counter-arguments"), to take specific roles (e.g., "explainer", "counter-argument provider"), and to switch roles after a certain sequence. These activities can be considered on a macro-level of grounding (e.g., "provide an explanation"). On a micro-level of grounding, collaboration scripts have the potential to support more fine-grained grounding activities (e.g., not only prompting to "provide an explanation", but also to "check for (mis)understanding of partner").

Furthermore, (external) collaboration scripts can not only support the execution of activities but also support the development of skills as an internal script (Vogel, Wecker, Kollar, & Fischer, 2017). An internal script is a learner's mental representation of an external script and comprises the knowledge about collaboration processes, also including knowledge about grounding activities. As a result of script use, an external script can become a part of an internal script ("internalization", see Fischer, Kollar, Stegmann, & Wecker, 2013). Such an internal script, which a learner can fall back on, is refined with each new experience during collaboration. For example, it is reconfigured when learners internalize that after providing an argument it is necessary to check for the understanding of the learning partner and to resolve misunderstandings. Briefly, if the execution of grounding activities is prompted by collaboration scripts, potentially, grounding skills (i.e., an internal script of the knowledge about grounding activities) can be developed.

2.2 Cognitive Group Awareness Tools

Another way of supporting grounding is the use of cognitive group awareness tools (cGATs) that increase the awareness of cognitive characteristics of learning partners, e.g., their knowledge, opinions, or assumptions (Bodemer et al., 2018). This information implicitly guides learners during learning processes in different ways (see Bodemer et al., 2018): (1) As a core function, providing information about learning partners supports partner modeling which can facilitate grounding processes between learners (e.g., adapting communication behavior to the knowledge level of a learning partner, see Clark & Murphy, 1982). Further functions of cGAT can support grounding processes additionally: (2) Highlighting of relevant information of the learning material constrains content-relevant communication which helps learners to focus on relevant aspects (e.g., focus grounding activities on topics that require clarification). (3) Presenting information on partner and self enables inter-individual comparisons, which trigger activities to solve socio-cognitive conflicts (e.g., different assumptions between learners highlight the need for the detection and clarification of misunderstandings). (4) Moreover, by collecting and presenting self-information, metacognitive processes can be stimulated (e.g., identifying own misconceptions on a topic). Thus, cGATs have the potential to support grounding by easing the effort of grounding by providing information about the learning partner(s), which otherwise would have been part of an explicit exchange between the learners or the information would not have been exchanged, at all.

Concerning the potential for cGATs to support grounding, more systematic research is needed. First research results underline that learners show more systematic communication behavior when partner information is provided and relevant information is highlighted (Bodemer & Scholvien, 2014). Learners with tool support first discuss conflicting issues and resolve misunderstandings or misconceptions, then proceed to less conflicting aspects, and, in the last step, reassure mutual understanding of initially conflicting issues. In contrast, results also show that learners without partner information proceed rather unsystematically, relying on perceptually relevant (not thematically relevant) information. However, the effect of transferring these grounding activities in terms of a structured proceeding of communication into a next phase of collaboration (grounding skill) could not be observed (Bodemer & Scholvien, 2014).

3. Outlook

This paper presents the work-in-progress status of our research project which aims at investigating the support of grounding during collaborative learning. The driving question is if grounding as a skill – a key qualification – can be developed with the help of tools. Support of grounding can be provided in different ways. In a more explicit way, collaboration scripts can support the execution of grounding activities by prompting these activities. With the help of scripts, not only the execution of grounding skills is possible, but also the development of grounding skills by internalizing externally scripted activities. In a more implicit way, cGATs reduce the effort for grounding by providing information on learning partners and learning material. CGAT prove to be an adequate support of communication and collaboration within a collaborative situation and help learners focusing their attention in complex learning situations (Schnaubert, Heimbuch, Erkens, & Bodemer, 2019). However, beneficial courses of action, as shown when the tool was used, have not been transferred to other similar situations without tool support (Bodemer & Scholvien, 2014). This study only provided partner information for grounding and highlighted information, but did not use information of the learners themselves within the tool, which might additionally support the need for grounding activities. Therefore, it is planned for the next step (and integrated into the work-in-progress poster) to investigate the transfer of grounding activities to other learning situations. Further research questions that will be addressed within the project are how implicit and explicit support methods can be combined in order to support grounding skill development.

References

Baker, M., Hansen, T., Joiner, R., & Traum, D. (1999). The role of grounding in collaborative learning tasks. In P. Dillenbourg (Ed.), *Collaborative learning: Cognitive and computational approaches* (pp. 31-63). Oxford, UK: Elsevier Science/Pergamon.

Bodemer, D., Janssen, J., & Schnaubert, L. (2018). Group awareness tools for computer-supported collaborative learning. In F. Fischer, C. E. Hmelo-Silver, S. R. Goldman, & P. Reimann (Eds.), *International handbook of the learning sciences* (pp. 351-358). New York, NY: Routledge/Taylor & Francis.

Bodemer, D., & Scholvien, A. (2014). Providing knowledge-related partner information in collaborative multimedia learning: Isolating the core of cognitive group awareness tools. In C.-C. Liu, H. Ogata, S. C. Kong, & A. Kashihara (Eds.), *Proceedings of the 22nd International Conference on Computers in Education ICCE 2014* (pp. 171-179). Nara, Japan: APSCE.

Clark, H. H., & Brennan, S. E. (1991). Grounding in communication. In L. B. Resnick, J. M. Levine, & S. D. Teasley (Eds.), *Perspectives on socially shared cognition* (pp. 127-149). Washington, DC: APA.

Clark, H. H., & Murphy, G. L. (1982). Audience design in meaning and reference. *Advances in Psychology, 9*(C), 287-299.

de Vries, E., Lund, K., & Baker, M. (2002). Computer-mediated epistemic dialogue: Explanation and argumentation as vehicles for understanding scientific notions. *Journal of the Learning Sciences, 11*(1), 63-103.

Dillenbourg, P. (1999). What do you mean by collaborative learning? In P. Dillenbourg (Ed.), *Collaborative-learning: Cognitive and computational approaches* (pp. 1-19). Oxford, UK: Elsevier.

Fischer, F., Kollar, I., Stegmann, K., & Wecker, C. (2013). Toward a script theory of guidance in computer-supported collaborative learning. *Educational Psychologist, 48*(1), 56-66.

Kollar, I., Wecker, C., & Fischer, F. (2018). Scaffolding and scripting (computer-supported) collaborative learning. In F. Fischer, C. E. Hmelo-Silver, S. R. Goldman, & P. Reimann (Eds.), *International handbook of the learning sciences* (pp. 340-350). New York, NY: Routledge/Taylor & Francis.

Roschelle, J., & Teasley, S. D. (1995). The construction of shared knowledge in collaborative problem solving. In C. O'Malley (Ed.), *Computer supported collaborative learning* (pp. 69-97). Berlin, Germany: Springer.

Schnaubert, L., Heimbuch, S., Erkens, M., & Bodemer, D. (2019). Cognitive group awareness tools: Versatile devices to guide learners towards discrepancies. In J. L. Shih et al. (Eds.), *Proceedings of the 27th International Conference on Computers in Education*.

Vogel, F., Wecker, C., Kollar, I., & Fischer, F. (2017). Socio-cognitive scaffolding with computer-supported collaboration scripts: A meta-analysis. *Educational Psychology Review, 29*(3), 477-511.

Study on English Learning Support Using Question Cards and Smart Speakers

Ayame KOBAYASHI a*, Shigeto OZAWA b
ᵃ Graduate School of Human Sciences, Waseda University, Japan
ᵇ Faculty of Human Sciences, Waseda University, Japan

Abstract: This study intended to clarify how children interact with smart speakers when they learn English as a second language. Second, it aimed to determine the topics children find easy when talking with smart speakers. Han. J. et al (2008) have stated that children's interactions in English with robots were effective for the learning of English words and for the acquisition of vocabulary. The subjects were eight students who had not experienced smart speakers. The researchers used 60 question cards to help beginners to ask questions to smart speakers and subsequently encouraged the children to create their own questions. The participating students exhibited two trends of preference in the questions they asked: first, students asked questions that assumed 'Alexa' was a human being, even though they knew it was an artifact; second, children selected questions that could be generated by exchanging words (nouns) and that could satisfy their intellectual curiosity. Specifically, children were found to ask questions such as "How many calories are in a donut?"

Keywords: smart speaker, English learning, utterance research, constructive interaction

1. Introduction

Smart speakers respond quickly and exhibit synchronicity. Thus, they are useful for output activities that are essential to language learning. The authors of this study examine effective ways of using familiar technologies such as smart speakers as instruments of educational support.

Miyake et al. (2012a, 2012b) and Ishiguro et al. (2011a) have evidenced the learning that can be achieved by introducing robots into practical applications of human-robot symbiosis. Han. et al. (2008) have asserted that children's interactions in English with robots were effective for the learning of English words and for the acquisition of vocabulary (Han, et al., 2008; and Kanda, et al. 2004).

Reeves and Nass (1996) have find the media equation that individuals' interactions with computers, television, and new media are fundamentally social and natural, like interactions in real life.

The purpose of this study is to clarify how children interact with smart speakers when they learn English as a second language. Second, the present investigation elucidates topics that are easy for children in their conversations with smart speakers.

2. Method

The subjects of this study consisted of eight children who learn English as a second language (a boy and a girl in the first grade of junior high school, a boy and a girl belonging to the sixth grade of elementary school, and two boys and two girls attending the fifth grade of elementary school).

In this study, 60 question cards (hereinafter referred to as cards) were used to investigate the types of utterances made by students when they talked to a smart speaker (Amazon Echo Dot Smart Speaker with Alexa). Fig.1 presents a sample card, the level division, and the number of individual categories and levels. The card used grammar that was aligned to English textbooks utilized in public elementary and junior high schools. For this reason, the level classification was the same as Level 1 for grammar expressions learned from elementary school to the first grade of junior high school. Four discrete levels were established. In addition, nine categories such as Who, What, Where, and so on were instituted. The size of the card was designed to fit 4 sheets of A4 paper vertically and 3 sheets horizontally. Copyright-free images were used from Shutterstock for the illustrations.

The 60 cards were classified into five groups. Groups 1 and 2 assumed everyday conversations. Group 1(daily-open) comprised 12 cards. Group1 was defined as questions whose responses changed from time to time. Group 2 (daily-closed) consisted of 9 cards. Group 2 represented questions whose answers would remain unchanged such as "When is your birthday?" Next, Groups 3, 4, and 5 envisioned questions that were used to obtain information. Group 3(interest-based) encompassed 14 cards and denoted Internet search questions on a subject of interest. Group 4(tool-based) contained 12 cards and questions in this category could be used to obtain information using a clock, a dictionary or other tools. Group 5(knowledge-based) included 13 cards that incorporated questions about knowledge that children learned at school or in their personal lives.
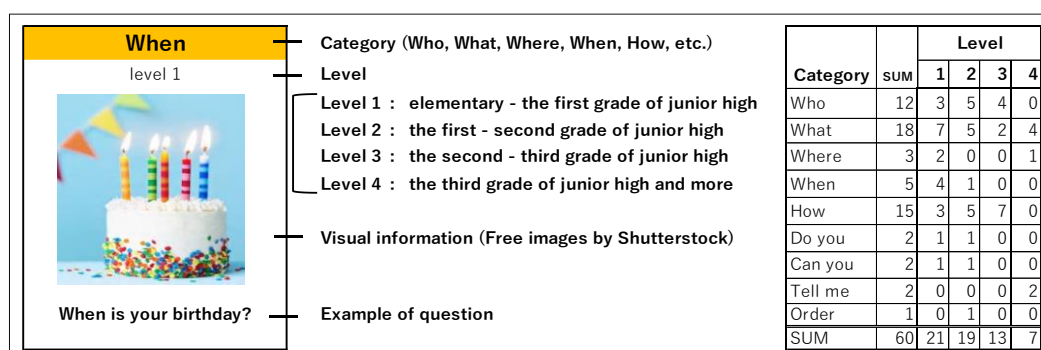
When		Category (Who, What, Where, When, How, etc.)
level 1		Level

Level 1 : elementary - the first grade of junior high
Level 2 : the first - second grade of junior high
Level 3 : the second - third grade of junior high
Level 4 : the third grade of junior high and more

Visual information (Free images by Shutterstock)

When is your birthday? — Example of question

Category	SUM	Level 1	2	3	4
Who	12	3	5	4	0
What	18	7	5	2	4
Where	3	2	0	0	1
When	5	4	1	0	0
How	15	3	5	7	0
Do you	2	1	1	0	0
Can you	2	1	1	0	0
Tell me	2	0	0	0	2
Order	1	0	1	0	0
SUM	60	21	19	13	7

Figure 1. A sample of the 60 question cards and the number of every category and level

Utterance analysis was conducted on the transcripts of the ICT recordings. The data accumulated in the Alexa application were also qualitatively analyzed using Excel. The survey period encompassed 7 weeks from May 27 to July 12, 2019. Regardless of how many times the same student repeated the same question, an utterance was counted only once because of instances in which the same question was asked multiple times in the same scene either because there was a problem with Alexa's voice recognition or because of the student's inability to understand the contents of Alexa's answer.

3. Results

Table 1 exhibits the number of utterances recorded by 8 students. The total aggregate of utterances made by the 8 students was 228 (N = 8, Ave = 28.5, SD = 5.72). By group, the participating students asked 46 (Ave = 5.8, SD = 0.83) daily-open questions, 56 (Ave = 7.0, SD = 2.12) daily-closed questions, 59 (Ave = 7.4, SD = 2.00) interest-based questions, and 41 (Ave = 5.1, SD = 1.96) tool-based questions. There were 26 cases (Ave = 3.3, SD = 1.64) of knowledge-based questions.

Table 1
The number of utterances of eight students for seven weeks

	Students A	B	C	D	E	F	G	H	SUM		AVE	SD
1. Daily-open	6	5	7	5	5	5	7	6	46	20.2%	5.8	0.83
2. Daily-closed	8	8	7	4	9	8	9	3	56	24.6%	7.0	2.12
3. Interest-based	10	7	6	9	8	8	8	3	59	25.9%	7.4	2.00
4. Tool-based	2	8	3	5	7	5	7	4	41	18.0%	5.1	1.96
5. Knowledge-based	5	5	2	3	5	3	3	0	26	11.4%	3.3	1.64
SUM	31	33	25	26	34	29	34	16	228	100.0%	28.5	5.72

Figure 2 depicts the 12 most popular questions that found place in the top 20% of all questions asked with the proportions recorded for each group. Daily-closed questions represented 41.7% of the top 20%, and this category was the most popular choice. The five cards chosen in this context asked questions such as "When is your birthday?" "Can you sing?" "How old are you?" "Can you beatbox?" and "Where are you from?" Daily-open questions formed 33.3% of the 12 most popular questions, and four cards were chosen, with questions such as "How are you?" "What's your favorite song?" "Who is your best friend?" and "What's your favorite Japanese food?" Interest-based questions took 16.7% of the 12 most popular questions and the two cards chosen were: "Who made Alexa?" and "How many

calories are in a donut?" Tool-based questions formed 8.3% of the most popular dozen and the selected question was "What time is it?" Knowledge-based questions did not find space among the top 20% of the questions that were asked by the participating students.

Some of the 60 question cards evoked spontaneous question generation. The question that most led to such unprompted production of original questions was "How many calories are in a donut?" Specifically, there were nine instances of the word 'donut' being reworded as chocolate, cake, pizza, pasta, hamburger, etc.
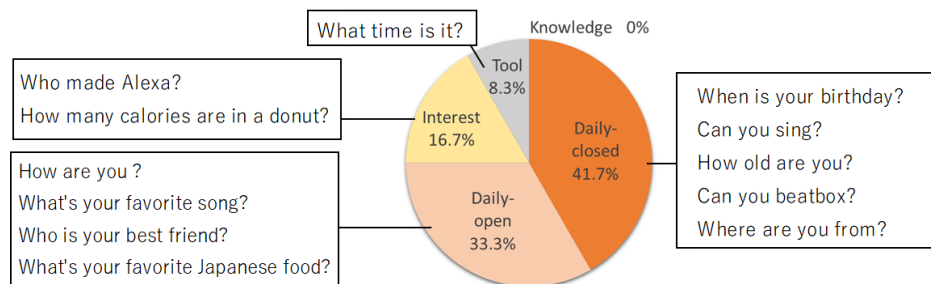

Figure 2. The 12 most popular questions in the top 20% with the proportions in each group

4. Discussion

Based on the results obtained from the utterance analysis of the 60 question cards, the researchers could identify two trends from the questions that the students liked and listened to. First, students tended to ask daily-closed and daily-open questions to Alexa; for example, when a student asked, "How are you?" Alexa would reply "I'm quite cheerful." Therefore, even if Alexa did not physically appear to be a robot, the students thought that Alexa was a friend who was learning with them. This result is consistent with the media equation theory (Reeves and Nass, 1996).

Second, the questions that most led to spontaneous question generation by students were those that could be produced by replacing words (nouns). Two trends were seen among these: first, students tended to choose questions with numbers for answers. Perhaps such questions were selected because numbers are clearly defined and relatively easy for beginners learning English. In addition, it is believed that surprises from results that were unexpected stimulated the intellectual curiosity of the participating children and led to a proactive learning attitude.

For these reasons, it seems natural to conclude that incorporating smart speakers into the learning environment could create many output opportunities necessary for language learning. Auxiliary materials such as question cards can be combined with the use of smart speakers to provide children with opportunities to generate their own questions.

Acknowledgements

References

J. Han, M. Jo, V. Jones and J. H. Jo. (2008). Comparative study on the educational use of home robots for children. *Journal of Information Processing Systems, vol.4 no.4, pp.159-168.*

Kanda, T., Hirano, T., Eaton D., and Ishiguro, H. (2004). Interactive robots as social partners and peer tutors for children: A field trial, *human-computer interaction,* Vol. 19, 61～84

Miyake, N. (2012a). Multi-person constructive interaction in real classrooms for conceptual change. Talk presented at ICLS2012 in the *Symposium on Intentional Approaches to Conceptual Change.*

Miyake, N. (2012b). A monitor also learns: What does it have to do with technology? Talk presented at ICLS2012, in the Symposium on Critical Aspects in Learning with Technology.

Miyake, N., Ishiguro, H., Dautenhahn, K., and Nomura, T. (2011a). Robots with children: Practices for human-robot symbiosis. In A. Billard, P. H. Kahn Jr., J. A. Adams, J. G. Trafton (Eds.), Proceedings of the 6th International Conference on *Human Robot Interaction,* HRI 2011, Lausanne, Switzerland, March 6–9.

Reeves, B., and Nass, C. (1996). The media equation: How people treat computers, television, and new media like real people and places. *Cambridge, UK: Cambridge University Press.*

Seamless Social Networking Course Design: An Preliminary Result of Indonesia-Taiwan Workers' Online Translation Course

Rotua ZENDRATO*, Ben CHANG

Institute of Learning and Instruction, National Central University, Taiwan

*rotuafernand@gmail.com

Abstract: Social networking platforms, such as Facebook, Twitter, Skype, WeChat and Line, are affecting and reshaping on people's daily communication. This phenomenon reveals that social networking platforms have the potential to be applied on learning field since communication plays an important part in learning behavior. A number of researchers have reported the promising results of integrating social networking platforms into formal and informal teaching and learning processes. However, less research described on how teachers conducting social networking platforms as tools in distance learning as students' environment for learning. Therefore, in this study, we propose an online course model that leads us to identify the model can increase the involvement of students during learning activities on social networking platforms. A preliminary observation description was conducted based on the design model we applied and we found that the model could be used to facilitate students' online learning process. Meanwhile, the students involved in the learning process mentioned that the use of social networking through this model has a positive impact on their studies. They also mentioned that the model can improve their involvement in their online English translation course which was the subject adopted in this study.

Keywords: Social networking platforms, Online course design, Learning activities

1. Introduction

The applications of social networking platforms have been using in many fields, and have the potential of applying in the education domain (Dabbagh & Kitsantas, 2012). Numerous studies reported a positive impact on students' academic experiences (Yu, Tian, Vogel & Kwok, 2010; Dabbagh & Kitsantas, 2012). However, integrating social networking in distance learning might not always lead to desirable outcomes. Some studies have suggested overcoming these weaknesses (Niu, 2017; Sembiring, 2018). For the learning purpose, while teachers are eager to design learning activities with social networking platforms, they should not only take advantage of the enhanced capacity of content distribution provided by social networking platform (Niu, 2017) but also need well-designed learning activities since learning has its method and unique approach. It is worth to explore how to design a good instructional and learning approach on social networking platform (Hung & Yuen, 2010). Currently, there have been few empirical studies investigating distance learning describe the model of learning activities design and enhance the effectiveness of social networking. Therefore, the goal of this paper is to establish an online social learning networking model that can enhance the effectiveness and involvement of students' distance learning. The preliminary result of Indonesian workers in Taiwan translation course using this model is reported and the result reveals a positive impact in their academic process using the model we proposed.

2. Social Networking Online Course Model

2.1 Steps to Design a Model

Before design learning content, as a distance learning course tutor, there are several steps the tutor should be prepared before applied. Following, each of the steps in the model's sequence is described:

Setting the objective of the lesson, Knowing students' background, Instructional strategy, Social networking application selection, and Evaluation.

2.2 Online Learning Model

In this study, Facebook is used through pre-class, in-class, and after-class because all the students were used to have Facebook for their interactions with their teachers, Skype is used only in-class because its video-conferencing facilitating, and YouTube as their video links to repeat and listen to the class is used in the after-class. In the beginning of the semester, the instructor explained to her class students the purpose of doing pre-class, in-class, and after-class activities. Figure 1 shows the model and their tools used.
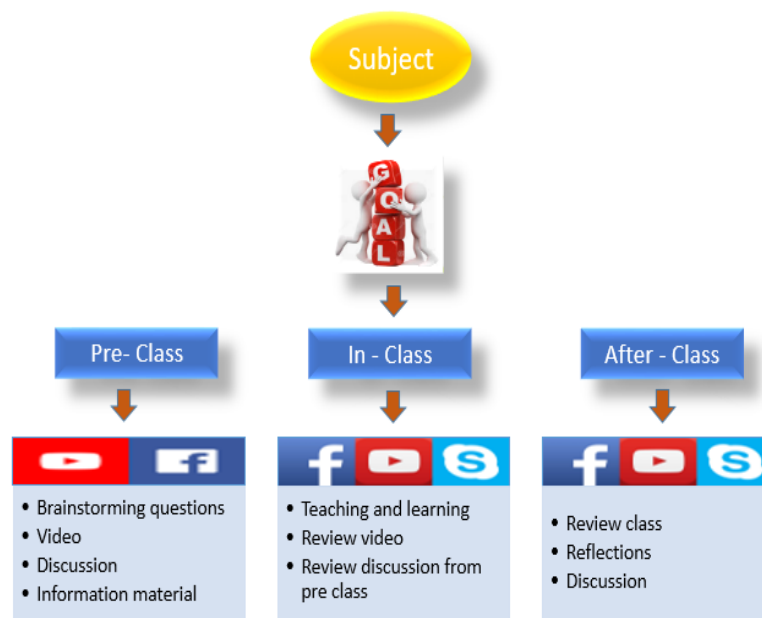
Figure 1. Online learning model.

Number	Standard Competence	Basic competencies	Activities			Material sources
	The students are able to:		Pre - Class (FB)	In - Class (FB and Skype)	After - Class (FB)	
1	Refine their language skills and learn to express themselves more accurately through intensive translation practice in both English – to – Bahasa and Bahasa- to _English.	Express their expectations and ideas on how to achieve them	Choosing the text they interest to learn in this course	Class orientation and syllabus discussion	Q and A English- to - Bahasa Word	Translation 789
2		Define what translation is and figure out the processes and problems in translation	Every students can write the tricks or what they bear in mind during translating the text	Discussing their tricks and look the different idea from other friend, explanation sample from text by teacher, self practice and discussion	reflection of new vocabularies and how to use it in the correct context on sentences	Translation 7 Modul 5 page 5.1 - Science and Technology- (Communication Technology: Main Argument) English - to - Bahasa

Figure 2. Example of the syllabus.

3. Preliminary Results

3.1 Background of the Participants

6 students took the translation class for this study, their range from adult students and young high-school fresh graduate students. The adult students generally have left school for several years. They all are workers at a factory or as a caregiver. They are busy every day and even Sunday they need to work. They have been learning English in an EFL context for six years. They were rated from high beginning to low intermediated in English study context and as for

their experience with the Internet technology, most of them use Facebook, Line, Instagram, YouTube, Whatsapp, and Skype. They use primarily social networks for chatting with family and friends, share and post their feeling, study and business. However, they did not do pre-class, in-class and after-class activities in their English class. They were highly motivated and considered it is a good chance to join the Indonesia Open University distance English major translation course because they needed to work and have no time to go to physical university but through this way they could gain education at their working place.

3.2 Result Before Applied the Model

The results obtained in the absence of this design are as follows: activities learning similar with traditional classes where only one direction occurred. To gain the first-hand observation and finding, the teacher also served as a researcher in this study. According to her observations, before applied the model, the students in their learning processes were passive, and the students were just waiting for instructions and not actively giving opinions. Due to the fixed class course design, the learning interaction occurred only once a week, and there was no discussion among fellow students even some of the knowledge could be already known by the other students.

3.3. Result After Applied the Model

Using online course model elaborated above indicates that the students' positive attitudes toward tasks and learning process. The results are as follows: they could enhance their learning productivities in their busy time, could give their comments and questions to the pre-task or post-task anywhere and anytime they want. Meanwhile, the students demonstrated more active on participating the learning activities and did not miss the lesson because of their limitations in attending the face-to-face class. Finally, they had ubiquitous learning using social networking specially since they were workers and could not attend the physical meeting class.

4. Conclusion

Given the positive results, social networking platform can be a suitable tool to increase students' motivation, foster independent learning and increase communication opportunities by using suitable design learning process. Limitations in this study are short time frame and subject that may not generalize on reliable results, small participants, and using qualitative data by a brief interview. Thus, more experimental studies are required to determine the influence of other variables on the improvement of the learning-teaching process and also more participants. Future studies also need to introspective data collection (during assignments) and retrospective (after assignments) support each other to produce more findings and make up for the shortcomings of each method individually. The group of participants namely adult students and young high-school fresh graduate students may count into account for analysis. The further comprehensive study may do quantitative research by observing that instructors maintain the entire project, such as frequent interactives contacts with students and notes from major events to track any changes in student motivation and involving in the discussion.

References

Dabbagh, N., & Kitsantas, A. (2012). Personal learning environments, social media, and self-regulated learning: A natural formula for connecting formal and informal learning. *The Internet and Higher Education, 15*(1), 3-8.

Niu, L. (2017). Using facebook for academic purposes: Current literature and directions for future research. *Journal of Educational Computing Research, 56*(8), 1384-1406.

Sembiring, M. G. (2018). Modelling the determinants of effective online tutoring programs. *Turkish Online Journal of Distance Education, 19*(3), 128-139.

Yu, A. Y., Tian, S. W., Vogel, D., & Kwok, R. C. W. (2010). Can learning be virtually boosted? An investigation of online social networking impacts. *Computers & Education, 55*(4), 1494-1503.

Investigating the Strategy of Kindergarten Teachers Integrate Technology into Block Learning Area

Wan-Chen CHANG

Department of Human Development and Family Studies, National Taiwan Normal University, Taiwan
*altheawcc@ntnu.edu.tw

Abstract: In kindergartens, playing blocks is productive and independent learning activities in children's daily life. Teachers rarely intervene in the process of building blocks for children. However, in recent years, research has found that the process of playing blocks helps young children develop STEM concepts. Hence, it is important for the teacher to guide and interact with children on how to play block. The purpose of this study is to investigate how kindergarten teachers integrate technology into the block learning area and enhance students' block playing. This study interviewed six kindergarten teachers from two schools. The preliminary results showed that the teachers' teaching strategies integrating technology into block learning area, including (1) providing pictures and videos for children to observe how to construct the building, (2) photographing the process of children's building blocks, and children could discover the problems of building blocks and discussing how to solve problems, (3) the children shoot their films when the products are demonstrated.

Keywords: block playing, technology, learning area, Kindergarten

1. Introduction

A play that a child plays by using unit blocks in various sizes are called a block play. Blocks which are found in construction materials are used creatively by a child. Legos, puzzles, unit blocks, plastic blocks, wooden blocks, colored blocks are among block plays (Phelps, 2012). The block play is the most popular construction game in the children's play. The block play refers to the object modeling activity carried out by the child to operate the building block. In the game, the child selects various shapes of building blocks and uses the building skills to build different objects, including tiling, extension, and enclosing. All along, the relevant research or the kindergarten teachers point out that building blocks are good game media, and building blocks can provide physical operation opportunities for children to learn many skills. More importantly, block play contributes to the cognitive development of a child. A child could learn the concepts of measurement, number, shape, and size develop by playing with blocks. According to Wellhausen and Kieff (2001), children's logical inference and problem-solving skills are developed in the block play process.

Building blocks provides young children with peer interaction and language development in a natural context. Children plan, communicate, and collaborate with others to form relationships, solve problems and share goals, and acquire mathematics and scientific concepts in the process of building blocks. Past research has found that increasing the complexity of building blocks through teaching teachers to help young children learn and develop in other areas in the future, such as Hanline, Milton, and Phelps (2001) found in the complexities of building blocks and late childhood reading. There is a predictive correlation between ability and self-regulation, and Similarly, Wolfgang, Stannard, and Jones (2001) have similar findings that preschool children are associated with the complexity of building blocks and the high school mathematics.

The purpose of the kindergarten to build various learning areas is to provide a variety of play material so that children can explore, operate, experiment or play, through this process can acquire new knowledge, even present personal creativity. When children have the chance to choose a learning area, "block learning area" is often a popular option for young children. Since there is no limit to the playing method of the building blocks, children can reassemble and rebuild at any time, so that the children can

play freely, always try and experiment, and when they are wrong, they can come back at any time and reduce the frustration of failure. Besides, the child can assemble any shape as desired, even though the two blocks are stacked together, the imagination can give it a different life. Therefore, the building blocks can promote the experiment, modification, and creation of the child. In addition, the types of building blocks are also quite diverse, including Great Wall blocks, unit blocks, hollow blocks, wooden blocks, LEGO, et cetera., so children can choose freely, have great elastic changes, and even match other material accessories, can expand the type of games for young children. For example, animal puppets, toy cars, marbles, doll, branches, and so on.

In the building block game, different skills and different abilities are required. Through the guidance of the teacher, the child can learn to build complex building blocks in the imitation, and then provide opportunities for the child to explore and learn (Ramani, Zippert, Schweitzer, & Pan, 2014). In this process, teachers need to motivate their children and mentoring. They can provide demonstrations, suggestions, support, and comments for young children. Teachers' involvement in children's building block games can determine the intervention strategy based on factors such as age and child development (Aksoy & Aksoy, 2017). In the kindergarten classroom, when the child carries out the learning area activities, although the teacher and the child have the opportunity to interact with the dialogue, or the teacher observes the performance of the child building blocks and photographs the child's work each time to leave the child's work record, but it found that the interaction between teachers and students is short-lived. Because teachers need to take care of the performance of other children in different learning areas, the intervention of science and technology can help teachers build the building blocks of the children in the eagle frame, such as how to induce children to think, test, experiment, and transform. To promote students' development of the building block stage, and even the acquisition of the STEM concept should be the focus of our attention.

In the teaching scene, kindergarten teachers are less involved in the process of children's independent learning when they are learning in the learning areas. This situation is also found in the block learning area. Teachers are rarely involved and lack relevant teaching courses. However, in recent years, research has found that the process of building blocks helps young children develop STEM concepts, and the guidance and interaction of teachers in children's block play is even more important. Therefore, the purpose of this study is to investigate how teachers can use technology to guide young children to learn in the building blocks.

2. Research method

2.1 Participants

The participants are 6 kindergarten teachers who all have taught over 10 years from 5 classes and two schools. The two kindergartens are public schools attached elementary schools and locate in Taipei city. The kindergartens serve families who are predominantly middle class and implement the theme-based curriculum and learning area. The five classes are mix-age classes which children aged 4-5. This study focused on block area where provides unit blocks, Kapla, wooden blocks and block accessories. The classes provide different block accessories, such as animals puppets, toy cars, marbles and so on.

2.2 Research method

The primary research method of this study is the interview method. Before interviewing with the teachers, the researcher observed that the child interacted with the teacher in the block learning area in each classroom three times. According to the observation results, the researcher designed the interview outline. The questions include (1) how to teach in the building blocks? (2) How do the teacher scaffold children in the block learning area? (3) How to end the construction of the block learning area?

3. The preliminary results

Preliminary research results can be discussed from three aspects: (1) providing pictures and videos for children to observe how to construct the building, (2) photographing the process of children's building

blocks, and children could discover the problems of building blocks and discussing how to solve problems, (3) the children shoot their films when the products are demonstrated.

(1) providing materials for children to observe how to construct the building

For children who aged 5 or with good block building skills, the teachers provide sample pictures or video to help children challenge and learn new skills. The video could provide a three-dimensional view of the building, allowing students to observe the different faces of the building. For children who aged 4 or with lower block building skills, the teachers observe their interest topics, and provide less complicated examples, such as the construction of a single shape and the construction of less building blocks. The teachers most collected pictures or video from APPs which other teachers shared.

(2) photographing the process of children's building blocks

The teachers filmed the video while the child is building the blocks. The teachers would discuss the problem with the child in the process. Letter, the teachers would playing videos in group discussions, letting young children engage in peer-to-peer conversations, find that building difficulties and discussing how to solve them can help children improve the way they build.

(3) the children shoot their films when the products are demonstrated.

At the end of the semester, children would publish blocks performance, and children use photographs or videos as posters or promotional videos. Children need to design their posters or the content of the video.

Acknowledgements

References

Aksoy, A. B., & Aksoy, M. K. (2017). The role of block play in early childhood.. In I. Koleva & G. Duman (Eds), *Educational research and practice* (pp. 104-113). Sofia: St. Kliment Ohridski University Press.

Hanline, M. F., Milton, S., & Phelps, P. (2001). Young children's block construction activities: Findings from 3 years of observation. *Journal of Early Intervention, 24*(3), 224-237.

Phelps, P.C. (2012). Let's build. Lewisville: Gryphon House.

Ramani, G. B., Zippert, E., Schweitzer, S., & Pan, S. (2014). Preschool children's joint block building during a guided play activity. *Journal of Applied Developmental Psychology, 35*(4), 326-336.

Wellhousen, K. and Kieff, J.E. (2001). *A constructivist approach to block play in early childhood*. Thomson Learning, Canada.

Wolfgang, C. H., Stannard, L. L., & Jones, I. (2001). Block play performance among preschoolers as a predictor of later school achievement in mathematics. *Journal of Research in Childhood Education, 15*(2), 173–180. https://doi.org/10.1080/02568540109594958

Supporting the Development of Students' Interdisciplinary Competence through the Smart Caring Technology Course

Calvin C. Y. LIAO*

College of Nursing, National Taipei University of Nursing and Health Sciences, Taiwan
*CalvinCYLiao@gmail.com

Abstract: In the past, nursing education in schools has long lacked the importance of incorporating information technology literacy and application skills. Therefore, there is little emphasis on the arrangement of relevant information technology courses, and the lack of long-term information literacy training for students, regardless of school care. The teachers and students of education seriously lack the interdisciplinary training experience and opportunities, which makes the connection between school education and industrial site demand. Furthermore, interdisciplinary training and learning is the key to developing students' problem-solving skills and diverse thinking. Hence, the development of "smart caring technology" theme Cross-domain courses have become an urgent task. About 50 different college students are expected to participate. Expected results will have a positive impact and may improve students' learning performance, the ability to apply proposals, and learning motivation.

Keywords: Smart Caring Technology, Interdisciplinary Training Curriculum, Design-based Research

1. Introduction

The global population structure is aging. According to the United Nations (Department of Economic and Social Affairs, Population Division, 2017), the young population of Taiwanese society has been declining over the years; and the elderly population has increased over the years. In this year, Taiwan will officially enter the old age society. Among them, the multiple complex diseases of elderly patients will increase the demand for care and require a large number of caregivers to invest. The lack of care for the nursing staff needs to be supplemented so that the medical education of the school must face medical care. Many new challenges, the school's original education methods are no longer due to new needs, new medical technology is continually developing, to improve medical quality and patient safety, but also to solve the problem of lack of human resources, smart medical care, and wisdom care has become an inevitable development trend.

Furthermore, the development of artificial intelligence and big data technology has brought about a fundamental change in the global health care industry. Smart technology is one of the key roles. Medical sites have begun to try to use various smart technologies to assist. Smart technology has already started to improve health. The care and medical care began to develop, and the traditional care model was being turned from "the care of the bed" to the "intelligent care." Further, the health care service has shifted from the conventional hospital bedside service to the home care of chronic diseases or institutional life services, and the focus has shifted from emergency treatment to health care — development of. And smart technology is the foundation to support change.

In short, because of the small population and aging of the population, the application of smart technology can extend medical care to remote homes or communities to provide remote care or medical care. Therefore, smart technologies have been widely regarded by many advanced countries — one of the important solutions to solving the problem of super senior society. However, in the past, nursing education in schools has long lacked the importance of incorporating information technology literacy and application skills. Therefore, there is little emphasis on the arrangement of relevant technology and technology courses. The long-term lack of information technology literacy training for students, regardless of school nursing education. The teachers and students seriously lack the cross-collar

experience and opportunities to transport technology to care, which makes the connection between school education and industrial site demand (Ong, & Cheong, 2019; Hammons, Fiese, Koester, Garcia, Parker, & Teegarden, 2019). At the same time, with the advancement of smart technology, smart hospitals, smart medical care, and smart care will come true in ten years, and the workplace has a higher expectation for nurses and care models. In the foreseeable future, smart medical care and smart care will inevitably become the new generation of hospitals.

2. Method

2.1 Research Design

This study will attempt to adopt the issue-based model as the new cross-domain curriculum design subject; the course activities will also involve problem-solving, case-based, self-directed, small group discussion, tutor-assisted, self-assessment and elements such as developing the interpersonal skill. Furthermore, as the newly developed "Smart Caring Technology" course is a cross-domain course, many people will misunderstand the training of cross-domain courses in order to make students become generalists who are familiar with more than two majors, or to make students become another professional expert training (Ong, & Cheong, 2019). In fact, in a limited school education time, it is almost impossible for students to be professionals or generalists at the same time. Therefore, this study will use previous researchers (Prasse, & Fafard, 1982) to point out that cross-domain training is not a generalist or specialist training concept. The curriculum design philosophy is to cultivate students' insights and differences ability to collaborate.

2.2 Interdisciplinary Course Design

The interdisciplinary course "Introduction to Smart Caring Technology" helps nursing students to understand, analyze, and improve different smart caring technologies. By grouping students with different professional backgrounds and thinking about various smart caring proposals (Ong, & Cheong, 2019). The goal of caring technology is to reduce a large amount of manpower generated by taking care of chronic diseases and disabled seniors to provide comprehensive or long-term care services, so that medical staff can help the challenges in the workplace through smart technology and effectively use manpower. It also reduces the need for a large number of caregivers.

The first part introduces the current development of smart caring technology, such as wearable devices, Internet of Things, artificial intelligence, big medical data, video technology, medical APP, mixed reality, etc., including various examples of using smart caring technology and related Methods and theories, such as the Wisdom Ward (including the bedside education system with nursing services, interactive TV, international bedside card information system, allowing patients to self-learn their knowledge of education, to watch TV on their own, to reduce care through self-service Personnel workload), nursing station dashboard, mobile physiological measurement system (measurement information can be downloaded through the App), medical treatment station. Or the demented elders are difficult to collect the most basic signs of life in the nursing work because of memory impairments.

In the second part, using the topic-oriented learning model, students need to propose or improve the application of smart caring technology. Through innovative culture and design thinking to solve the problem of health care and aging care. Students need to use the relevant wisdom and care technology, and think about how to use the information technology in the medical care related fields, and have the wisdom to develop a health education environment, such as Physiological health monitoring technology; accompanying robots; disease treatment; Drug administration monitoring; Remoting care; Cloud health care Internet of Things; virtual reality, or other possible related issues.

2.3 Upcoming Work

The study was conducted by about 50 students from a nursing university in the northern region. The main source was students about 21 to 22 years old. Most of the second-tech students obtained the nurse's license at the time of specialization, while the four-grade students began to practice in the hospital. However, there was little contact with information technology (IT), and there was a general

lack of basic knowledge about the application of IT to care. Most students may also lack the confidence and motivation to learn about IT students, and their learning that affects their subsequent exposure to the course activities. Although life in the past may have been exposed to general consumer electronics, the medical-grade products in the workplace have been purchased less. In the subsequent teaching activities, it is still necessary to investigate students' past experience in information technology use. In addition, when students conduct special topics, they use heterogeneous groupings and groups of four to five people, so that students have the opportunity to think, construct and discuss with peer groups of different professional backgrounds, and learn from multiple perspectives and considerations.

Acknowledgements

References

Prasse, D. P., & Fafard, M. B. (1982). Interdisciplinary training and professional interaction: A training challenge. *Teacher Education and Special Education*, *5*(1), 26-29.

Ong, B., & K. C. Cheong (2019). An Analysis of The Impact of An Interdisciplinary Project Assignment on Students' Learning Outcomes. *International Journal of Education, Psychology and Counseling*, 4 (30), 22-34.

Hammons, A. J., Fiese, B., Koester, B., Garcia, G. L., Parker, L., & Teegarden, D. (2019). Increasing undergraduate interdisciplinary exposure through an interdisciplinary web-based video series. *Innovations in Education and Teaching International*, 1-11.

Exploring the Possibility of Leveraging Spherical Video-based Immersive Virtual Reality in Secondary Geography Education

Morris Siu-Yung Jong[a]*, Chin-Chung Tsai[b], Haoran Xie[c], Frankie Kwan-Kit Wong[a], Vincent Tam[d] & Xiaohua Zhou[a]
[a]*The Chinese University of Hong Kong, Hong Kong*
[b]*National Taiwan Normal University, Taiwan*
[c]*The Education University of Hong Kong, Hong Kong*
[d]*The University of Hong Kong, Hong Kong*
*mjong@cuhk.edu.hk

Abstract: This work-in-progress poster discusses our preliminary work on exploring the possibility of harnessing spherical video-based immersive virtual reality (SV-IVR) in learning and teaching of Physical Geography. In particular, it focuses on delineating (i) the rationale behind our initiative, and (ii) the proposed direction of how to adopt SV-IVR in the context of formal schooling in Hong Kong.

Keywords: Spherical video-based immersive virtual reality, physical geography, school education

1. Spherical Video-based Immersive Virtual Reality (SV-IVR)

Immersive virtual reality (IVR) is regarded as an important technological innovation to be adopted in schools in the next triennium (Freeman et al., 2017; Jane et al., 2017). However, creating high-fidelity animation-based IVR is quite expensive (Hernández et al., 2016), which hinders its widespread adoption in formal schooling (Liu et al., 2017). On the contrary, spherical (360-degree) video-based IVR (SV-IVR) can offer teachers a viable and affordable alternative to incorporate immersive virtual learning elements into their teaching practice (Elmezeny et al., 2018). While the educational use of SV-IVR is still an emerging research area, not much attention has been paid to its application in formal school education (Hwang et al., 2018).

2. High-school Physical Geography Curriculum in Hong Kong

In order to align with the educational reform for promoting student-centredness in school education in Hong Kong (Education Bureau, 2010), the statutory high-school geography curriculum has been revamped. The new curriculum lays more emphasis on theme-based and enquiry-oriented learning (Curriculum Development Council, 2014). Among the six themes in the curriculum structure, three are related to Physical Geography (PG), such as, "River and Coastal Environments." In each theme, there are several geographic modules, each of which consists of a focal enquiry question, for example, "What are the challenges posed by the management of river and coastal systems? How & why?".

In line with the advocacy made by many geography educators and researchers (e.g., Anderson, 2009; Bonnett, 2008; Gabler et al., 2009), the new curriculum highlights that providing students with authentic outdoor enquiry-oriented learning experiences in interacting with the real-world environments is crucial to learning and teaching of the PG-related themes. Unfortunately, due to practical problems, such as safety issues, weather instability, and constraints in time, money and manpower, it is always challenging for teachers to organize outdoor enquiry-based fieldwork for students (Jong, 2015, 2019; Geng et al., 2018). In fact, studies on teachers' implementation of the new geography curriculum have revealed that generally the classroom activities are still teacher-centred and textbook-driven (e.g., Yeung, 2016).

3. Enquiry-based Learning and Teaching of PG with SV-IVR

We aim to leverage SV-IVR to tackle the problems discussed in the previous section. Normally, Geography teachers in Hong Kong use a 12-day teaching cycle to cover a geographic module, with four lessons evenly distributed in each cycle. The present proposed pedagogical design (see Figure 1) is grounded on Pedaste et al.'s (2015) 5-phase enquiry learning model: Communication, Orientation, Investigation, Explanation and Reflection. An important piece of our coming work is to conduct empirical research to evaluate the pedagogical effectiveness of the proposed pedagogy.
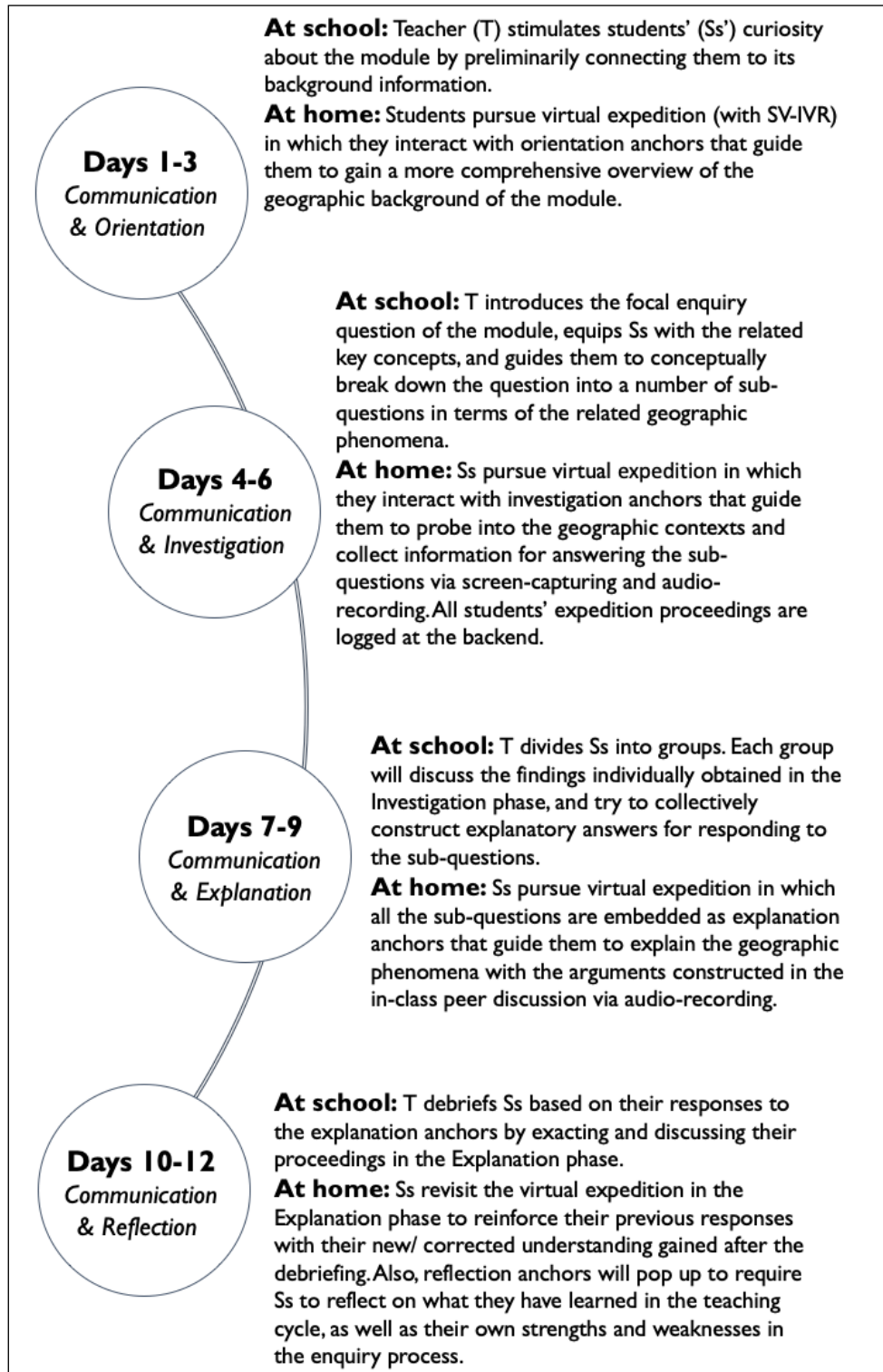

Days 1-3
Communication & Orientation

At school: Teacher (T) stimulates students' (Ss') curiosity about the module by preliminarily connecting them to its background information.
At home: Students pursue virtual expedition (with SV-IVR) in which they interact with orientation anchors that guide them to gain a more comprehensive overview of the geographic background of the module.

Days 4-6
Communication & Investigation

At school: T introduces the focal enquiry question of the module, equips Ss with the related key concepts, and guides them to conceptually break down the question into a number of sub-questions in terms of the related geographic phenomena.
At home: Ss pursue virtual expedition in which they interact with investigation anchors that guide them to probe into the geographic contexts and collect information for answering the sub-questions via screen-capturing and audio-recording. All students' expedition proceedings are logged at the backend.

Days 7-9
Communication & Explanation

At school: T divides Ss into groups. Each group will discuss the findings individually obtained in the Investigation phase, and try to collectively construct explanatory answers for responding to the sub-questions.
At home: Ss pursue virtual expedition in which all the sub-questions are embedded as explanation anchors that guide them to explain the geographic phenomena with the arguments constructed in the in-class peer discussion via audio-recording.

Days 10-12
Communication & Reflection

At school: T debriefs Ss based on their responses to the explanation anchors by exacting and discussing their proceedings in the Explanation phase.
At home: Ss revisit the virtual expedition in the Explanation phase to reinforce their previous responses with their new/ corrected understanding gained after the debriefing. Also, reflection anchors will pop up to require Ss to reflect on what they have learned in the teaching cycle, as well as their own strengths and weaknesses in the enquiry process.

Figure 1. Design of Enquiry-based Learning and Teaching of a PG-related Module with SV-IVR.

References

Anderson, J. (2009). *Understanding cultural geography: Places and traces*. New York, NY: Routledge.

Bonnett, A. (2008). *What is geography?* London, UK: SAGE.

Curriculum Development Council. (2014). *Geography: Curriculum and assessment guide (Secondary 4–6)*. Hong Kong: Education Bureau.

Education Bureau. (2010). *New senior education curriculum*. Hong Kong: Education Bureau.

Elmezeny, A., Edenhofer. N., & Wimmer, J. (2018). Immersive storytelling in 360-degree videos: An analysis of interplay between narrative and technical immersion. *Journal of Virtual Worlds Research, 11*(1), 1–13.

Freeman, A., Adams Becker, S., Cummins, M., Davis, A., & Hall Giesinger, C. (2017). *NMC/CoSN horizon report: 2017 K–12 edition*. Austin, TX: The New Media Consortium.

Gabler, R. E., Petersen, J. F., Trapasso, L. M., & Sack, D. (2009). *Physical geography* (9th ed.). Belmont, CA: Brooks and Cole.

Geng, J., Jong, M. S. Y., Luk, E. T. H., & Jiang, Y. (2018). Comparative study on the pedagogical use of interactive spherical video-based virtual reality: The EduVenture-VR experience. In F. L. Wang, O. Au, T. Konno, C. Iwasaki & C. Li (Eds.), *Proceedings of the 4th International Symposium on Educational Technology (ISET 2018)* (pp. 261–263). Piscataway, NJ: IEEE.

Hernández, Y., Pérez-Ramírez, M., Zatarain-Cabada, R., Barrón-Estrada, L., & Alor-Hernández, G. (2016). Designing empathetic animated agents for a B-Learning training environment within the electrical domain. *Educational Technology & Society, 19* (2), 116–131.

Hwang, G. J., Jong, M. S. Y., & Shang, J. J. (2018). Call for papers: Special issue on innovative pedagogic uses of spherical video-based virtual reality. *Interactive Learning Environment*s. Retrieved June 20, 2019, from https://www.tandfonline.com/toc/nile20/current

Jang, S., Vitale, J. M., Jyung, R. W., & Black, J. B. (2017). Direct manipulation is better than passive viewing for learning anatomy in a three-dimensional virtual reality environment. *Computers & Education, 106,* 150-165.

Jong, M. S. Y. (2015). Context-aware geography field trip with EagleEye: Teachers' first experience. In M. Chang & Y. Li (Eds.), *Smart Learning Environments* (pp. 77–93). Heidelberg: Springer.

Jong, M. S. Y. (2019). Sustaining the adoption of gamified outdoor social enquiry learning in high schools through addressing teachers' emerging concerns: A three-year study. *British Journal of Educational Technology, 50*(3), 1275–1293.

Liu, D., Dede, C., Huang, R., & Richards. J. (Eds.). (2017). *Virtual, augmented, and mixed realities in education*. Singapore: Springer.

Pedaste, M., Mäeots, M., Siiman, L. A., de Jong, T., van Riesen, S. A. N., Kamp, E. T., Manoli, C. C., Zacharia, Z. C., & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review, 14*, 47–56.

Yeung, P. M. (2016). The new senior secondary geography curriculum: Challenges and prospects. *Hong Kong Teachers' Centre Journal, 8*, 52–63.

Comparison between International and Korean CSCL Research

Ji-Yeon JEONG[a], Su-Jong SEO[a] & Heisawn JEONG[ab*]
[a]*Department of Interaction Design, Hallym University, South Korea*
[b]*Department of Psychology, Hallym University, South Korea*
*heis@hallym.ac.kr

Abstract: This study explores the relationship between international and regional CSCL research by comparing CSCL research published in international journals and CSCL research published in Korean journals. Bibliographic Coupling (BC) analysis was used to map the two corpora of CSCL research. Preliminary results suggest that the Korean CSCL research shares research interests with the international CSCL research, and yet have different foci.

Keywords: CSCL, Bibliographic Coupling Analysis

1. Introduction

Academic research is a global enterprise, being carried out by researchers distributed around the world. They share research interests and missions so that, for example, the goal of CSCL research is to support collaborative learning with computers. Research outcomes, although produced in distributed manners, are shared through publications. The development of communication and transportation technologies along with the adoption of English as an international language of science have led to the emergence of "international" research communities. And yet there are costs that come with the internalization of research, such as the loss of linguistic and rhetorical diversity and the marginalization of works published in non-English journals (Tardy, 2004). In this study, we explore whether and how a regional CSCL research, in this case Korean CSCL research published in Korean journals, may differ from the international CSCL research published in international journals. The current study is built on our prior work in which we applied the Bibliographic Coupling (BC) analysis to an international CSCL corpus and identified major and minor CSCL research clusters (Jeong, Seo, Jeong, Hmelo-Silver, Grauwin, 2019). In the current study, we created a BC map of Korean CSCL research and compared the two maps to understand the extent to which a regional (i.e., Korean) CSCL research is aligned with and/or diverge from the global CSCL research.

2. Methods

The international CSCL research corpus was constructed in prior research and consists of 869 papers published in international journals (Jeong et al. 2019). The Korean CSCL corpus consists of 195 papers published in Korean journals. In both corpora, paper selection was based on searches in the major CSCL journals and major databases (e.g., Web of Science and ERIC for the international corpus and KCI for the Korean corpus). While the two corpora were constructed in a similar manner, they differ in their scopes. The international corpus covers research from 2005-2014, whereas the Korean corpus contains research from 2005-2016 due to the fact that it was constructed later. The two corpora also differ in their coverage of the learning domains. All learning domains are included up to 2009 in both corpora, but some of the non-STEM domains (e.g., humanities) are excluded from the international corpus after 2010 due to the change in funding agency, which made the international corpus biased toward STEM domains. These differences in the two corpora are taken into accounts in interpreting the outcomes.

In BC analysis, papers were linked together if they share references (Kessler, 1963). The more references they share, the stronger the link becomes. A community detection algorithm (an implementation of the Louvain algorithm) is then applied to the network of these papers. The algorithm partitions the publications into major clusters of research that are linked closely to each other.

3. Findings

3.1 Descriptive Comparisons between the International and the Korean Corpus

We first compared descriptive features of the two corpora (see Table 1). First, the two differ in their sizes. The size of the Korean corpus is quite large (about 22% of the international corpus) even after we consider the fact that it covers a longer period of research. The relatively large size of Korean CSCL corpus shows that CSCL is an active area of research in Korea, though it was not one of the key contributors to the international corpus (Jeong et al., 2019). Second, the two corpora differ in their coverage of the learning domains. The proportion of STEM studies is higher in Korean corpus (65% vs. 58%), in spite of the fact that the international corpus is biased toward STEM domains. It appears that there is a stronger emphasis on STEM in Korean CSCL research compared to international CSCL research.

"Collaborative learning" was the mostly frequently used author-assigned keyword in both corpora, but it appears that the international CSCL research emphasizes computer-mediated communication, interactive learning environments, and teaching/learning strategies, whereas the Korean CSCL research emphasizes interaction, academic achievement, wiki, and blended learning. There is more emphasis on achievement in Korean CSCL research. The Korean CSCL may also have a narrower research focus compared to international CSCL research, examining a specific type of interactive learning environment (i.e., Wiki) and/or teaching/learning strategies (i.e., blended learning), a natural outcome considering its smaller size.

Table 1

Descriptive Characteristics of the International and the Korean CSCL Corpus

	International Corpus (N=869)	Korean Corpus (N=195)
Learning domain	STEM (58%) > non-STEM (42%)	STEM (65%) > non-STEM (35%)
Most frequent author's keywords	1. Collaborative Learning (11.4%) 2. Computer-Mediated Communication (11.3%) 3. Collaborative Learning/Cooperative Learning (10.6%) 4. Interactive Learning Environment (10.4%) 5. Teaching/Learning Strategies (8.6%)	1. Collaborative Learning (7.7%) 2. Interaction (6.7%) 3. WIKI (5.6%) 4. Academic Achievement (4.6%) 5. Blended Learning (4.6%)
Most cited references	1. Vygotsky. (1978). Mind in society: Development of higher psychological processes (14.3%) 2. Dillenbourg. (1999). Collaborative learning: Cognitive and computational approaches. advances in learning and instruction series (7%) 3. Kirshner et al. (2002). Three worlds of CSCL: Can we support CSCL? (5.6%)	1. Henri. (1992). Computer conferencing and content analysis (8.2%) 2. Vygotsky. (1978). Mind in society: Development of higher psychological processes (7.7%) 3. Harasim. (1990). Online education: perspectives on a new environment (5.1%)

Similar patterns emerged when most cited references were compared. Vygotsky (1978) was highly cited in both corpora, although the extent varied between the two corpora (14.3% vs. 7.7%). Vygotsky (1978) is a critical publication of sociocultural theory that provided a framework to understand social influence and tool mediation. High citation of his work indicates that CSCL research is strongly guided by sociocultural framework, although its influence is little less in Korean CSCL research. In the international corpus, Dillenbourg (1999) and Kirshner et al. (2002) rank second and third. They also rank 7th (3.6%) and 11th (3.1%) in the Korean corpus, indicating somewhat diminished but still strong influences in Korean CSCL research. On the other hand, Henri (1992) and Harasim (1990) rank first and third in the Korean corpus, but 85th (1.6%) and 1,436th (.6%) in the international corpus. Their uneven influences in the two corpora suggest that Korean CSCL research may draw on knowledge bases different from the mainstream of international CSCL research, likely due to the fact that it focuses on sub-areas of international CSCL research.

3.2 BC Map Comparisons between the International and the Korean Corpus

Korean CSCL map consists of seven clusters, whereas the international BC map consists of ten clusters (see Figure 1). Given the size difference, it is not surprising that there are more clusters covering a wider array of research topics in the international BC map (note that the cluster labels in Figure 1 are based on most frequent and yet distinct keyword of the clusters). The two maps also differ in its structure, so that the international CSCL BC map has a clear center, the argumentation cluster, which is well-connected to the rest of the clusters. The clusters in the Korean CSCL map were also well-connected, but it did not appear to have a central cluster.

As can be seen from Figure 1, argumentation cluster appears in both maps, but appears to be differentially emphasized. The argumentation cluster is the second biggest cluster (n=127; 15%) along with the learning environment cluster and positioned at the center in the international map, whereas it ranks fourth (n=18; 9%) and positioned at the periphery in the Korean map. Argumentation appears to be a more prominent research topic in the international CSCL research. The examination of the both argumentation cluster also suggests that the two may approach CSCL from a different perspective. For example, cognitive load theory (Sweller et al., 1998) strongly guides research in the Korean argumentation cluster, but not in the international argumentation cluster.
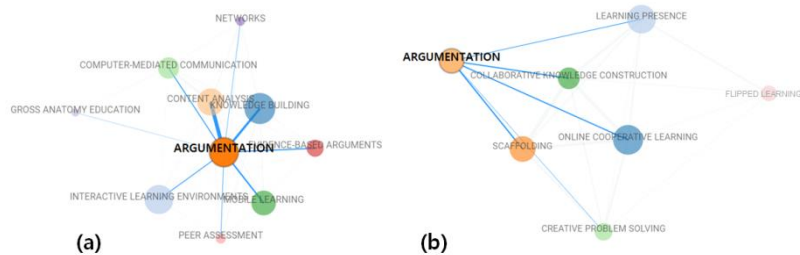

Figure 1. International (a) and Korean (b) BC map of CSCL research.

4. Summary and Discussions

In this study, we examined the relationship between the international and Korean CSCL research using a BC analysis. By definition, Korean CSCL research constitutes the international CSCL research. As such, it is aligned with the international CSCL research with shared research interests and common references, but there also exist important differences in what is being researched and emphasized. These are likely to reflect the local values and emphasis in research and education. Research communities around the world are increasingly connected to each other, forming a large body of "international" research. This can help researchers to share their research findings and benefit from each other. And yet, language barriers prevent researchers from reaping these benefits. We should strive for lowering these and other barriers so that researchers around the world can benefit from each other's work more fully. At the same time, we should keep in mind that education is situated in local contexts. Internationalization of academic research should not mean abandoning local values and needs but should lead to an enrichment of our understanding about how to support learners to communicate and collaborate effectively around the world.

Acknowledgements

References

Dillenbourg, P. (1999). *Collaborative learning: Cognitive and computational approaches*. New York, NY: Elsevier Science.

Harasim, L. M. (1990). *Online education: Perspectives on a new environment.* Westport, CT: Greenwood Publishing Group Inc.

Henri, F. (1992). Computer conferencing and content analysis. In A. R. Kaye (Ed.), *Collaborative learning through computer conferencing* (pp. 117-136). Berlin: Springer-Verlag.

Jeong, H., Seo, S., Jeong, J., Hmelo-silver, C., & Grauwin, S. (2019). What can be learned about computer-supported collaborative learning from a bibliographic. In the proceedings of the 2019 CSCL Conference. 712-718.

Kessler, M. M. (1963). Bibliographic coupling between scientific articles. *American Documentation*, *24*, 123–131.

Sweller, J., Van Merrienboer, J. J., & Paas, F. G. (1998). Cognitive architecture and instructional design. *Educational psychology review*, *10*(3), 251-296.

Tardy, C. (2004). The role of English in scientific communication: lingua franca or Tyrannosaurus rex? *Journal of English for Academic Purposes*, *3*(3), 247-269.

Vygotsky, L. S. (1978). *Mind in society: The development of higher mental process*. Cambridge, MA: Harvard University.

Teaching System for Operation of Artificial Respirator

Ren KANEHIRA[a]*, Yasuhiro ITO[a], Masanao KATO[b], Naoki MIWA[c] & Hideo FUJIMOTO[d]
[a]*School of Medical Sciences, Fujita Health University, Japan*
[b]*Fujita Health University Hospital, Japan*
[c]*Graduate School of Health Sciences, Fujita Health University, Japan*
[d]*Nagoya Institute of Technology, Japan*
*kanehira@fujita-hu.ac.jp

Abstract: This study deals with a computer supported teaching system for artificial respirator operation. The system is characterized by the capability of learning both operation techniques and related medical textbook knowledge. Effort was given on the improvement of proficiency and trouble-shooting during practice. After a certain teaching practice, the effect of the system was verified with experiments. Obtained results were well feed-backed for some adjustment and improvement in the system for better teaching effects. Useful hints for new approach to technical teaching in medical machine operation has been obtained through our sequential work of the proposal, construction, teaching practice and effect verification of the system.

Keywords: Computer Training System, Skill Learning Support, Clinical Engineering, Operation of Medical Machines, Trouble Shooting

1. Introduction

With the rapid development of ICT (Information Communication Technology), various computer-supported training-learning systems have been proposed for medical treatments, particularly for those in practical skill training which has been difficult in conventional teaching and training methods. Similarly, advanced technologies in information and engineering are applied to clinical engineering as well (Education IT Solutions EXPO, 2019).

This study deals with the construction of a training-learning system for the operation of medical machines in clinical engineering (Kanehira, et al., 2016). Although there have been various teaching systems for conventional knowledge learning using E-learning, those with practical operation capabilities are still rare. The reason may lie in the difficulties to share the knowledge of operations (obtained though experience and body physical memory) only by language communications (Furukawa, K., 2009). Accordingly, this study proposed a computer-supported teaching system capable of learning both operation and theoretical knowledge at the same time, taking the operation and trouble shooting in respirator as an example.

Artificial respirators used in hospitals are quite different in the panel shape, button position, and operation methods for different system makers, making the operation complex to produce mistakes. In fact, an investigation on the 4th grade students in our university shows that most of them are poor in knowledge and operation technique on respirators. Therefore, this study pays attention to a more effective teaching on the operation and trouble-shooting with artificial respirator.

2. Supporting to Operations on Medical Machines

A clinical engineer must to do a wide range of works such as the operation, management, maintenance and repairing of medical machines. They are asked to master high level of professional knowledge and operation skills. On the other hand, there is only limited time in university for their study, so it is difficult to master knowledge and skill on so many medical machines, particularly those for trouble-shooting.

As a solution, computer supported teaching systems with low cost and good operation capability and repeatability for clinical engineering are required.

In this research, while clarifying the problem in the operation method acquisition of the medical equipment, the problem solving method has been examined and proposed. The necessity of real-time teaching using teacher data that emphasizes operability and skill improvement using multimedia was confirmed (Kanehira, et al., 2017).

3. Technique Training System for Operation of Artificial Respirator

3.1 System Construction and Teaching Contents

In this study, we constructed a virtual environment with computer for learning and training for the panel operation of respirator. Operations can be easily and repeatedly done on computer without practical use of a real machine. Special attention was paid on training and learning on trouble shooting during operations.

The respirator of [Servo Ventilator 300A] was chosen as the system model. The operation panel of the model was realistically reproduced on computer screen as the top page of a Power Point electronic teaching material, each operation button being linked to related [knowledge] and [operation] pages as shown in Figure 1.
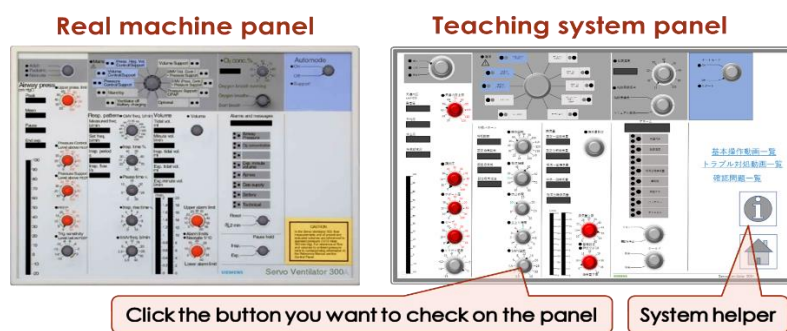

Figure 1. Top screen of system

The related [knowledge] page explains with an easy understand way the general knowledge of a respirator, while the operation teaching such as model setting and trouble shooting was done using animation textbook. The confirmation of knowledge and operation was done using questions in national examination with software of THINQ Maker. A right or wrong judgement was given real timely with detailed explanation (Fig.2).

Figure 2. Confirmation after learning

Serious medical accidents may occur if an operator makes a mistake in the panel operation of the respirator. Therefore, the mistaken operation should be reset as quickly as possible. This study paid special attention to such trouble shooting. The situations for 9 possible troubles were selected, and the set value as the cause of trouble and whether there is self-breathing were provided on the computer screen.

3.2 Verification Experiment

A verification experiment was carried out on 20 students of the 4th grade in our university to confirm the effect and the points where needs improving. An environment was prepared with the teaching system on PC and a real respirator beside (Fig.3).

The following steps were arranged for a comparison with or without using the teaching system: 1) fill in a questionnaire before experiment, 2) an instruction to respirator, followed by practice operation of 5 minutes, 3) trouble shooting practice before using the teaching system, provided with 3 troubles randomly selected from the most frequent 9, 4) fill in a questionnaire once more, 5) trained using the teaching system, 6) trouble shooting practice after being trained with the teaching system, 7) fill in the final questionnaire.
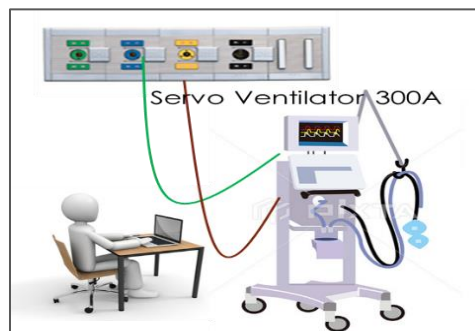

Figure 3. Experiment configuration for verification

On the average time used for trouble shooting, it is 2 minutes 41 seconds before and 1 minutes 9 seconds after the use of teaching system, with a large reduction of trouble shooting time of 1 minutes 33 seconds. 18 students of the total 20 examinees are with decreased trouble shooting time, and 95% of the examinees claimed a resolution of the weak feeling against respirator, indicating an increased confidence to trouble shooting. There are some suggestions for further improvement of the system such as to enrich the textbook knowledge, to provide more figures and tables to make the screen much easier to understand, and to increase the number of questions provided with different difficult levels.

4. Conclusion

This study deals with a computer supported teaching system, taking an example of the panel operation of the respirator. The system is characterized by the capability of learning both operation techniques and related medical textbook knowledge. Spatial effort was given to the trouble-shooting experience, and the effect was confirmed by comparing the trouble shooting time with or without the use of teaching system. Further improvement of the system was also suggested for better training results.

Acknowledgements

References

Education IT Solutions EXPO (2019). E-learning Japan, *https://www.edix-tokyo.jp/ja-jp/edict.html*

Kanehira, R., Ohashi, A., Fujimoto, H. (2016) Training System for Puncture Technique of Hemodialysis, *Communications in Computer and Information Science*, Springer, CCIS 618, 312-317.

Furukawa, K. (2009) Skills Science Introduction: Approach to the elucidation of embodies knowledge. pp.157-185, Ohmsha

Kanehira, R., Ohashi, A., Fujimoto, H. (2017) Training System for Operation of Dialysis Puncture in Clinical Engineering, Proceedings of 13th International Conference on Fuzzy Systems and Knowledge Discovery, IEEE, 3086-3090.

Knowledge-based recommendation system for teaching computational thinking in primary level students

Julio Vera-Sanchi, Eduardo De-Rivero[b], Christian Condori-Mamani[c], Vidal Soncco-Merma [d], Gustavo Suero-Soto [e], Klinge Villalba-Condori [f]

[abcdef] Universidad Catolica de Santa Maria, Peru

[a]jveras@ucsm.edu.pe
[b]ederivero@ucsm.edu.pe
[c]ccondorim@ucsm.edu.pe
[d]vsoncco@ucsm.edu.pe
[e]gsuero@ucsm.edu.pe
[f]kvillalba@ucsm.edu.pe

Abstract: The proposal is a video game developed in Unity, which interacts with the students according to their degree of studies and, according to the STEM curriculum, it is the subject that the student has to learn and in what degree of difficulty, so Once the registration is complete, the video game will provide levels according to your academic degree so that the student interacts with the video game and use the Vector Machine Support (SVM) algorithm that enters the student data and video game data, such as its level, difficulty, time and number of movements and its result send it to the recommendation system to determine what the student should learn and provide related links or documentation, or see if he learned and at what level, verify the SVM because it is a discriminatory classifier formally defined by a hyperplane of separation, which in our case only interests us to know if the student learned or not.

Keywords: Recommendation system, machine learning, computational thinking.

1. Introduction

At present we have a large number of students, who receive basic training and who does not agree with the vanguard of the educational system such as computational thinking. Part of our reality is the still existing digital divide that exists in our country Peru, since only 48.7% of the population aged 6 and over have access to the Internet. But if we separate the urban area from the rural area, the difference is marked, in the urban area 58.2% has a connection, while the rural area only 15.4%, this digital divide means that resources and technologies cannot be accessed to train teachers and the development in computational thinking students. The gamification in the educational context and development of computational thinking helps to understand about the concepts its application in daily problems, from a playful point of view, improving the learning process of students, that is why there is a set of applications that help to develop certain skills, but many of these systems do not have an intelligent approach to all the data that can be collected through children's interaction with these applications.[22] As part of a change in this approach to the development of computational thinking is that we make use of Machine Learning techniques, to make the processing of all the information collected by students, through algorithms that collect the high dimensionality of the data set of the interactions to generate learning predictions or not, and that serves us as part of a process for the generation of a knowledge-based recommendation system that helps students, recommending educational resources found in a specialized database according to the STEM methodology (Science, Technology, Engineering and Mathematics), this proposal is based on creating an adaptive learning environment according to the students' current knowledge.[21]

2. Conceptual Framework

2.1 Recommendation Systems

Recommendation systems (RS) are software tools and techniques that offer suggestions on the elements that can be used by the user. In this introductory chapter we briefly discuss basic ideas and concepts of RS. Our main objective is to delineate, in a coherent and structured manner, the chapters included in this manual and help the reader navigate the extremely rich and detailed content offered in the manual. [12] To provide a first overview of the different types of SR, it has been possible to find about six different kinds of recommendation approaches, but as the need grows and new problems arise, they can increase but the most important are:

- Content based: The system learns to recommend items similar to what the user liked in the past. The similarity of the elements is calculated based on the characteristics associated with the elements compared. For example, if a user has positively rated a movie that belongs to the genre of comedy, then the system can learn to recommend other movies of this genre. [12]
- Collaborative filtering: the simplest and most original implementation of this approach [16] recommends the active user the articles that other users with similar tastes liked in the past.
- Knowledge-based: Knowledge-based systems recommend elements based on specific domain knowledge about how certain features of the item meet the needs and preferences of users and, ultimately, how the item is useful for the user. Notable knowledge-based recommendation systems are based on cases [2]. In these systems, a similarity function estimates how much the user's needs (description of the problem) coincide with the recommendations (solutions of the problem). Here the similarity score can be interpreted directly as the utility of the recommendation for the user. Restriction-based systems are another type of knowledge-based RS. In terms of knowledge used, both systems are similar: user requirements are collected; repairs for inconsistent requirements are automatically proposed in situations where solutions cannot be found; and the results of the recommendations are explained. The main difference lies in the way the solutions are calculated. Case based recommendations determine recommendations based on similarity metrics, while restriction-based recommendations predominantly exploit predefined knowledge bases that contain explicit rules on how to relate customer requirements to article characteristics. Knowledge-based systems tend to work better than others at the beginning of their implementation, but if they are not equipped with learning components, they can be overcome by other shallow methods that can exploit human / computer interaction records (such as of Collaborative Filtering). [9]
- Hybrid recommendation systems: These RSs are based on the combination of the techniques mentioned above. A hybrid system that combines techniques A and B tries to use the advantages of A to correct the disadvantages of B. For example, Collaborative Filtering methods suffer from problems of new items, that is, they cannot recommend items that do not have qualifications. [9]

2.2 Computational Thinking

At present, there is a great current of judgments in the world that support the use of the computer in the teaching-learning process, which allow the development of various types of thinking, skills and competencies of a student of the 21st century. Computational thinking has been positioned as an alternative to develop the aforementioned characteristics. [10]. "Computational Thinking is a problem-solving process that includes, but is not limited to the following characteristics" [20]:

- Formulate problems so that computers and other tools can be used to solve them.
- Organize and analyze data logically.
- Represent data using abstractions, such as models and simulations.
- Automate solutions through algorithmic thinking.
- Identify, analyze and implement possible solutions in order to find the most efficient and effective combination of steps and resources.
- Generalize and transfer this problem-solving process to a great diversity of these.[20]

　　Existing literature supports the inclusion of TC in the K-12 curriculum (educational systems for primary and secondary schooling. It is used in the United States, Canada, Turkey, Philippines, Australia and Ecuador. It is formed by the initial in English for garden of infants or Kindergarten (between four to six years of age) and the number indicating the last grade (12; between seventeen and nineteen) of free education.), in multiple subjects and from Primary grades onwards. The use of computers as a context

for CT skills is often possible, but care must be taken to ensure that CT does not combine with programming or instructional technology in general. [19]

2.3 STEM Methodology

The term STEM is the acronym for the English terms Science, Technology, Engineering and Mathematics. The term was coined by the National Science Foundation (NSF) in the 1990s. [8] the term STEM, only dried, only serves to group the 4 major areas of knowledge in which scientists and engineers work. The concept of "STEM Education" (STEM Education) has been developed as a new way of teaching Science, Mathematics and Technology together (in general, not only computer science) with two distinct characteristics: [11]

- Teaching-learning of Science, Technology, Engineering and Mathematics in an integrated manner rather than as compartmentalized areas of knowledge. Integrated instruction means any program in which there is an explicit assimilation of concepts from two or more disciplines.
- With an engineering approach to the development of theoretical knowledge for its subsequent practical application, always focused on solving technological problems. [14]

In Table 1, we list several of those standards that could be relevant to our teaching concept.[7]

The student may be able to	Level	Grade
Recognize that the software is created to control computer operations.	1	Initial
Understand and use the basic steps in solving algorithmic problems (for example, problem statement and exploration, examination of sample instances, design, implementation and testing)	1st	3rd to 3rd grade
Develop a simple understanding of an algorithm (e.g., search, sequence of events or classification) using exercises without a computer	1st	3rd grade
Use the basic steps in solving algorithmic problems to design solutions (for example, problem statement and exploration, sample sample exam, design, solution implementation, test, evaluation)	2nd	4th grade to 1st grade
Define an algorithm as a sequence of instructions that can be processed by a computer	2nd	4th grade to 1st grade
Act search and classification algorithms.	2nd	4th grade to 1st grade
Describe and analyze a sequence of instructions that are followed (for example, describe the behavior of a character in a video game according to the rules and algorithms)	2nd	4th grade to 1st grade
Represent the data in several ways, including text, sounds, images and numbers	2nd	4th grade to 1st grade
Use abstraction to break down a problem into sub problems	2nd	4th grade to 1st grade
Use predefined functions and parameters, classes and methods to divide a complex problem into simpler parts	3rd	2nd to 2nd secondary
Explain how sequence, selection, iteration and recursion are building blocks of algorithms	3rd	2nd to 2nd secondary
Describe how different types of data are stored in a computer system.	3rd	2nd to 2nd secondary
Compare and contrast simple data structures and their uses (for example, matrices and lists)	4	2nd to 4th secondary
Decompose a problem by defining new functions and classes.	5th	2nd to 4th grade

2.4 Support Vector Machine - SVM

A support vector machine (SVM) is a discriminative classifier formally defined by a separation hyperplane. In other words, given the training data labeled (supervised learning), the algorithm generates an optimal hyperplane that categorizes new examples. In two dimensional spaces, this hyperplane is a line that divides a plane into two parts where each class is on each side.

Vector support machines or Support Vector Machine are a set of supervised learning algorithms that are properly related to classification and regression problems. Given a set of data (of samples) we can label the classes and train an SVM to build a model that predicts the class of a new sample. Basically, an SVM is a model that represents the sample points in space, separating the classes into 2 spaces as wide as possible by means of a separation hyperplane defined as the vector between the 2 closest points of the 2 classes, to which It's called support vector. When new samples (data) are mapped to that model, depending on the spaces to which they belong, they can be classified into one or the other class. svm02 [17]

The SVM seeks a hyperplane that optimally separates the points of one class from that of another. In this concept of "optimal separation" is where the fundamental characteristic of the SVM resides, they are also known as maximum margin classifiers, because they look for the hyperplane that has the maximum distance (margin) with the points that are closest to it. [13]

The SVM has adjustment parameters that are:

2.4.1 Nucleus

Hyperplane learning in linear SVM is done by transforming the problem using some linear algebra. This is where the nucleus plays a role.

2.4.2 Regularization

The Regularization parameter (often called parameter C in the python sklearn library) tells the SVM optimization how much you want to avoid misclassifying each training example. For large values of C, the optimization will choose a hyperplane with a lower margin if that hyperplane does a better job of correctly classifying all training points. On the contrary, a very small value of C will cause the optimizer to look for a separation margin of greater margin, even if that hyperplane mistakenly classifies more points. The images below (same as image 1 and image 2 in section 2) are examples of two different regularization parameters. The left one has an erroneous classification due to the lower regularization value. A higher value leads to results as correct.
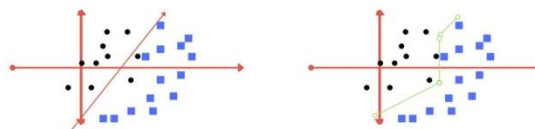

Figure 1: Left: low regularization value, right: high regularization value
Source: self made.

2.4.3 Gamma

The gamma parameter defines how far the influence of a single training example goes, with low values that mean "far" and high values that mean "near." In other words, with low gamma, the points away from the plausible separation line are considered in the calculation of the separation line. Where as high gamma means that the points near the plausible line are considered in the calculation.[13]

Figure 2: Gamma types, high and low Source: self made.

2.4.4 Margin

And finally, the last but very important feature of the SVM classifier. SVM to core tries to achieve a good margin. A margin is a line separation to the nearest class points. A good margin is one in which this separation is greater for both classes. The images below give a visual example of good and bad margins. A good margin allows points to be in their respective classes without crossing to another class..[13]
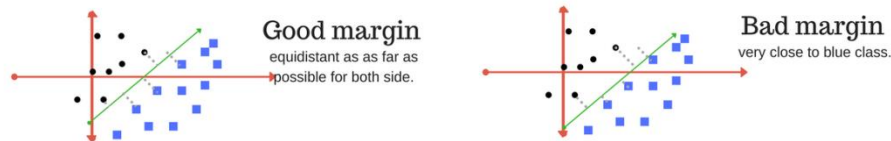

Figure 3: Types of margins, good margin and bad margin Source: self made.

2.5 Gammification

Gamification has been defined as a process for improving services with (motivational) possibilities to invoke gaming experiences and additional behavioral outcomes [6] [5]. In defining gamification, Huotari and Hamari [31] highlight the role of gamification in invoking the same psychological experiences as games (in general). Deterding et al. deterding2011game, on the other hand, emphasize that the possibilities implemented in gamification have to be the same as those used in games, regardless of the results. However, it is not clear what possibilities are exclusive to the games, as well as what psychological results can be strictly considered as a result of the games. From the perspective of these definitions, there is room for a wide variety of studies that could be framed as gamification.[13]

3. Proposal

3.1 Data Model

Table 2 shows the data model used as a proposal in the computational thinking recommendation system. A brief explanation of the model will be given below. A basic entry for data models is the tuple < Topic, Difficulty >, indicates the value of the difficulty in each topic. In our research, the themes have been selected based on the Curriculum Mesh based on the teaching methodology STEM.

The level of skills for different subjects was modeled on a 3-point scale (grades). The tuple < topic, difficulty > has the relationship between a topic and its degree of difficulty, because according to the curriculum mesh depending on the grade of the student will determine its difficulty. It also has another meaning in the case of the student's ability with a subject. For example: a user's skill level is described in a topic in their user profile (year in which it is found), and on the other hand, it indicates the required skill of a topic in levels for the video game. The user profile in relation to computational thinking includes skills and their learning goals, where they have to learn. The source of information would be (a) Curriculum: it is what gives us the basis to see what the student needs to learn and to what level of difficulty in relation to their year, (b) Evaluation: how it is obtained from the evaluation that makes the video game. The goal is to see if the student learns or what is missing to finish learning the subject, for this, the results of the video game are used and processed by the recommendation system. For the current paper, we have considered the following main aspect for the application that are required: (a) the levels assigned to the user. In order to have an attainable goal, the recommendation system needs to use the STEM curriculum to have exactly what goals the student needs.

3.2 Recommendation System Architecture

The architecture of the recommendation system receives several inputs as can be seen in the figure 4, such as: Game data, Curriculum, Student Data, Levels and Difficulty. Next, each of the entries will be detailed in context:

Tuple Theme-Skill	
Topic	One or more set of STEM Curriculum Mesh
Skill	One of {1: Bad, 2: Fair, 3: Good}
User Data Model	
User-ID	Primary User Identifier
Student Name	Full Name
Year	Academic Year in which the student is
Skills	A tuple arrangement < *topic, difficulty*>
Level Model	
ID-Level	Primary Level Identifier
Description	Description of the level
Issue-Difficulty	A tuple arrangement <*theme, difficulty*>

Tuple Level-Time	
ID-Level	Primary Task Identifier
Time	Classified in seconds
Tuple Level-Scores	
ID-Level	Primary Task Identifier
Scores	Ranked the number of moves
User Assignment	
User-ID	Primary User Identifier
User Level	A tuple arrangement < *level, time* >

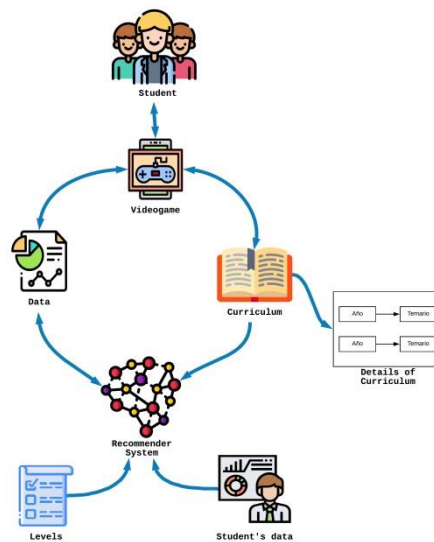*Table 2: Data Model. Source: Self-made.*

Figure 4: Video Game Architecture

- Videogame - Game data: It is the user interface, it is the one that is responsible for capturing user inputs and as it relates to the system, are the levels that the user completes and plays, each level receives what the student It has taken time to complete the level as your total time, number of movements (scores) from the starting point to the goal and will be stored in a matrix to be sent to the recommendation system.
- Curriculum: This is given by the STEM [4] methodology whose teaching chart for Computational Thinking was as follows: The proposal of this paper is focused on students in the second grade of primary school, so according to 1 it should be focused on understanding and using the basic steps in solving algorithmic problems, See how the steps work for an algorithm to work, and a simple

understanding of what an algorithm is. In addition, since its level is 1, it is of the least difficulty since it only needs to understand how it works and how it can be applied so that in the video game it will be the sequence of steps to reach the goal the way of solving the algorithm and according to your number of movements see how efficient your algorithm is.

- User data: These are the student's data such as their first name, last name, gender, and city, but their most important or interesting data to the recommendation system is in which academic year they are in to validate it with the matrix of the curriculum mesh.
- Levels: These are all the activities performed by the user in the video game and are classified according to their level of difficulty and the characteristic of computational thinking at that level.

3.3 Methodology

This paper aims to investigate and develop a knowledge-based recommendation system [18], with core an algorithm of Super Vector Machine (SVM) [9] supervised learning whose objective is to indicate whether the student learns or not based on a training data and then analyze it in the recommendation system to decide whether the student, in the case he did not learn, recommend a help text or Tell you some other similar activity that you can do to better understand the subject in question. Next, the proposal will be shown, the architectures that comprise the recommendation system and how it interacts with the entries of both the user and an entry that is the curricular mesh, where all the skills that are necessary will be, for this case it will be developed in an application mobile. The paper proposal is a learning method through a videogame for teaching computational thinking, defined in a knowledge-based recommendation system for personalized teaching for each student. Students who wish to learn about computational thinking can do so through a video game developed at Unity, but with guided teaching, this is where the recommendation system comes in to see their progress and analyze according to their input variables and give a recommendation through a prediction. The details are:

- Students will enter the mobile video game developed at Unity and register to have their progress and see, according to their year, what they have to learn in relation to the curriculum.
- Once identified, they will be given the level (subject) to complete with their degree of difficulty.
- Students will be able to interact through the video game that captures the numbers of movements (scores) and the time it takes.
- The records stored by the video game will be part of the entry for the recommendation system, along with the curriculum.
- Through an SVM the recommendation system will evaluate the input data resulting in whether the student learned or did not learn.
- Subsequently, the recommendation system based on the results will dictate that the student needs to learn and if he did not learn, he needs to reinforce so that the issue is clear with his respective difficulty.

3.4 Recommendation Algorithm

The recommendation system is based on the theoretical framework of the STEM curriculum. Student data and video game data (the time it takes to complete the level, the total number of movements, what level and how difficult it is) are the input data for the recommendation system that first passes through the SVM algorithm.

The SVM algorithm has as input data or dimensions the degree, level, difficulty, scores, time and as an objective variable the result (which would be whether it learned or not). The algorithm disaggregates based on a line of separation between the data that is necessary to define whether the student learned or did not learn.

For the training part of the algorithm a dataset of 435403 records containing the input data was used, of which 70 % was collected for training data, and the remaining 30 % for test data. In addition, cross-validation will be implemented so that the algorithm does not fit the data in the event that the dataset has repeated consecutive rows to improve its training.

Then you will want to see its accuracy of recommendation to see if, based on the 30 % that we separated for testing, it did a good job of recommendation and to finish, the whole procedure of the

algorithm will be stored in a pickle to be used in the repository that we will use for the videogame to connect with the operation and indicate its student results with the recommendation system based on the curriculum.

A student should be recommended to other levels (or difficulties) according to their results that suits their current situation. This should not be too difficult or too easy for him. Therefore, the usefulness of a learning content with respect to the current knowledge of the user is determined by the current knowledge of the user in the subject and the nature of the learning object and its level of difficulty by adding its number of movements (scores) and the time it took to do it.
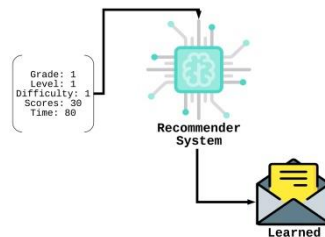

Figure 6: Example of the operation of the recommendation system

3.5 Implementation

To perform the tests, an application was developed on the Unity platform called CGAME, which has two games called MST and TorresH, which help us obtain data for our recommendation system.

3.5.1 CGame

The application has a Login view, in which you have to enter a valid email and password, you also have the registration view in case you do not have a valid account. Once inside the application it will show us the games that will help us to carry out the tests.
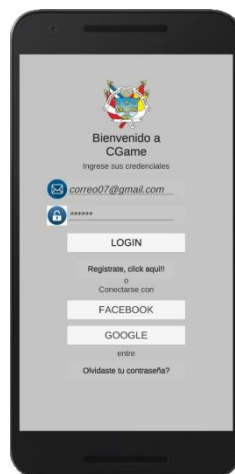

Figure 7: CGame - Login

3.5.2 MST

This game consists of moving a cube through all the positions that mark you in the game, to successfully overcome the game, one must use the minimum number of possible movements, these types of problems are solved using algorithms such as the Minimum Expansion Tree (Minimum Spanning tree). This game has three levels (easy, intermediate and difficult), once each level is completed, you get data such as the number of movements and the time it took to overcome that level. The data obtained are sent to the recommendation system which returns additional information to strengthen their knowledge and skills in case they have not satisfactorily exceeded the level.

MST that will teach the student in relation to computational thinking is pattern recognition and algorithm resolution, since to complete the game, the student must move the cube from an initial point to an end point (marked the purple quadrant) and the less movements generated, the more optimal the resolution of the level will be and follow a sequence of steps to complete the level, so that you

understand and use the basic steps in solving problems, by steps and therefore understand a compression Simple operation of an algorithm.

Figure 8: MST - Intermediate Level / TorresH – Advanced Level

3.5.3 TorresH

This game is a simulation of the mathematical game of the Towers of Hanoi, it consists of a number of perforated discs of increasing radius that are stacked inserted into one of the three posts fixed to a board. The objective of the game is to transfer the stack to another of the posts following certain rules, such as that a larger disc cannot be placed on top of a smaller disc. This problem can be solved by recursion and iteratively. In the same way as the previous game, we obtain the number of movements and time, and pass them to the recommendation system.

TorresH has the operation of a tower of Hanoi that, if we compare it with computational thinking, we would cover what is the decomposition, abstraction and resolution of algorithms, since to complete the level, the student has to move The whole tower of blocks from one side to the other without a larger block being on top of the other, only a smaller block can be on top of another. As a decomposition we have the tower divided into blocks of different sizes, the abstraction as a solution to the problem is that, as we can move the blocks between one of smaller size and another and as resolution of algorithms, we have the steps to follow to complete the level, and So understand the definition of an algorithm as a sequence of instructions that can be processed by a computer and explain how the sequence, selection, interaction and recursion in our videogame are building blocks of algorithms.

Once the student's results are obtained in the MSTo in TorresH, an HttpRequest request will be sent to the service where the Recommendation System will be hosted and through its body a JSON will be sent with the following format: {user: 20 , level: 1, difficulty: 2, time: 100, scores: 10, grade: 2} and the answer that the request will give us HttpRequest will be if the student learned or what is missing to comply with what is indicated according to his academic year. As you can see in the following example: {result: 'Didn't learn', help: 'https: //csunplugged.org/en/topics/kidbots/integrations/finding-shapes/'}

4. Results

Synthetic data was tested, that is, the evaluation was done with a methodology expert and data generated randomly from the curriculum using a program to generate the data with a total of about 435403 records, implementing cross-validation or crossvalidation, which is a technique used to evaluate The results of a statistical analysis and ensure that they are independent of the partition between training and test data. It consists of repeating and calculating the arithmetic mean obtained from the evaluation measures on different partitions. It is used in environments where the main objective is prediction and you want to estimate the accuracy of a model that will be implemented. [3] It is a technique widely used in artificial intelligence projects to validate generated models. Using cross validation gave an accuracy of 96 % using 70 % of the data for the test side and the remaining 30 % for simulation.

A graph of precision recall was made, which is defined as the fraction of all the relevant instances divided by the obtained instances. Recovery is the fraction of relevant instances that have been obtained over the total number of relevant instances. Both accuracy and recovery are based on an understanding and measure of relevance. [10] Which indicated that its average accuracy is 92 %.
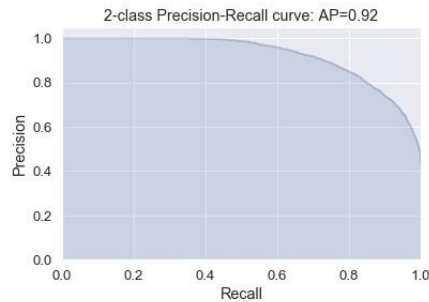
Figure 10: Precision recall.

5. Conclusion

In this paper there was an experimentation and interpretation of the results obtained using a knowledge-based recommendation system, as you can see the experiment was done with synthetic data on second grade elementary students who want to learn about computational thinking but in a dynamic way and through a video game that helps them understand how computers work in a simple way. In the paper you can see the different entries to the system by users such as their data, the curriculum and video game data such as time, scores and number of movements. In the results section we can see that the system has a good prediction for the recommendation of contents since it reaches a 96 % accuracy.

References

[1] K. Brennan and M. Resnick. New frameworks for studying and assessing the development of computational thinking. In *Proceedings of the 2012 annual meeting of the American Educational Research Association, Vancouver, Canada*, volume 1, page 25, 2012.

[2] D. BRIDGE, M. H. GOKER, L. McGINTY, and B. SMYTH. Case-¨ based recommender systems. *The Knowledge Engineering Review*, 20(3):315–320, 2005.

[3] P. A. Devijver and J. Kittler. *Pattern recognition: A statistical approach*. Prentice hall, 1982.

[4] S.-C. Fan and K.-C. Yu. How an integrative stem curriculum can benefit students in engineering design practices. *International Journal of Technology and Design Education*, 27(1):107–129, Mar 2017.

[5] J. Hamari. Transforming homo economicus into homo ludens: A field experiment on gamification in a utilitarian peer-to-peer trading service. *Electronic commerce research and applications*, 12(4):236–245, 2013.

[6] K. Huotari and J. Hamari. Defining gamification: a service marketing perspective. In *Proceeding of the 16th international academic MindTrek conference*, pages 17–22. ACM, 2012.

[7] M. S. Khine. *Computational Thinking in the STEM Disciplines: Foundations and Research Highlights*. Springer, 2018.

[8] Y. Koren, R. Bell, and C. Volinsky. Matrix factorization techniques for recommender systems. *Computer*, (8):30–37, 2009.

[9] T. Mahmood and F. Ricci. Towards learning user-adaptive state models in a conversational recommender system. In *LWA*, pages 373–378.
Citeseer, 2007.

[10] G. G. Meza. Precision and recall, 2018.

[11] G. O. Rebollo, I. M. R. Albaladejo, F. G. Cuadra, and A. C. Sanchez.´ Implantacion de la nueva asignatura "rob´ otica" en ense´nanza secun-˘ daria y bachillerato. *Investigacion en la escuela´* , (87):65–79, 2015.

[12] F. Ricci, L. Rokach, and B. Shapira. *Introduction to Recommender Systems Handbook*, pages 1–35. Springer US, Boston, MA, 2011.

[13] J. A. Rodrigo. Support vector machines. https://rpubs.com/Joaquin$_A$R/267926,2017.

[14] R. E. Satchwell and F. L. Loepp. Designing and implementing an integrated mathematics, science, and technology curriculum for the middle school. *Journal of Industrial Teacher Education*, 39(3):41–66, 2002.

[15] B. Schafer, J. Konstan, and J. Riedl. E-commerce recommendation applications, data mining and knowledge discovery, vol 5 (1–2), 2001.

[16] J. B. Schafer, D. Frankowski, J. Herlocker, and S. Sen. *Collaborative Filtering Recommender Systems*, pages 291–324. Springer Berlin Heidelberg, Berlin, Heidelberg, 2007.

[17] N. C. SHUJUN HUANG. Applications of support vector machine (svm) learning in cancer genomics. *Cancer Genomics Proteomics*, Dec 2017.

[18] J. K. Tarus, Z. Niu, and G. Mustafa. Knowledge-based recommendation: a review of ontology-based recommender systems for e-learning. *Artificial Intelligence Review*, 50(1):21–48, Jun 2018.

[19] A. Yadav, S. Gretter, J. Good, and T. McLean. Computational thinking in teacher education. In *Emerging research, practice, and policy on computational thinking*, pages 205–220. Springer, 2017.

[20] Villalba-Condori, K. O., Cuba-Sayco, S. E. C., Chávez, E. P. G., Deco, C., & Bender, C. (2018, October). Approaches of learning and computational thinking in students that get into the computer sciences career. In Proceedings of the Sixth International Conference on Technological Ecosystems for Enhancing Multiculturality (pp. 36-40). ACM.

[21] Espinoza-Suarez, S., Falen, J. M. M., Chipana, S. S., Villalba-Condori, K. O., & Castro-Cuba-Sayco, S.(2019) Project-oriented learning for the achievement of educational outcomes.

[22] Silveira, I. F., & Villalba-Condori, K. O. (2018). An Open Perspective for Educational Games. Journal of Information Technology Research (JITR), 11(1), 18-28.

Multi-label search platform for open educational resources based on purposes learning

Julio Vera-Sancho[a], Gustavo Suero-Soto[b], Lushianna Tejada[c], Sonia Castro-Cuba-Sayco[d] & Klinge Villalba-Condori[e]

[a, b, c, d & e] *Universidad Catolica de Santa Maria, Peru*

[a]*jveras@ucsm.edu.pe*
[b]*gsuero@ucsm.edu.pe*
[c]*ltejada@ucsm.edu.pe*
[c]*scastroc@ucsm.edu.pe*
[d]*kvillalba@ucsm.edu.pe*

Abstract: Open Educational Resources (OER) repositories stores a large amount and variety of data from multiple sources, and these presents relevant information to the educational learning process; but nowadays, thinking computing takes great importance, and that's why a search system of specialized educational resources in this area is of great need. This work presents the use of Data Mining in OER repositories, for the construction of a multi-label search platform. The process of extracting information is based on Web Scraping techniques, and the use of a multi-label classifier based on Multi Layer Perceptron. This work contributes to a search of OERs based on purposes learning, using as a case study the area of thinking computing.

Keywords: neural networks, classification, scraping, resources educational resources

1. Introduction

Currently, the internet has managed to connect all people and has generated a great amount of information, including in education, generating educational material to improve teaching in schools. All this educational material is available and stored in different repositories of open educational resources (OER) (Liñán and Perez, 2015) that are oriented to help teachers to prepare a better session to improve the learning process based on the characteristics and progress of the students. In this way, the teacher performs different searches to find content that suits what He needs and the class that he wants to teach. This work proposes a system of recommendation based on purpose, where the teacher at the time to performs the search for a particular topic in addition to choosing one or several labels, which will help to choose the purpose of the class to give. The proposed system enters to different repositories, to obtain the content related to the topic, and to identify the purpose of each metadata found, and to show the desired result by the teacher at the end.

2. Theorical Framework

2.1 *Purpose Learning*

When we talk about the purpose of learning, it is based on the pedagogical intentionality of the teacher, who is responsible of the design of your class. The Constructive Alignment is very pedagogically efficient and is based on the SOLO taxonomy (Structure of Observed Learning Outcome) (Levicoy, Obreque, Vásquez, y Salvatierra, 2017) which distinguishes between superficial learning and deep learning. As students learn, the results of their learning first show quantitative and then qualitative phases of increasingly complex structure (Villalba, Cuba, Deco, Bender, y García-Peñalvo, 2017) This

taxonomy is that we find levels of understanding and recurrent actions that are important for learning and each level of understanding is linked to actions as shown below in the table 1:

Table 1

Levels of understanding and recurrent action

Levels of understanding	Abstract enlarged
Relational	0
Multistructural	0
Unistructural	0
Recurrent actions	0

The SOLO taxonomy is an excellent means to classify the expected learning from the most concrete levels to the most abstract and complex levels. Which ensures us to have a learning that goes from the most superficial to the deepest (Villalba-Condori 2018).

2.2 *Open Educational Resources (OER)*

The OER may also be referred to as a digital object or object of digital learning, which serves to provide information and / or knowledge, as well as can help the generation of knowledge, skills and attitudes according to what the person needs(Aguila and Burgos, 2010). The use of TICs each time are more necessary in different fields, and one field where is taking strength is Education, to improve the process of teaching and learning. Open educational resources (OER) are found as shared open content in public repositories(Arias, Zermeño, and Chávez, 2015) which we can make use of, but going further we can say that the OER itself is to share the result of a design process (instructional), in which the knowledge and experience of a designer (teacher) is applied to produce a specific resource (Arias and cols., 2015), describing what the process is in a more exact way and how the content is shown in the REA, and in a certain way it is improving the content that is stored every day, thanks to the feedback that is generated (Espinoza-Suarez 2019).

2.3 *Web Scraping*

The World Wide Web contains a great amount of information that is valuable resource for tasks, such as machine learning, data mining or systems of recommendation (Smedt and Daelemans, 2012). Web Scraping is a software technique aimed at extracting information from websites (Vargiu and Urru, 2013). They generally simulate the manual exploration of the World Wide Web through the use of low-level hypertext extraction protocols or integration of web browsers. It is a technique of information retrieval from the Web through a bot that is generally called Spider.

This technique is used to extract information and be able to give life to search engines or recommendation systems. The extraction of information is mainly the extraction of text, an information retrieval task aimed at automatically discovering information from different text resources (Ristoski, Paulheim, Svátek, and Zeman, 2016). In extracting information, text mining is used to remove relevant information from text files by relying on linguistic and statistical algorithms *(Vargiu and Urru, 2013).*

2.4 *Scrapy*

Scrapy is an open source web crawling framework written in Python. Its main objective is to provide help and support for an efficient web crawling practice. Scrapy allows you to track websites and extract data that can be structured or not to be used in a wide range of applications of scientific interest (Kouzis-Loukas, 2016).

2.4.1 *Scrapy Architecture*

As shown in Figure 1, the architecture of the Scrapy library with its components that allows generating a data flow that takes place within the data extraction system. As a whole, each one of the components and the data flow allows obtaining more detailed and clear information of each website (Smedt and Daelemans, 2012). The Scrapy engine is its main component, whose main objective is to control the

flow of data among all the other components. The engine generates requests and manages events against an action. The Scheduler receives the requests sent by the engine and queues them (Wang and Guo, 2012). The aim of the downloader is to search all web pages and send them to the engine, which then sends web pages to spiders, which contains the logic that allows analyzing websites and extract data from each particular website. The element pipe processes the elements side by side after the spiders extract them (Myers and McGuffee, 2015).
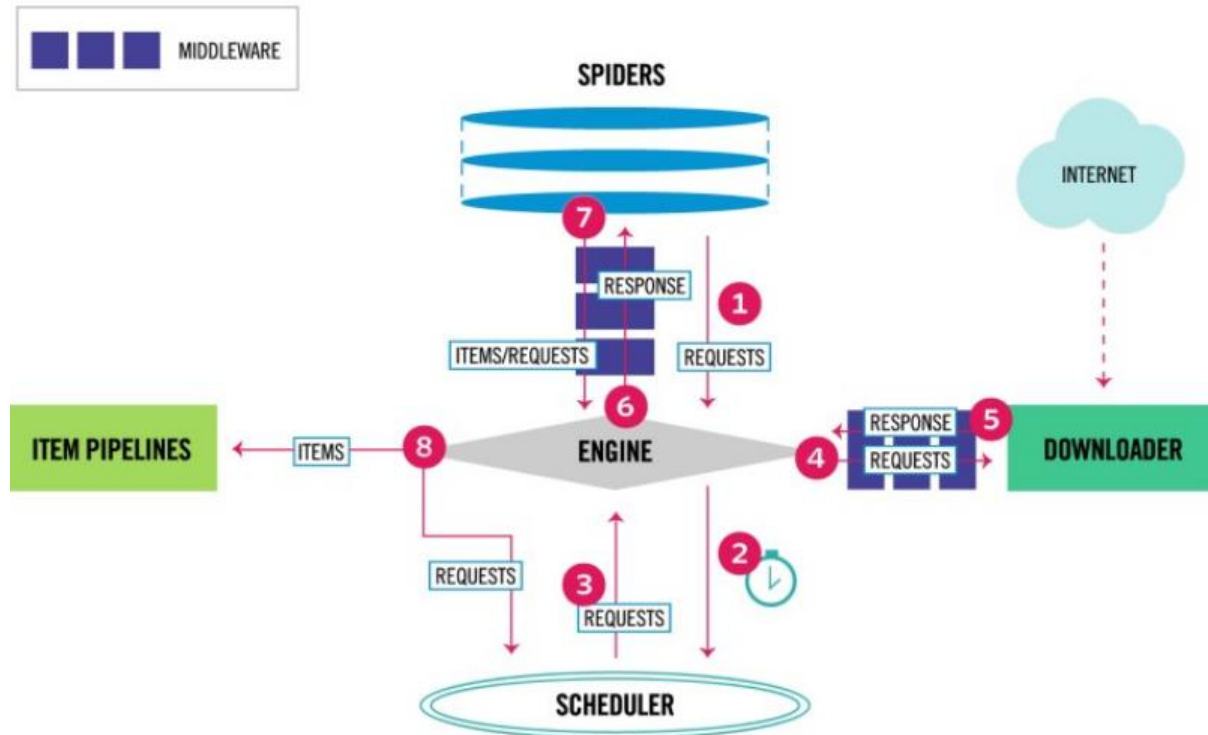

Figura 1: Scrapy Library architecture (Myers y McGuffee, 2015)

2.5 *TF=IDF*

It is an abbreviation of the Reverse Document Frequency formula, whose purpose is to define the importance of a keyword or phrase in a document (Dadgar, Araghi, and Farahani, 2016). In order to process the documents or texts, it is necessary to make a mathematical representation of the text, for which we use this algorithm.

The frequency of a term in a document is simply the number of times the term appears in that document. The value is usually normalized to prevent large documents from acquiring an unusual advantage. In this way, the importance of the term ti in the document dj is given by

$$TF_{i,j} = \frac{n_{i,j}}{\sum_k n_{k,j}} \qquad (1)$$

Where *n, j* is the number of occurrences of term considered in the document *dj* and the denominator is the number of occurrences of all the terms in the document *dj*. the inverse frequency of the document that is calculated with:

$$IDF_i = log\frac{|D|}{|\{d_j : t_i \in d_j\}|} \qquad (2)$$

Where we define the numerator as the total number of documents, and the denominator where the number of documents where the term *ti* appears (i.e., *nij/0*), and is where the calculation of TF-IDF for the term t i in the document *dj*

$$TF - IDF_{i,j} = TF_{i,j} x IDF_i \qquad (3)$$

2.6 *Multilayer Perceptron*

The multilayer perceptron (MLP) is one of the simplest neural networks, and it is based on a neural network that is the perceptron, and MLP architecture is characterized because it has its neurons grouped in layers of different levels and each one of the layers can be formed formed by a set of neurons and three different types of layers are distinguished which are: the input layer, the hidden layers and the output layer (Bishop, 2006). In the figure 1.6 an MLP model is shown, where the connections of the always are directed forward, that is, the neurons of one layer are connected with the neurons of the next layer, which means that it is a unidirectional network feedforward (Zhang, Towsey, Xie, Zhang, and Roe, 2016).
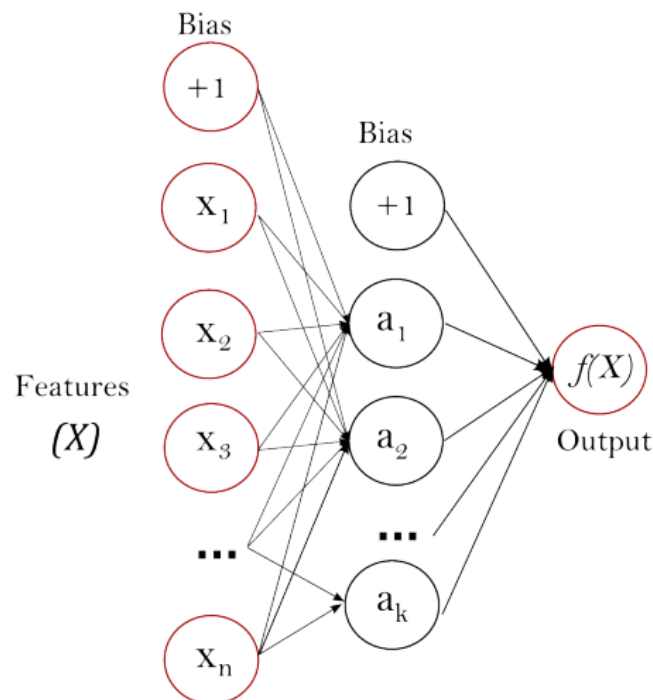

Figura 2:Architecture of a multilayer perceptron (Buitinck and cols., 2013)

The MLP is a supervised learning algorithm that learns a function to train a dataset, given a set of characteristics X=x1, x2, ..., xm where m is the number of dimensions of the input and these characteristics come to form the set of neurons {xi |x1, x2, ..., xm}, Where each neuron in the hidden layer is the value of the weight of each neuron by the value of the characteristic that is: w1x1 + w2x2 + ... + wmxm The output nodes are those that indicate if the new instance belongs to a class or not, according to the activation function these will take values from 0 to 1, or from −1 to +1.

3. Methodology

The present research project proposes, to create a search platform for open educational resources, using a multi-label classifier as a Machine Learning technique, which is a multilayer perceptron, for which the following architecture of the proposal is proposed:
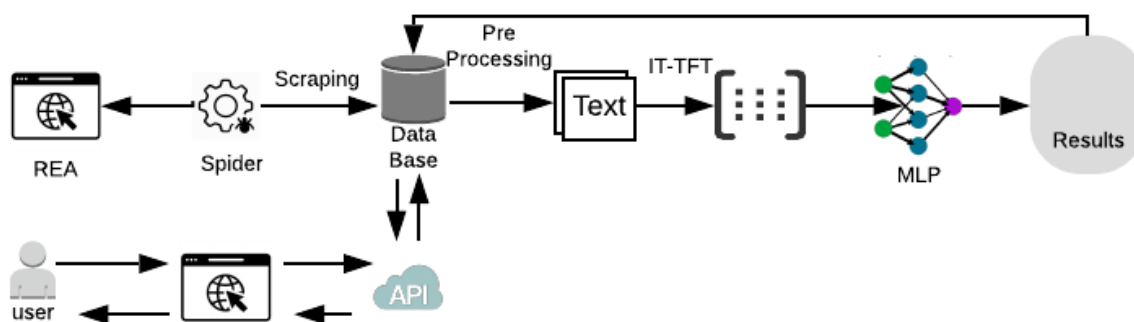
Figura 3: Architeture of model proposed (Buitinck y cols., 2013)

3.1 *Data Extraction*

In this stage of our proposal, scraping techniques are used to extract data from REA Repositories, such as: OERCOMMONS, Temoa, Procomun, for this we use the Scrapy library, which will allow us to create spiders, to extract the data more important to create a database with these resources, these are the fields extracted from these repositories: Title, Author, Description, Link, Subject, Material Type and also generate a field to perform the searches that we call "Labels"; field will serve as index of search of the contents.

A script (spider) was generated that helps to automate the searches on each page and get the information for each field that is being required. The script (spider) are divided into two parts:

The first part will analyze and search the links on the main search page of the repository, where each link that leads to each educational object to be analyzed will be obtained, advancing by each page until reaching the last one, for this part a function called Parse is generated that will help with the automated search of all links.

Second, after obtaining the link of each educational object, the spider enters each link to obtain the information of the fields that were previously selected. Another function called parse_mongo is generated which receives the link sent in the previous function called parse, through request and response objects, and the necessary data is obtained.

After applying the scrapping techniques to obtain the data, but none of the learning objects have a label assigned and in order to process them, a certain amount of them need to have labels assigned to be able to train the MLP classification algorithm, and for this, so different people experts in the field will perform this assignment manually.

For the assignment were considered generic verbs that fit several taxonomies including SOLO taxonomy, in addition to these verbs containing cognitive processes that have similarities between them, so that the classification will take the cognitive processes that will help to understand to the teacher at the time of preparing his OER(Villalba, Cristina, Bender & Cuba, 2019). While the verbs will be used on the same platform at the time of the searches.

There are generic verbs in the right side that have numbers assigned under them, those numbers represent Cognitive Processes, in total there are twelve verbs and three or four Cognitive Processes assigned to each one. The relation for verb/Cognitive Processes is describe in Table 3.

Table 3
Generic Verbs and Cognitive Processes (Villalba, Cristina, Bender & Castro, 2019)

Verb	#	Cognitive Processes
Identify o Recognize	1	Reception of information
	2	Characterization
	3	Recognition
Discriminate	1	Reception of information

	4	manifestation of the differences	
	5	identification and verification of characteristics	
Compare	1	Reception of information	
	6	Identification of individual characteristics	
	7	Verification of characteristics of two or more objects of study	
Select	8	Determination of criteria or specifications	
	9	Information search	
	10	Identification and verification of criteria or specifications with prototypes	
	11	Choice	
Organize	1	Reception of information	
	12	Identification of the elements that will be organized	
	13	Determination of criteria to organize	
	14	Disposition of the elements considering established criteria and order	
Analyze	1	Reception of information	
	15	Selective observation	
	16	Division of the whole into its parts	
	17	Interrelation of the parties to explain or justify	
Infer	1	Reception of information	
	18	Premise identification	
	19	Contrasting the premises in context	
	20	Formulation of deductions	
Judge or Prosecute	1	Reception of information	
	21	Criteria Formulation	
	22	Contrast criteria with the referent	
	23	Issuance of opinion or judgment	
Represent or Diagram or Schematize or Design or Graph or Draw	24	Observation of the object or situation to be represented	
	25	Description of the form / situation and location of its elements	
	26	Order generation and representation sequencing	
	27	Representation of the external and internal form or situation	
Argue	1	Reception of information	
	28	Selective observation of the information that will support	
	29	Presentation of the arguments	
Apply or Use	1	Reception of information	
	30	Identification and sequencing of the principle, process or concept to be applied	
	31	Execution of processes and strategies	
Formulate or Pose	1	Reception of information	
	32	Item Identification	
	33	Interrelation of the elements	
	34	Presentation of the interrelations	

3.2 *Pre processing*

With pre processing, we seek to improve the quality of the data set, through techniques or a series of steps that help to obtain more and better information, achieving quality data that will help us to improve the analysis of this data.

As part of the pre processing, the texts must be represented in a way that is maintainable for our MLP, A large amount of data is stored in different languages, containing strange characters, text that is not useful, etc. So you have to apply different techniques that help us improve data and make sense. For this stage you have the following techniques that will be applied for pre processing: Data cleaning and TF-IDF.

3.2.1 *Data Cleaning*

Data Cleaning will help us to ensure the quality of the data. In this step, all the data will be placed in lowercase, so that there is no duplication of data at the time of applying TF-IDF or in the classification algorithms, then the removal of different tags, special characters and digits will also be done.

Also the elimination of words that in the text are very repetitive or words that do not give a special meaning to the text (eg, from, after, before, the, them, etc) that are called stopwords, they will be removed from the data in order to have real data that has value and also reduce the amount of data for better processing.

3.2.2 *TF-IDF*

Through the python scikit-learn library, the TF-IDF algorithm will be applied through the TfidfVectorizer class, to build a frequency matrix, in addition to replacing the data that are "null" or "empty" obtained by the scraping technique for 0, which at the end of this processing will give us a matrix of *nxm*, where n will be the number of words for each description and m the number of descriptions of the OER.

Table 4
TF-IDF Words Weights

	Term	Weight
8029	science	0.039497
7428	reading	0.038644
5241	life	0.038016
8748	students	0.026403
110	activity	0.023320

After pre processing all the data a final matrix is composed by the set of documents as an index, the vocabulary created from the documents that are stored in the variable *cv* and is obtained in the form *cv.get_feature_names()* that will be the columns of the matrix and as content is will have the weights obtained with the tf-idf algorithm.

3.3 *Multi Label Classification*

For do out the multi-label classification, it receives the output matrix of the TF-IDF as input and, for the generation of the labels, we will use the recurrent actions defined in the table 3 which will allow us to carry out the multi-label classification, for which due to the large amount of data is that we have proceeded to divide the dataset, 40% for training our neural network, and 60% to perform the new classifications of the proposed model, then it is necessary to normalize the data so that they have zero mean and standard deviation one, After Normalizing, for the architecture of our neural network we use the following structure, an input layer with the quantity of neurons as words in the vocabulary, two hidden layer with 100 neurons, and many output layers as labels quantity. Once the multi-label

classification has been carried out as a result, we will generate a table of the associated labels for each REA, and these labels will be stored in the database in order to perform the corresponding search.

3.4 *Search Based on Purpose Learning*

Once we have implemented our proposal, we proceed to create an interface, through a web page to search for educational content, based on learning purpose, for which we receive the terms to search, and the categories based on the generic verbs in Table 3, so that it works is that through a REST API service, it is that a request is sent with the term to search and the categories, and as a result it returns a JSON with all the resources that contain those categories, based on our field "Label" that are the Cognitive processes in our database.

4. Result

As part of our results, we show the implemented platform, using the scraping techniques of three OER repositories, and storing in a database, in addition to obtaining the accuracy measure, with respect to training data and new data. To be classified by our MLP network, it is worth mentioning that without performing the StopWords, our frequency matrix increases its size excessively, for which dimensionality reduction techniques can be used, but one disadvantage is that we would lose the nature of the words already We are looking for verbs to make the classification of the OER. As a case study we have used OER, based on computational thinking and mathematics, because if we do not delimit the research, it would be very general what we would have to validate for all the cases that can be found in these repositories, so we will focus only on computational thinking as an alternative to search for specialized content in this area.

In the table 5, we show the Precision-Recall, that is a useful measure of success of prediction when the classes are very imbalanced, in information retrieval, precision is a measure of result relevancy, while recall is a measure of how many truly relevant results are returned, the precision-recall, we show only 6 labels, and we use 1759 elements as prediction data,

Table 5
Precision-recall of classification multilabel

	Precision	Recall	f1-score	support
0	0.56	0.51	0.53	768
1	0.41	0.24	0.30	87
2	0.57	0.48	0.52	414
3	0.17	0.10	0.12	21
4	0.52	0.40	0.45	400
5	0.35	0.16	0.22	69
Micro avg	0.54	0.44	0.49	1759
Macro avg	0.43	0.31	0.36	1759
Weighted avg	0.53	0.44	0.48	1759
Samples avg	0.04	0.04	0.04	1759

And as a final result, there is a search platform based on learning purpose with different labels to select and to enter a text to search, then shows results with the algorithms applied.
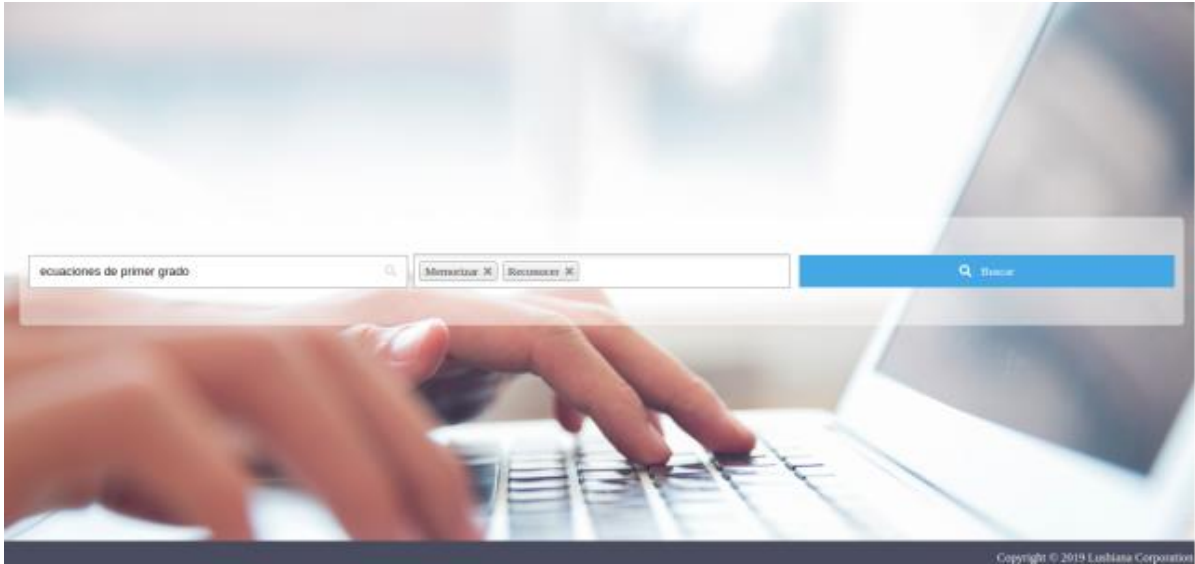
Figure 15: Screen of the proposal of the search platform based on learning purpose[4]
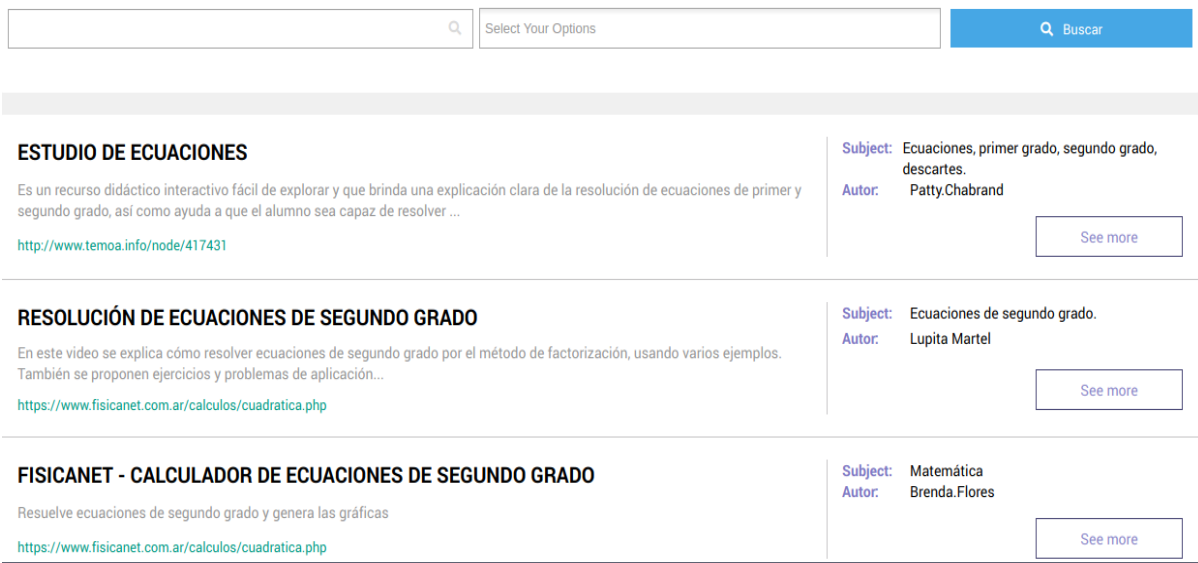

Figure 16: Screen of the proposal of the search platform based on learning purpose, results [4]

5. Conclusion

In recent years the development of specialized search systems has grown significantly, being very useful in different fields and particularly in education. In this work, an architecture of a content search system has been proposed under a SOLO taxonomy approach, which is focused on using the verb proposed as a learning purpose. This verb displays internally cognitive processes or learning processes that will serve as classification labels and allows more specialized searches of OER. In addition, a complete model is shown from the extraction of different repositories, until the conformation of a repository fed by external sources. In this way, the search system can be articulated by learning purpose, taking into account the teacher's intention of teaching and the need of the student focused on cognitive processes.

References

Aguila, J. V. B., y Burgos, V. (2010). Distribución de conocimiento y acceso libre a la información con recursos educativos abiertos (rea) . La educación.

Arias, D. P. H., Zermeño, M. G. G., y Chávez, M. M. P. (2015). Uso de recursos educativos abiertos en ambientes virtuales de aprendizaje para una educación inclusiva y de calidad. Revista de Investigación Educativa del Tecnológico de Monterrey, 6(11), 29–35.

Bishop, C. M. (2006). Pattern recognition and machine learning (1st ed. 2006. Corr. 2 nd printing ed.). Springer. Descargado de http://gen.lib.rus.ec/book/index.php?md5=6B552B24CAE380BB656F7AAEF7F81B46

Buitinck, L., Louppe, G., Blondel, M., Pedregosa, F., Mueller, A., Grisel, O., . . . Varoquaux, G. (2013). API design for machine learning software: experiences from the scikit-learn project. En Ecml pkdd workshop: Languages for data mining and machine learning (pp. 108–122).

Dadgar, S. M. H., Araghi, M. S., y Farahani, M. M. (2016, March). A novel text mining approach based on tf-idf and support vector machine for news classification. En 2016 ieee international conference on engineering and technology (icetech) (p. 112-116). doi: 10.1109/ICETECH.2016.7569223

Espinoza-Suarez, S., Falen, J. M. M., Chipana, S. S., Villalba-Condori, K. O., & Castro-Cuba-Sayco, S (2019) . Project-oriented learning for the achievement of educational outcomes . Volume 46, Pages 639-648

Kouzis-Loukas, D. (2016). Learning scrapy.

Packt Publishing Ltd. Levicoy, D. D., Obreque, A. S., Vásquez, C., y Salvatierra, M. O. (2017). Organización de las respuestas sobre tablas estadísticas por futuras maestras de educación infantil desde la taxonomía solo. Didasc@ lia: Didáctica y Educación , 8 (2), 193–212.

Liñán, L. C., y Pérez, Á. A. J. (2015). Educational data mining and learning analytics: differences, similarities, and time evolution. International Journal of Educational Technology in Higher Education, 12 (3), 98–112.

Myers, D., y McGuffee, J. W. (2015). Choosing scrapy. Journal of Computing Sciences in Colleges, 31 (1), 83-89. Ristoski, P., Paulheim, H.

Smedt, T. D., y Daelemans, W. (2012). Pattern for python. Journal of Machine Learning Research, 13 (Jun), 2063–2067.

Vargiu, E., y Urru, M. (2013). Exploiting web scraping in a collaborative filtering-based approach to web advertising. Artif. Intell. Research, 2 (1), 44–54.

Villalba, K., Cuba, S. C., Deco, C., Bender, C., y García-Peñalvo, F. J. (2017, Oct). A recommender system of open educational resources based on the purpose of learning. En 2017 twelfth latin american conference on learning technologies (laclo) (p. 1-4). doi: 10.1109/LACLO.2017.8120899

Wang, J., y Guo, Y. (2012). Scrapy-based crawling and user-behavior characteristics analysis on taobao. En 2012 international conference on cyber-enabled distributed computing and knowledge discovery (pp. 44–52).

Zhang, L., Towsey, M., Xie, J., Zhang, J., y Roe, P. (2016). Using multi-label classification for acoustic pattern detection and assisting bird species surveys. Applied Acoustics, 110, 91–98.

Villalba, K., Cristina, C., Bender, C., Castro, E. (2019). A Methodology to assign Educational Resources with Metadata based on the Purpose of Learning.

Villalba-Condori K. O. et al., "Learning Objects to Strengthen Learning. Experience in Regular Basic Education in Perú," 2018 XIII Latin American Conference on Learning Technologies (LACLO), São Paulo, Brazil, 2018, pp. 499-504. doi: 10.1109/LACLO.2018.00088

TUTORIALS

Web-based game development for beginners: A Hands-on Learning Experience

Ahmed Tlili[a], Ting-Wen Chang[b]
Smart Learning Institute of Beijing Normal University
[a]ahmed.tlili23@yahoo.com
[b]tingwenchang@bnu.edu.cn

Abstract: This tutorial aims to help beginner participants start developing their own web-based games using game engines. Particularly, this tutorial uses "Construct2" game engine to help participants develop a mini game from scratch. It then shows them how to export and deploy the files of the game (developed using Construct2) on an online server. This allows other users to access the game from their computers using their web browsers and play it. In this tutorial, the instructor will apply the hands-on learning strategy where he develops the game on his laptop with the help of a projector, so participants can see the programming process. The participants then start doing the programming as well on their computers. The instructor can also go between the participants when needed and help them in case there any bugs.

Planning, Designing and Orchestrating: Learner-Centric MOOcs using the LCM model

Veenita Shah[a1], Jayakrishnan M.[b2], Sridhar Iyer[a3], Sahana Murthy[a4]
[a]India Institute of Technology Bombay, India
[b]Indian Institute of Technology Madras, India
[1]veenita.shah@iitb.ac.in
[2]jkm@nptel.iitm.ac.in
[3]sri@iitb.ac.in
[4]sahanamurthy@iitb.ac.in

Abstract: As MOOCs are expanding in popularity and scope, problems such as lack of learner engagement and low participation in discussion forums have been reported. Challenges in MOOCs not only include large numbers of learners but great diversity in learners' background, ages, experiences, and motivation for participating. While issues such as certification, equitable access, and sustainability are being discussed, without advances in the pedagogical format, MOOCs may end up being an online version of a traditional lecture format. Instructors, especially those who are new to the online learning format need support in designing MOOCs to promote learner engagement, address learner diversity and cultivate peer learning. The Learner-centric MOOC (LCM) model guides instructors in maintaining a learner-centric pedagogical approach while planning, designing and orchestrating a MOOC. The model provides a set of guidelines, activity formats and actions that instructors can apply during various stages of the MOOC instructional design process. In this tutorial, we describe the structural and dynamic aspects of the LCM model, demonstrate the application of the model in various MOOCs and illustrate research results from MOOCs based on the LCM model. We will share activity constructors and templates that have been developed to scaffold instructors in applying the LCM model to design their MOOC.

Virtual World and Quests Creation on MEGA World (Multiplayer Educational Game for All)

Maiga Chang
Athabasca University, Canada
maiga.chang@gmail.com

Abstract: A multiplayer online role-play game (MORPG), called MEGA World (MEGA stood for Multiplayer Educational Game for Assessment in v1.0 back to 2010 and now stands for Multiplayer Educational Game for All), has been designed and developed since 2010. MEGA World is a web-based massively multiplayer educational game platform which supports any languages and is capable of access any existing external resources (e.g., multimedia, materials, online meetings, etc.)(Chang & Kinshuk, 2010[1]). Teachers can create their virtual worlds as well as create learning and assessment activities (i.e., quests in the game) of different learning subjects for students' for instances English, and Java Programming, Flash ActionScript, research methods (Kuo, Chang, Kinshuk, & Liu, 2010[2]; Li, Zou, Xie, Wang, & Chang, 2018[3]; Lu, Luo, Chang, Kuo, & Li, 2018[4]; Xu, Chang, Chen, Chen, & Kinshuk, 2016[5]). Students can learn specific knowledge and reach the learning goal by taking and solving those quests while playing.

The current version of MEGA World[6] (Multiplayer Educational Game for All) is v2.1 and supports eight quest types for teachers to create: greeting, item collection and delivery, sorting, treasure hunting and digging, calculation, fill-in-the-blank, short answer, and speaking-based conversation quest type (Chang, Chen, Wu, & Yu, 2019[7]). In this version of the game, students can have their own avatars and see others visually.

In this tutorial, we are going to show participants how to use MEGA World as well as teach participants how to create virtual worlds, NPCs, quests (individual quest and quest chain) and their quest items and rewards for their courses or learning topics.

From topic and research question to published manuscript: A 10-step process to writing a research article through the use of FOSS Tools and open access information

Trevor Watkins[a], Feng-Ru Sheu[b]
[a]George Mason University
[b]Kent State University
[a]twatkin8@gmu.edu
[b]fsheu@kent.edu

Abstract: Many academic libraries around the world has had to deal with budget cuts which limits and reduces access to resources that are behind a paywall. Resources such as research databases, journals, conference proceedings, proprietary software tools, etc. that students and faculty rely on for publishing manuscripts can be taken away as soon it is not fiscally viable to keep them. There is currently little to no Information literacy and research methodology scholarship that discusses the details of how to conduct research with an emphasis on the use of free and or open source tools with open access resources.

In this tutorial we take participants through a 10-step research process of moving from idea to published manuscript guided by the use of Free and Open Source (FOSS) tools beyond the research paywall. Participants will learn how to investigate and utilize open source and free software tools for brainstorming and ideating in a structured way (XMind mind mapping tool), reference management (Zotero), conducting literature reviews (InfoBoosters), academic writing (LaTeX), research management (OpenProject), and quantitative and qualitative data analysis (Julia programming language). Learning outcomes include establishing a working knowledge of the FOSS tools used in the tutorial, understanding and being able to locate the best research resources beyond the paywall (Open Access), and complete a manuscript within a 10-step process.

EARLY CAREER WORKSHOPS

An Investigation of the Impact of Gamification on Novice Programmers' Achievement and Learning Experience

Jenilyn AGAPITO

Ateneo Laboratory for the Learning Sciences, Ateneo de Manila University, Philippines
*jagapito@ateneo.edu

Abstract: Gamification is becoming a popular classroom intervention used in computer science instruction. It is used to encourage student behaviors to improve learning experience and achievement. However, existing studies have mostly implemented reward-based game elements which have resulted to contrasting behaviors among students. Meaningful gamification, the use of game design elements to encourage users build internal motivation is contended to be a more effective approach. The work presented in this paper explored how the use of a tool founded on meaningful gamification affect the achievement and learning experience of novice programmers. It also studied how different user types, as characterized by the Gamification User Types Hexad, vary in their response to different game design elements.

Keywords: gamification, meaningful gamification, novice programmers, CS1

1. Introduction

Games are used as models for engaging learners (Kapp, 2012). Gamification is the use of game design elements in non-game contexts (Deterding et al., 2011). However, implementations usually adopt reward-based gamification which is effective in contexts that call for short-term behavior change (Nicholson, 2015). Nicholson defines *Meaningful Gamification* as the use of game elements in non-game contexts to help a user build intrinsic motivation (Nicholson, 2015). This is built on the Self-Determination Theory (SDT) (Deci and Ryan, 2002) which states that intrinsic motivation has 3 components: 1) mastery – learning for competence; 2) autonomy – having control of paths; and 3) relatedness – refers to one's social engagement. Educators can capitalize on this in creating gamified environments that could develop students' intrinsic motivation. Also, people can exhibit varying behaviors once subjected to the same situation due to personality differences (Paunonen and Ashton, 2001). This is something to note when designing interventions aimed at reaching a wider range of users.

2. Research Objective

The work presented here investigated how a tool founded on meaningful gamification affects the achievement and learning experience of novice programmers. Moreover, the research meant to explore how different user types, as determined by the Gamification User Types Hexad Scale (Marczewski, 2015), vary in their response to various game design elements.

3. Methodology

The main objective of the study was to experiment on the use of gamification in an introduction to programming (CS1) class. To realize this, a gamified programming-based activity management system specifically designed for CS1 classes was developed. The system was designed with game design elements selected by purposely mapping them to the components of the SDT. The elements are feedback cycles, freedom to fail, and progress to support mastery; control to enable autonomy; and

collaboration for relatedness. These were implemented as system features and user interactions with them were logged. An expert evaluation was conducted to draw feedback from CS1 instructors with regards the implementation of the different game design elements. Two iterations of testing were conducted on different sets of students. Data on the students' interactions with the different game design elements were analyzed to come up with characterizations of their use of the system.

4. Findings

The primary motivation of the research is to contribute quantitative accounts of how meaningful gamification impacts novice programmers' achievement and learning experience. Results show positive effects on achievement of both strong and weak students. Control, feedback, and freedom to fail helped strong students get even better scores. They were much useful to the weaker students who most need the opportunity to improve. The effect on learning experience was favorable. The score was found to be a useful form of feedback despite user types. Freedom to fail through re-attempts was used by everyone. Additionally, varying user types take control of which items they answer in the activities.

5. Future Plans

Moving forward, the intention is to explore further how gamification or game-based learning environments could be better leveraged in education to support and enhance the learning experiences of learners. Identifying particular game elements that positively impact learning environments and achievement in specific contexts is something of interest.

6. Challenges and Questions

Some questions of interest are: (1) What particular game elements positively impact the learning experience and achievement of learners? and (2) How can a gamified or game-based learning system be designed to sustain learner engagement even beyond the novelty of their first interaction with it?

Acknowledgements

References

Deci, E. L., & Ryan, R. M. (2002). Handbook of self-determination research. University Rochester Press.

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011, September). From game design elements to gamefulness: defining gamification. In Proceedings of the 15th international academic MindTrek conference: Envisioning future media environments (pp. 9-15). ACM.

Kapp, K. M. (2012). Games, gamification, and the quest for learner engagement. T+ D, 66(6), 64-68.

Marczewski, A. (2015). Gamification Mechanics and Elements. In Even Ninja Monkeys Like to Play: Gamification, Game Thinking & Motivational Design. CreateSpace Independent Publishing Platform, 165–177.

Nicholson, S. (2015). A recipe for meaningful gamification. In Gamification in education and business (pp. 1-20). Springer International Publishing.

Paunonen, S. V., & Ashton, M. C. (2001). Big five factors and facets and the prediction of behavior. Journal of personality and social psychology, 81(3), 524.

University teachers designing for active learning

Kashmira DAVE
Charles Darwin University, Australia
kashmira.dave@cdu.edu.au

Abstract: Presented is a concept that forms the basis of a larger research project which aims to understand the university lecturers design practices to foster creativity. The research findings of author's PhD dissertation show that the university teachers' design practice can be improved by paying more careful attention to explanation of the rationale for each designed task. When the communicative function of a task design is given proper emphasis – acknowledging the need for students to make designed tasks meaningful – then better outcomes become more likely.

Key words: Educational design, university teaching and learning, creativity, how students learn

1. Introduction

Over recent decades, there has been a perceptible shift of emphasis in higher education from teaching by telling to learning by doing. This increases the importance of well-designed *tasks*, particularly in digital environments. Teachers design tasks for students, as a way of structuring and scaffolding their learning activities (Prosser & Trigwell, 1999). Task specifications rarely determine what students then do (Dave, 2017). Rather, task specifications can be understood as resources on which students draw in the process of shaping their own learning activities. How students make sense of the tasks they are set also becomes an important influence of what and how they learn.

Educational design is a hybrid practice. For some people, it is a professional practice with roots in systematic approaches to instructional design (Gagné, 1974). For others, it is just a part of what they do as lecturers – often 'taken for granted' and not seen as needing special skills, concepts, methods or training (Bennett, Agostinho, & Lockyer, 2016; Goodyear, 2015). A key concern of professional educational designers is to ensure rigor through the use of structured methods and appropriate learning theory in designing and/or selecting learning materials that align with learning outcomes . In contrast, few higher education lecturers have specific training in design methods or learning theory and little experience in using explicit methods and theory to guide the 'designerly' aspects of their work. How then do university lecturers design learning tasks for their students? Despite the practical importance of good task design for effective learning outcomes, there is little research on how university lecturers engage in task design.

2. Research Aims & Methodology

This study set out to improve our understanding of how university teachers design tasks and how students then interpret the tasks set for them. The research focused on three main objectives – to provide a better, empirically informed, understanding of: (1) university teachers' design decisions - with particular attention to their design rationales (2) students' interpretations of their teachers' design intentions, and (3) teachers' reflections on their students' interpretations of the designed tasks, with particular attention to potential areas of match and mismatch between intentions and interpretations.

A case study methodology was employed, involving close examination of nine individual cases – each being a course taught by a university teacher. Data were collected in three phases from teachers and students using semi-structured interviews with teachers, written responses from individual students and student focus groups. The three phases of data collection addressed each of the three research objectives in turn. Analysis was conducted using verbal data and thematic analysis techniques.

3. Results

Results show that when teachers explain how they designed tasks they draw upon a range of beliefs about what constitutes good teaching and learning, on contextual factors, and on particular needs and characteristics of the student cohort. Results also show that students interpret teachers' design intentions less accurately when

(a) the intended learning outcomes are complex and/or

(b) when the teacher is not explicit about the intended learning outcomes or the rationale for the task.

In this admittedly small sample, teachers' designs including explanations of the *how* of a task, rather than the *why*. Students expressed a need to get an explanation of this missing or implicit task rationale, so that they could better understand the task from a whole of course perspective. This study has practical implications for helping university teachers improve how they design tasks for students, particularly by paying more careful attention to explanation of the rationale for each designed task. When the communicative function of a task design is given proper emphasis – acknowledging the need for students to make designed tasks meaningful – then better outcomes become more likely.

4. Challenges & Questions

As the technology is invariable part of education now, it pauses new challenges for teachers simplify the intended outcomes. When technology is used to achieve learning outcomes, one more layer of complexity is added to the task. Thus, teachers may have to consider:

- Could the outcome be achieved without using technology?
- Why using that particular technology would be the best choice to achieve the outcome?
- Which technology is suitable for the particular task?
- Does use of the particular technology present any learning challenge for students? If students are expected to learn the new technology/part of technology, is it forming the part of assessment?
- Did the lecturer explored the affordances of the particular technology that he/she is trying to use?

In this research project, all the task used some form of technology and that paused some additional challenges for the teachers while designing the task and for students while doing the tasks.

The broader research project would involve the creation of structured guidance for the university teachers to help with their design in form of patterns (Goodyear & Yang, 2008). The work could expand to more practical work result into a repository of a well-designed tasks that the teachers could readily use in conjunction with the patterns.

The project could have the dimension of professional development for the teachers to understand what design is in their context and apply their customised notion of design to their own disciplines. Existing design support tools may be explored in context during this exercise (Laurillard, Kennedy, Charlton, Wild, & Dimakopoulos, 2018).

References

Bennett, S., Agostinho, S., & Lockyer, L. (2016). The process of designing for learning: understanding university teachers' design work. *Educational Technology Research and Development*, 1-21. doi:10.1007/s11423-016-9469-y

Dave, K. (2017). *University teachers designing for active learning: intentions, interpretations and the semantic turn in design.* (PhD). The University of Sydney, Sydney. (http://hdl.handle.net/2123/16846)

Gagné, R. M. (1974). *Principles of instructional design*. New York: Holt, Rinehart and Winston.

Goodyear, P. (2015). Teaching as design. *HERDSA Review of Higher Education, 2*, 27-50. Retrieved from http://www.herdsa.org.au/?page_id=3745

Goodyear, P., & Yang, D. F. (2008). Patterns and Pattern Languages in Educational Design. In L. Lockyer, S. Bennett, S. Agostinho, & B. harper (Eds.), *Handbook of Research on Learning Design and Learning Objects: Issues, Applications, and Technologies*
(Vol. 1, pp. 167-187)). Hershey, PA: Information Science Reference

Laurillard, D., Kennedy, E., Charlton, P., Wild, J., & Dimakopoulos, D. (2018). Using technology to develop teachers as designers of TEL: Evaluating the learning designer. *British Journal of Educational Technology, 49*(6), 1044-1058. doi:10.1111/bjet.12697

Prosser, M., & Trigwell, K. (1999). *Understanding learning and teaching : the experience in higher education*. Buckingham, England: Open University Press.

An Interactive Canvas of the Ideation Process in STEM Education

Biyun HUANG[*]

Centre for Learning Sciences and Technologies, The Chinese University of Hong Kong, China
*lucyhuang99@gmail.com

Abstract: The ideation process is essential for fostering high-quality STEM education outcomes. Although the use of technological tools in STEM education may improve students' learning efficiency and promote students' learning engagement, few studies were devoted to scaffolding the thinking of students in this area. This study proposes to develop an interactive canvas to facilitate the ideation process based on the characteristics and needs of secondary students. In the development of the interactive canvas, we referenced the EDIPT model and other theories to support our design. The design will be tested in middle schools in Hong Kong and will be further improved after the trial.

Keywords: STEM, interactive canvas, ideation process, EDIPT

1. Introduction

Currently, both policy makers and educators are paying increasingly more attention to STEM education (Skinner, Saxton, Currie, & Shusterman, 2017). In contrast to the traditional lecturing approach, STEM education emphasizes the integration of learning with real-world tasks so as to develop students' problem-solving capabilities and twenty-first-century skills (e.g., creativity) (Lee, Chai, Hong, 2019). Empirical research on STEM education shows that idea-centered knowledge building is effective in promoting collaboration and high-level thinking as well as high-quality STEM products (e.g., Hong, Lin, Chen, and Chen, 2018). Student ideation is one of the key elements in ensuring successful STEM outcomes. However, there is a lack of technological tools supporting ideation processes targeting middle school students.

2. Research Goals

This study aims to develop an interactive canvas that facilitates students' ideation and collaboration in STEM courses, which matches the characteristics and needs of middle school students. The interactive canvas will be used and tested in actual STEM courses in Hong Kong using quasi-experiments. The research question is, to what extent does the interactive canvas influence students' 1) participation, 2) STEM product, and 3) motivation?

3. The Design of Interactive Canvas

One of the theoretical foundations of the interactive canvas is the five stage empathize-define-ideate-prototype-test (EDIPT) model (d.School, 2010). In the empathize stage, learners need to make efforts to understand the physical and emotional needs of a targeted group. In the define stage, learners need to delineate the challenges to be undertaken by considering the needs of the users and the context. In the ideate stage, learners need to generate a range of ideas for possible solutions. In the prototype stage, learners select the potential solutions and start building prototypes. In the test stage, learners use the prototypes, solicit feedback, and refine the solutions. See Figure 1.
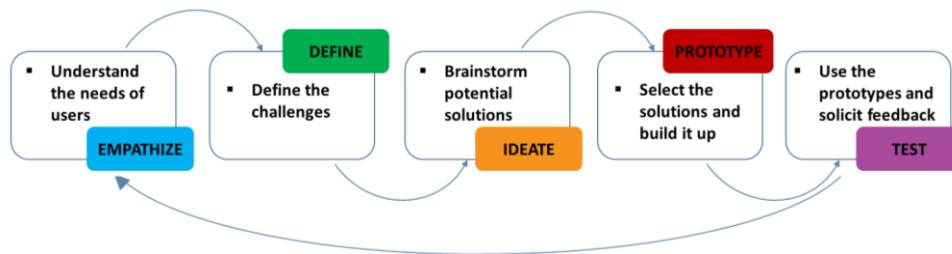
Figure 1. EDIPT Model and key procedures adapted from d.School (2010)

Conventionally, teachers followed the EDIPT model to guide the exploration process of students by using sticky notes, tape, and other non-technology based tools. While these items were widely available, their use was problematic for the following reasons: inconvenient storage and organization of notes; not facilitating the in-depth construction of knowledge (Chalmers, Carter, Cooper, & Nason, 2017); no interactive reminders; no provision of instant feedback, contextualized databases or multimedia notes; and no promotion of community building. Hong et al. (2018) established an online knowledge-building environment, which supported the functions of note-taking, searching, and community building, for university students, and found the environment promoted collaboration and inquiries. Nevertheless, the issue has not been fully addressed in middle schools' contexts as of yet. Achilleos et al. (2017) conducted a survey study to understand the impact of social media and competition on students' STEM learning experience, but they did not assess other technology-supported functions, such as interactive reminders and instant feedback. To bridge this gap, the study proposes the development of an interactive canvas that features: a convenient way of keeping and tracking the notes of each curriculum unit; facilitation of the in-depth construction of knowledge; interactive reminders or notes; instant feedback with gamification; a contextualized database; multimedia notes; and community building.

4. Discussion and Future Plans

An interactive canvas has the potential to engage learners in the STEM learning process as a community and stimulate in-depth inquiry. It is worthwhile to investigate the efforts to develop an interactive canvas that meets the needs and matches the characteristics of middle school students. The researchers may encounter the following problems when building it, such as understanding the needs of secondary level STEM educators and students, setting up a relevant and supportive interdisciplinary resource bank, and breaking through technical bottlenecks. In response to the challenges, the researchers plan to work closely with educators, professional system developers, and interdisciplinary experts to explore solutions, run trials and test the system in iterative cycles.

References

Achilleos, A. P., Mettouris, C., Yeratziotis, A., Papadopoulos, G. A., Pllana, S., Huber, F., & Dinnyes, A. (2018). SciChallenge: a social media aware platform for contest-based STEM education and motivation of young students. *IEEE Transactions on Learning Technologies, 12*(1), 98-111.

Chalmers, C., Carter, M. L., Cooper, T., & Nason, R. (2017). Implementing ''big ideas'' to advance the teaching and learning of science, technology, engineering, and mathematics (STEM). *International Journal of Science and Mathematics Education*, *15*(1), 25–43.

d. school (2010). Retrieved from https://dschool-old.stanford.edusandbox/groups/designresources/wiki/36873/attachments/74b3d/ModeGuideBOOTCAMP2010L.pdf

Hong, H. Y., Lin, P. Y., Chen, B., & Chen, N. (2019). Integrated STEM learning in an idea-centered knowledge-building environment. *The Asia-Pacific Education Researcher*, *28*(1), 63-76.

Lee, MH., Chai, C.S. & Hong, HY. (2019) STEM education in Asia pacific: Challenges and development. *The Asia-Pacific Education Researcher*, 28(1). https://doi.org/10.1007/s40299-018-0424-z

Skinner, E., Saxton, E., Currie, C., & Shusterman, G. (2017). A motivational account of the undergraduate experience in science: Brief measures of students' self-system appraisals, engagement in coursework, and identity as a scientist. *International Journal of Science Education, 39*(17), 2433–2459.

Exploring Common Code Reading Strategies in Debugging

Christine Lourrine TABLATIN[a,b*]
[a]*Ateneo de Manila University, Philippines*
[b]*Pangasinan State University, Urdaneta City, Philippines*
*tablatinchristine@gmail.com

Abstract: Code reading is a prerequisite of program comprehension which is a fundamental task in software development. Strategies employed on code reading affect the programmer's success rate of understanding tasks such as debugging. However, there is still limited knowledge about the code reading strategies used by students while performing bug finding task. In this paper, the author describes a summary of her research on novice programmer debugging skills using eye tracking data as a methodology. Eye tracking data were extracted and analyzed using visual effort metrics and sequential analysis of scanpaths using a clustering algorithm to determine common code reading patterns. The author's research findings revealed differences on the code reading patterns and code reading strategies of high and low performing students. Empirical evaluation on the effectiveness of the strategies used by high performing students was also conducted which suggests that by teaching these strategies to students, improved debugging performance can be observed.

Keywords: Eye tracking, debugging code reading patterns, sequential analysis, code reading strategies.

1. Introduction

Debugging is a necessary skill for students learning programming but can be a major stumbling block, particularly for novices. Hence, it is imperative that research be conducted to discover new methods or strategies which could help students improve their debugging and code comprehension skills. One of the interesting approaches to study how programmers read code, is the use of eye tracking data. Eye tracking is a technique that provides a direct measure of the visual attention of a programmer, which is far less intrusive compared to the more established think-aloud protocol. Recent studies have used eye tracking to uncover programmer's cognitive processes while performing tasks such as program comprehension (Chandrika and Amudha, 2017, Jbara and Feitelson, 2016, Lin, et al., 2016). While efforts have been made to understand how programmers read code, we still have limited knowledge on code reading patterns. Further studies are needed to come up with general code reading patterns and visual strategies of different comprehension tasks. This study aimed to analyze and interpret the code reading patterns and infer strategies of students while performing code comprehension to detect bugs.

2. Theoretical Framework

Eye tracker is used to capture visual attention by collecting eye-movement data of a participant while performing a task and have recently become a common tool used to perform empirical studies in programming (Sharafi, et al., 2015). Increased use of eye tracking data is based on the assumptions relating to eye-movements and comprehension. Eye movements are closely linked to the allocation of attention and the frequency of fixation provides information on the importance of the element in the visual stimulus. Duration of fixation on the other hand, provides information on the complexity of the visual stimulus (Nivala, et al., 2016). Using these visual effort metrics, we can identify the visual attention pattern of a subject while performing comprehension task. Further, analyzing scanpath as a whole entity could draw explicit conclusions on the nature and interpretation of the cognitive processes which can be used to infer code reading strategies.

3. Methods

Eye tracking data of students performing bug finding task from four universities in the Philippines were recorded and stored in a CSV file format. The data were then segmented to extract the timestamp, fixation location and fixation duration of the eye gazes which were used for the analysis. The OGAMA (Open Gaze and Mouse Analyzer) software was used to get the coordinates of the Areas of Interest (AOIs) of the stimulus. The fixation points were then mapped to these AOIs to construct the individual scanpaths. To determine the visual attention patterns, fixation counts and fixation durations were calculated for each AOIs. Sequential analysis of the generated scanpath was performed using Scanpath Trend Analysis with a tolerance to reveal common code reading patterns and code reading strategies.

4. Major Findings and Achievements, to date:

Initial work on code reading patterns using Scanpath Trend Analysis (Tablatin and Rodrigo, 2018) revealed that high performing students use varied code reading patterns while low performing students follow similar patterns. Further, STA has weak performance in generating the common scanpath of high performing students. This may be due to the fact that high performing students used varied code reading patterns. To account for the individual differences in code reading exhibited by high performing students, STA with a tolerance was used (Tablatin and Rodrigo, 2018). This algorithm generated common scanpaths that are more similar to the individual scanpaths which means it performs better than the STA without a tolerance. STA with tolerance was used in the analysis of the dataset of my dissertation to identify the common code reading strategies employed by the students.

5. Challenges and Questions

One of the challenges of conducting this study was making inferences on the cognitive processes of the group of students based on their code reading patterns. Further, the type of injected errors and the complexity of programs are different from each stimulus, which made it difficult to identify code reading strategies specific to the type of programs. The errors and the complexity of programs may have an effect on the code reading patterns. Thus, more eye tracking experiments using programs of the same type of errors and code complexity may be conducted to validate the results of this study.

References

Chandrika. K. R., and Amudha, J. (2017). An Eye Tracking Study to Understand the Visual Perception Behavior while Source Code Comprehension. International Journal of Control Theory and Applications. International Science Press vol. 10(19)

Jbara, A., and Feitelson, D. G. (2016). "How Programmers Read Regular Code: A Controlled Experiment Using Eye Tracking," 2015 *IEEE 23rd International Conference on Program Comprehension*, Florence, pp. 244-254. doi: 10.1109/ICPC.2015.35

Lin, Y. T., Wu, C. C., Hou, T. Y., Lin, Y. C., Yang, F. Y.,& Chang, C. H. (2016). Tracking students' cognitive processes during program debugging—An eye-movement approach. *IEEE transactions on education, 59(3)*, 175-186. Retrieved from https://ieeexplore.ieee.org/document/7312518/

Nivala, M., Hauser, F., Mottok, J., and Gruber, H. (2016). Developing visual expertise in software engineering: An eye tracking study. 2016 IEEE Global Engineering Education Conference (EDUCON), Abu Dhabi, 2016, pp. 613-620. doi: 10.1109/EDUCON.2016.7474614

Sharafi, Z, Soh, Z., and Guéhéneuc, Y-G. (2015). A systematic literature review on the usage of eye- tracking in software engineering. Information and Software Technology 67 (2015), 79–107.

Tablatin, C. L. S. (2018). Analysis of Static Code Reading Patterns. In *Proceedings of the 18th Philippine Computing Science Congress*. (pp. 32-43). Retrieved from https://drive.google.com/file/d/1PGrCmNIv4_mEot5SnBEhCngsHGUMQrkl/view

Tablatin, C. L. S. (2018). Identifying Common Code Reading Patterns using Scanpath Trend Analysis with a Tolerance. In *Proceedings of the 26th International Conference on Computers in Education*. Retrieved from http://icce2018.ateneo.edu/wp-content/uploads/2018/12/C3-08.pdf

Studying Computational Thinking through Collaborative Design Activities

Joey HUANG

Doctoral Candidate, Indiana University Bloomington, USA
huang220@iu.edu

Abstract: Previous studies have focused on examining individuals' computational thinking (CT) practices in varied learning contexts. This study aims to expand the current framework of CT by investigating how CT is practiced through collaborative design activities with Scratch. Using a mixed methods design, including video-recorded class observations, artificat analysis, this microethnographic study proposes collaborative CT by examining students' interactions and learning processes in a middle school classroom. By identifying the patterns of CT practices which emerged through collaborative design activities, this study informs how CT is socially practiced in small groups.

Keywords: Computational thinking, collaboration, collaborative design, computer science education

1. Introduction

Computational thinking (CT) will be a fundamental skill by the middle of the 21st century, just like reading, writing, and arithmetic (Wing, 2006). CT entails a series of problem-solving processes, such as recognizing patterns, and systematically breaking down a problem, and then composing an algorithmic solution. Collaborative design activities are defined to be a knowledge creation process which involves students actively communicating and working together to create a shared view of joint design ideas and decisions. Learning through collaborative design activities has been proven to deepen students' content knowledge through practices and advance their problem-solving skills to solve complex and multifaceted problems (Hakkarainen et al., 2013). Studies have shown that collaborative learning is beneficial for middle schoolers learning CT and programming knowledge, and these experiences relate to positive attitudes and confidence in learning computer science (Werner et al., 2012). Prior studies have focused on *individuals*' CT learning and developing in varied learning contexts besides computer science (CS). However, little attention has been paid to learning of CT through collaborative design activities, focusing on how CT is socially situated and practiced through collaboration (e.g., Chowdhury et al., 2018). To fill this gap in the prior research, the author worked alongside middle school teachers to investigate how students in middle school classrooms learn CT collaboratively to better understand the development of CT.

2. Research Goals

The aim of the study is to investigate how students learn CT through collaborative design activities in a middle school classroom and how these activities can be designed to facilitate CT learning. In this study I ask: 1) How do students learn CT through collaborative design activities? 2) What are the contextual factors (i.e., design activities, project type) that support CT over time? 3) How do students interact during collaborative design activities? To what extent do the interactions influence their CT practices? This study was a part of a dissertation research aimed to extend the current CT framework from individual to collaborative dimension in learning of CT.

3. Theoretical Framework

This study is grounded constructionist perspectives on learning (Papert, 1991), which illuminate the impact of learning by creating, iterating, and interacting to investigate students' CT learning through

collaborative design activities. In this study, I applied Brennan and Resnick's CT framework, particularly focusing on CT concepts (e.g., loops, conditionals) and CT practices (e.g., testing and debugging), to examine students' CT practices through collaborative design activities with Scratch (https://scratch.mit.edu/), which users can create their own interactive stories, games, and animations via block-based programming.

4. Methodology

The study was conducted in an urban public middle school in a midwestern U.S. state. Participants included 12 students in four focus groups in an elective programming course for 8th graders. The author worked closely with the teacher to create collaborative design activities for a five-week curriculum, which was adapted from *Creative Computing* (Brennan et al., 2014). The methodological approaches included video and artifact analyses to examine students' learning processes.

5. Preliminary Results

Preliminary coding results showed that patterns of CT practices emerged through collaborative design processes. All four groups showed a greater number of experimenting and iterating practices during the planning stage. Additionally, all of the groups demonstrated experimenting and iterating in both the planning and coding stages; however, these practices were more pronounced in the latter stage. In the planning stage, students identified a concept for their project and developed a script to implement the design. In the coding stage, they were able to experiment and iterate their design by identifying the variables of the script and developing a plan to modify the variables.

6. Significance of the Study

This work contributes to the growing body of research on K-12 CS education. I hope to extend the current scope of CT by providing an in-depth exploration of learning and collaboration for younger students. By bridging the framework of CT with collaborative design activities, these findings enhance the understanding of CT in learning, collaborating, creating computing design projects.

For a broader impact, the study provides a provocative way to investigate CT and consider it as collaborative practice not for how we should manage or necessarily accommodate them within existing educational structures, but for what these implementation differences tell us about the forms of learning and literacy that are already instantiated within instruction aimed at fostering learning in CS education.

References

Brennan, K., & Resnick, M. (2012, April). New frameworks for studying and assessing the development of computational thinking. In *Proceedings of the 2012 annual meeting of the American Educational Research Association, Vancouver, Canada* (Vol. 1, p. 25).

Brennan, K., Balch, C., Chung, M. (2014). Creative Computing. Developed by the ScratchEd team at the Harvard Graduate School of Education and released under a Creative Commons license, CC BY-SA 4.0..

Chowdhury, B., Bart, A. C., & Kafura, D. (2018). Analysis of collaborative learning in a computational thinking class. In *Proceedings of the 49th ACM Technical Symposium on Computer Science Education* (pp. 143-148). ACM.

Hakkarainen, K., Paavola, S., Kangas, K., Seitamaa-Hakkarainen, P. (2013). Sociocultural perspectives on collaborative learning: Toward collaborative knowledge creation. In C. E. Hmelo-Silver, C. A. Chinn, C. Chan, & A. M. O'Donnell (Eds.), *The international handbook of collaborative learning* (pp. 57-73). New York: Routledge.

National Research Council. (2010). *Report of a workshop on the scope and nature of computational thinking*. National Academies Press.

Papert, S. (1991). Situating constructionism. In I. Harel & S. Papert (Eds.), *Constructionism* (pp. 1-14). Hillsdale, NJ: Lawrence Erlbaum Associates.

Werner, L., Denner, J., Campe, S., & Kawamoto, D. C. (2012). The Fairy Performance Assessment: Measuring Computational Thinking in Middle School. In *Proceedings of the 43rd ACM Technical Symposium on Computer Science Education* (pp. 215–220). New York, NY, USA: ACM.

Wing, J. M. (2006). Computational thinking. *Communications of the ACM*, *49*(3), 33-35.

DOCTORAL STUDENT CONSORTIUMS

Analysis of "Evaluation Behavior" Using Students' Peer Assessment Process Data

Izumi HORIKOSHI [a*] & Yasuhisa TAMURA [b]
[a] *Graduate School of Science and Technology, Sophia University, Japan*
[b] *Dept. Information and Communication Sciences, Sophia University, Japan*
*izumihorikoshi@eagle.sophia.ac.jp

Abstract: In this study, we have focused on students' peer assessment and analyzed evaluation behavior using data from the evaluation process. Peer assessments by students are problematic in terms of reliability and validity. Many previous studies have discussed the reliability or validity of peer assessment, based on the evaluation scores of the peer assessment. However, the "Evaluation Process", that is, who, when, and which items were evaluated in what order, has not been studied. For this issue, in this research, we have proposed to acquire the "Evaluation Process" data in peer assessment and to analyze and visualize the students' "Evaluation Behavior". As a preliminary result, this study identified a range of characteristic evaluation behaviors, indicating the possibility that each student might have a unique style of evaluation and that there are students who do not take evaluation seriously. We expect that we will be able to estimate the students' motivation on the peer assessment or evaluation ability, and also to improve the design of the peer assessment form or the conditions of the peer assessment based on the "Evaluation Behavior".

Keywords: Peer assessment, Evaluation behavior, Learning analytics

1. Introduction

With the growing popularity of active learning in recent years, the practice of making presentations in class and evaluating these through peer assessment has increased. Peer assessment is defined as "an arrangement in which individuals consider the amount, level, value, worth, quality, or success of the products or outcomes of learning of peers of similar status" (Topping 1998, p. 250). According to Fukazawa (2010), the general benefits of peer assessment in learning situations are enhancing learner motivation (Orsmond, Merry & Reiling, 1996) and also reducing the teachers' burden (Brown 1998).

Although peer assessments are useful, these can also be seriously flawed in terms of reliability and validity when conducted by students. Several studies have been conducted in order to address these concerns. Previous studies have mostly discussed the reliability and validity of evaluation scores in peer assessments. In other words, the "Evaluation Process," that is, who, when, and which items were evaluated and in what order, has not been studied in terms of technology and significance.

In order to address this gap in research, in this study, we propose to acquire the "Evaluation Process" data in peer assessment and to analyze and visualize the students' "Evaluation Behavior".

2. Related Work and Our Study

2.1 Conventional Studies Discussing Quality of Peer Assessment

As mentioned in Chapter 1, peer assessments made by students are weak in terms of reliability and validity, and this issue has been studied extensively (Fujihara, Ohnishi & Kato, 2007). According to Fukazawa (2010), several studies have discussed reliability and validity using the correlation coefficient between scores given in evaluations by teachers and in peer assessments made by students. These studies can be placed into two categories: those that conclude that peer assessments made by students are as reliable as teacher assessments and those that question the reliability and validity of peer assessments made by students. Fukazawa cites three studies as examples of the former (Miller & Ng,

1996; Hughes & Large, 1993; Stefani, 1994) and also cites two studies as examples of the latter (Stefani, 1994 and Freeman, 1995).

We focused on the fact that any related research has discussed reliability and validity based on the score of peer assessments. However, we are considering it is difficult to conclude that the evaluations are "similar" just because the evaluation scores are similar. This is because there might be cases where the scores given by students are similar but their behaviors during the process of evaluation are different.

2.2 Paradata" Studies in Web Surveys

On the other hand, we found many previous studies focusing on behavior during the answering process in Web Survey research field. In the disciplines of social science and statistics, the number of computer-assisted interviews and Web surveys have increased. Computer-assisted interviews or Web surveys have advantages that traditional surveys do not have. For example, data related to the process of responding to the surveys are automatically generated. These log data related to response behavior, such as response time or interruption during answering the questionnaire, which is also called "paradata" (Couper, 1998), and these have been used to verify the quality of survey responses. No single formal definition exists for paradata. However, according to Olson and Parkhurst (2013), "examples of paradata collected automatically by many computerized survey software systems include timing data, keystroke data, mouse click data... (p.43)" and so on.

In studies on paradata, "response time" has frequently been the main focus. According to Couper and Kreuter (2013), response time is readily available in most computer-assisted interviewing systems. Based on the literature, "shorter response times" are associated with a "lack of motivation to answer accurately, caused by continuous survey (Yan & Tourangeau, 2008)" and "longer response times" are associated with "lower scores on knowledge items (Heerwegh, 2003)."

3. Expected Contribution of this Research

As described above, many previous studies on peer assessment have discussed the reliability and validity based on the score of peer assessments. On the other hand, we found many previous studies focusing on behavior during the answering process in Web Survey research field. Although the research fields are different, the analysis of "Evaluation Behavior" in peer assessment, which is the focus of this study, and that of "Response Behavior" or answering behavior in the field of social research are quite similar in terms of data and behavior. For this reason, we expect that there is a great possibility in visualizing and analyzing evaluation behavior to obtain valuable findings in peer assessment.

When this study is completed, it will be possible to understand in more detail the situation of the students during peer assessment. We believe that leads to visualizing issues that could not be seen with the conventional method based only on the scores. Furthermore, we expect that we will be able to estimate the students' motivation on the peer assessment or evaluation ability and also to improve the design of the peer assessment form or the conditions of the peer assessment based on the "Evaluation Behavior."

4. Preliminary studies and Results

We have already started preliminary studies and have reported some of the results in oral presentations [Horikoshi & Tamura, 2017a; 2017b; 2018a; 2018b; 2018c and 2018d]. In the preliminary studies, we aimed to achieve the following three objectives: (1) to investigate research on the evaluation process and behaviors, organize these, and compare these with our research, (2) to establish a method of acquiring the evaluation process data and visualize evaluation behavior, and (3) to extract characteristic evaluation behaviors.

First, we investigated similar studies and considered the relationship with our proposal. As a result, it became clear that there have been a lot of studies in social science, which acquire answering process data of surveys and questionnaires. We have already addressed this result in detail in Chapter 2.

Second, we developed a Web-based form as the peer assessment tool to detect students' evaluation process data using HTML, JavaScript, and PHP. Using this form, we conducted experiments to acquire "Evaluation Process" data of actual classes in which assessments were made and visualized the "Evaluation Behavior."

Finally, we extracted and discussed characteristic evaluation behaviors. As a result, this study identified a range of characteristic evaluation behaviors, indicating the possibility that each student might have a unique style of evaluation and that there are students who do not take evaluation seriously. For example, we found the following characteristic evaluation behaviors: "did not evaluate sequentially" or "evaluated in a short time". Furthermore, it was also suggested that each student showed similar evaluation behavior in every evaluation of all the presentations in the class. On the other hand, there are students who "complete evaluation before the start of presentation" or "incorrectly evaluate to a group not giving a presentation". Therefore, we need to be aware of the possibility that each student might have a unique style of evaluation behavior. However, at the same time, we also need to be aware that there are students who are not working seriously on evaluation, not on the learner's evaluation style, and that those students often make evaluations in a short time.

5. Future Research

The preliminary studies revealed the significance of conducting research on the evaluation process and evaluation behavior in peer assessment. As the next step, we will work on the following tasks:

First task: to compare the "Evaluation behavior" by our proposed method analyzed this time with the "Score" that has been treated by the conventional method

> In the preliminary studies, it became clear that there are learners who spend a long time on evaluation and short learners. Therefore, for the next step, it is necessary to verify whether there is a difference in the degree of reliability and validity of the scores, depending upon the time taken for the evaluation or depending upon the evaluation behavior pattern (sequential or nonsequential).

Second task: to discuss evaluation behavior quantitatively

> In the preliminary studies, we visualized and discussed the evaluation behavior qualitatively using graphs. Qualitative methods are suitable for discussing the characteristics of each student. However, qualitative methods have limitations in understanding or discussing the characteristics of the entire class and also features from the qualitative analysis are not machine-readable. Therefore, as the next step, a method to discuss the characteristics of evaluation behavior quantitatively needs to be developed. To be specific, we are planning to propose feature variables to quantitatively express the characteristics of evaluation behavior, such as short evaluation time or tendency to choose high scores. The feature variables will include , for example, "Evaluation Time", "Click Count", "Mean of the score", "Standard deviation of the score", "Mean of the evaluation timestamp", or "Standard deviation of the evaluation timestamp".

Third task: the establishment of extraction and interpretation of characteristic evaluation behaviors

> It is necessary to construct an interpretation hypothesis for the characteristic evaluation behavior extracted in the preliminary studies and to verify whether our interpretation hypothesis is correct, using a questionnaire or an interview schedule. In addition, we expect that it would be effective to compare with the findings of the interpretation of the answering behavior of the paradata research mentioned earlier or to compare with the findings of the conventional method using the score.

Fourth task: to clarify the relationship between the above-mentioned characteristic evaluation behavior and "class design" or "evaluation form design".

> In the preliminary studies, we discussed only the nature and style of individual reviewer as the cause of characteristic evaluation behavior. However, we have hypothesized that "class design," such as "how many times the teacher makes the students evaluate in each class," "how many minutes the presentation length is," or "How many evaluation items the students evaluate during a presentation" can influence students' motivation or seriousness and this might lead to behavior. We also hypothesized that "evaluation form design" such as "whether the form is multiple choice type or rubric type," "the wording of criteria," or "whether the selector is pre-selected or not"

might influence students' behavior. These hypotheses were formed by us because we found similar hypotheses and findings in research on paradata (For instance, Masuda, Sakagami, and Kitaoka, 2017).

References

Brown, J. D. (1998). *New ways of classroom assessment. new ways in TESOL series II. innovative classroom techniques.* ERIC.

Couper, M. (1998). Measuring survey quality in a CASIC environment. *Proceedings of the Survey Research Methods Section of the ASA*, 41-49.

Couper, M. P., and Kreuter, F. (2013). Using paradata to explore item level response times in surveys. *Journal of the Royal Statistical Society: Series A (Statistics in Society)*, 176(1), 271-286.

Freeman, M. (1995). Peer assessment by groups of group work. *Assessment & Evaluation in Higher Education, 20(3), 289-300.*

Fujihara, Y., Ohnishi, H., Kato, H. (2007). Review of Research on Peer Evaluation. *Journal of Multimedia Aided Education Research*, 4(1), 77-85.

Fukazawa, M. (2010). Validity of Peer Assessment of Speech Performance. *Annual review of English language education in Japan*, 21, 181-190.

Heerwegh, D. (2003). Explaining response latencies and changing answers using client-side paradata from a web survey. *Social Science Computer Review,* 21(3), 360-373.

Horikoshi, I., and Tamura, Y. (2017a). Analysis of Students' Peer Assessment Processes. In Yang, J. C. et al. (Eds.), (2017). *Proceedings of the 25th International Conference on Computers in Education*, 25-30.

Horikoshi, I., and Tamura, Y. (2017b). Timing Acquisition of Students' Peer Assessment. *Japanese Society for Learning Analytics report*.

Horikoshi, I., and Tamura, Y. (2018a). Evaluation Behavior Analysis in Peer Assessment using Evaluation Process Data: Comparison with Response Behavior Analysis using Paradata in Web Survey. *Proceedings of the 46th Annual Meeting of the Behaviormetric Society*, 46, 196-199.

Horikoshi, I., and Tamura, Y. (2018b). Comparison of Evaluation Behavior between Learner and Teaching Assistant during Peer Assessment of Oral Presentation. *Research report of JSET Conferences*. 18(5), 37-44.

Horikoshi, I., and Tamura, Y. (2018c). Analysis of "Evaluation Time" in Peer Assessment based on Evaluation Log. *Proceedings of the Annual Conference of Japanese Society for Information and Systems in Education*, 43, 325-326.

Horikoshi, I., & Tamura, Y. (2018d) Feature Extraction of Learners' Motivation from Peer Assessment Process Logs. In Yang, J. C. et al. (Eds.) (2018). *Proceedings of the 26th International Conference on Computers in Education*, 352-354.

Hughes, I., & Large, B. (1993). Staff and peer-group assessment of oral communication skills. *Studies in Higher Education*, 18(3), 379-385.

Masuda, S., Sakagami, T., & Kitaoka, K. (2017). Responding to Many Items in a Questionnaire Increases Middle Category Response. The Japanese journal of behaviormetrics, 44(2), 117-128.

Miller, L., & NG, R. (1996). Autonomy in the classroom: Peer assessment. *Taking control: Autonomy in language learning*, 133-146.

Olson, K., and Parkhurst, B. (2013). Collecting Paradata for Measurement Error Evaluations. Kreuter (Eds.), *Improving Surveys with Paradata*, 43-72. F. Wiley.

Orsmond, P., Merry, S., & Reiling, K. (1996). The importance of marking criteria in the use of peer assessment. *Assessment & Evaluation in Higher Education*, 21(3), 239-250.

Stefani, L. A. (1994). Peer, self and tutor assessment: Relative reliabilities. Studies in Higher Education, 19(1), 69-75.

Topping, K. (1998). Peer assessment between students in colleges and universities. *Review of educational Research*, 68(3), 249-276.

Yan, T., and Tourangeau, R. (2008). Fast times and easy questions: the effects of age, experience and question complexity on web survey response times. *Applied Cognitive Psychology*, 22(1), 51-68.

Development of a computational thinking assessment tool for lower secondary students in Malaysia

Filzah Zahilah MOHAMED ZAKI*, Su Luan WONG, Mas Nida MD KHAMBARI & Nur Aira ABD RAHIM
Faculty of Educational Studies, University Putra Malaysia, Malaysia
*gs52106@student.upm.edu.my

Abstract: The rise of computational thinking (CT) inclusion in education systems across the world has prompted the needs to effectively measure the computational skills for various educational level, i.e. from early childhood, elementary, secondary (K-12 education) up to adult learners. In this paper, the essence of a research proposal is presented, which focuses on developing and designing an instrument suitable for Malaysian adolescent (i.e. secondary school level students) context. The paper aimed at outlining the research objectives, and limitations and the suggested research design. Delphi technique and interview will be deployed during the first phase of the study to obtain consensus from experts identified in the field, followed by the development of the instrument. Next, the instrument will be validated, and later tested with a group of students taking Basics of Computer Science subjects in schools. The research has implication for many stakeholders, mainly for educators involved in teaching the subject in school setting. The development of this instrument would benefit in assessing appropriate CT skills and practice, in the context of Malaysian education. Among the overarching contribution includes advocating CT as another critical 21st century skillset and enhancing individual competency in problem solving.

Keywords: computational thinking, assessment, Delphi technique, instrument validation.

1. Introduction

Research on computational thinking in education is becoming more substantial due to the awareness among policy makers of the high demand from current digital society, to equip students with 21st century learning skills and its overarching aim to produce digitally literate and competent citizens in the current 4th Industrial Revolution (4th IR) era. Across different countries, curriculum was revamped, and CT framework and its assessment has become one of the priorities in countries which has implemented CT in their educational curriculum. The emerging CT concepts must be added on the new set of competencies required by the new digital generations. All over the world, CT idea has challenged many education scenario in terms of the development of competency models, pre-service teacher education, and integration of CT into curriculum (Kafai, 2016). Many studies have provided evidence on the relevance of CT in both K-12 education and in higher education. Various research suggested the importance of CT to nurture interest and understanding in Science, Technology and Engineering (STEM) courses, for students at different education level. The National Research Council (2010) emphasized the significance of introducing CT to students as early as possible, and assisting them to understand the application of these essential skills. Countries such as England, Finland, South Korea, and Australia have made it compulsory for school children to learn computing or CT (Rich, Jones, Yoshikawa, & Perkins, 2017) .

In Malaysia, the former Prime Minister emphasised the need to integrate CT skills into selected subjects, starting from 2017 with Year 1 primary students (2017) until secondary schools. For secondary schools, the subject called 'Asas Sains Komputer' or basic computing is offered in selected schools for Form 1 to Form 3 students (age range between 13 to 15 years old) which includes the CT elements. In Malaysia, educators who teach the subject are given a short course on CT concept prior to teaching the subject.

The research aimed to contribute in the area of CT assessment, within the scope of lower secondary school level. Besides, it has potentials to facilitate teachers in their measurement of CT at secondary school settings. This effort also could promote better problem-solving ability and innovation amongst lower secondary school students by using computational thinking.

2. Research objectives

The process of developing the right measurement tool for CT skills requires examining and considering existing alternatives and evaluating their effectiveness. The aim requires exploring CT elements or key constructs which is suitable for depiction of problem-solving ability, whilst building a valid and reliable instrument. Hence, the main purpose of the study is to develop an instrument to measure CT skills amongst lower secondary school students in the Malaysian context, besides examining current practices and investigating common issues in assessing CT at lower secondary schools.

2.1 Research questions
1. What are the key constructs of the Computational Thinking (CT) skills instrument that can measure problem solving ability amongst lower secondary students in Malaysian school?
2. What are the content validity related evidences that the items developed are a valid measure of problem-solving ability amongst lower secondary students in Malaysian school?
3. What are the internal consistency related evidences that the items developed are a reliable measure of problem-solving ability amongst lower secondary students in Malaysian school?
4. What are the construct validity related evidences that the items developed are a valid measure of problem-solving ability amongst lower secondary students in Malaysian school?
5. How is CT skills assessment being integrated into current teaching and learning practice, in lower secondary classroom setting?
6. What are the common issues in the assessment of CT, amongst educators in lower secondary school in Malaysia?

2.2 Research limitations
The predicted limitations for this research would be identifying expert panels and getting their cooperation. Also, ensuring their commitment for every round of consultation would remain a challenge given the time constraints. The instrument development process will also possess its own challenge as it will require a lot of iterative process whereby validity will be the most essential aspect to look after, throughout the process.

3. Literature review

3.1 CT Definitions
There is little consensus on a common definition of CT, although there was some agreement on the similarities and differences. Therefore, it is important for everyone to acknowledge the diversity in definitions by different authors and organizations. Among the selected ones from the literature are listed in Table 1 below.

Definitions of Computational Thinking

No	CT Definition	Author
1	"… is the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent"	(Wing, 2011)
2	"..an individual's ability to recognize aspects of real-world problems which are appropriate for computational formulation and to evaluate and develop algorithmic solutions to those problems so that the solutions could be operationalized with a computer"	ICILS 2018 (Fraillon, Ainley, Schulz, Friedman, & Duckworth, 2018)
3	(Operational definition of CT). CT is regarded as a problem-solving process which comprises of (but is not limited to) 1) formulating problems in a way that enables us to use a	The International Society for Technology in

computer and other tools to help solve them; 2) logically organizing and analyzing data; 3) representing data through abstractions such as models and simulations; 4) automating solutions through algorithmic thinking (series of ordered steps); 5) identifying, analyzing, and implementing possible solutions with the goal of achieving the most efficient and effective combination of steps and resources; 6) generalizing and transferring this problem-solving process to a wide variety of problems.	Education (ISTE) and the Computer Science Teachers Association (CSTA), 2011.

3.2 Related theories

Constructivism, as coined by Piaget, indicated that children construct their own knowledge through experience It has remained as the main theory and reference to the history of CT, where the 'constructionism' concept was later introduced (Papert, S., & Harel, 1991) which extends the definition of constructivism. In constructionism, learning process was considered as developing knowledge structures regardless of learning conditions. This "learning by making" implication resonates with the notion of CT. An example of the theoretical framework application is the Computational Thinking Pedagogical Framework (CTPF), developed from constructionism and social-constructivism theories (Kotsopoulos et al., 2017).

Recently, the International Computer and Information Literacy Study (ICILS) introduced measures for students' competency in CT by implementing computer-based tests (Fraillon et al., 2018). In this context, it means new responsibilities for schooling systems in order to offer the opportunity for every child to contribute well in the digital world (Eickelmann, 2019). In Malaysia, prior to the introduction of CT, the Digital Competency Standard (DCS) has been introduced as a measurement tool to assess students' digital competencies, at selected schools (Mohamed Shuhidan, Mohamed Shuhidan, Abu Bakar, & Abd Hakim, 2016). The DCS was based on Ministry of Education ICT skills set, ISTE standards, UNESCO media and Information Literacy Standards (Zainudin & Educational Technology Division, 2016). The initiated DCS program is related to the effort of embedding CT concept into Malaysian primary and secondary education curriculum.

3.3 CT Assessments

From the literature, there are different techniques of assessing CT ability or skills, at different levels of education. Among the well-known ones are the assessment tools related to software ("The Fairy Assessment" in Alice program, Dr Scratch and the popular Scratch by Massachusetts Institute of Technology, a visual programming software, which inculcates CT). Other techniques include Computational Thinking Test or CTt (Román-gonzález, 2015; Román-González, Pérez-González, & Jiménez-Fernández, 2017), Bebras (or Beaver) Challenge, competition-based questionnaire (Dagienė & Stupurienė, 2016; Liz, Araujo, Andrade, & Guerrero, 2019), multiple evaluation approach, online assessment tool (Computational Thinking Pattern Analysis, or CTPA (Ioannidou, Bennett, & Repenning, 2011), Real Time Evaluation and Assessment of Computational Thinking, or REACT (Koh, Basawapatna, Nickerson, & Repenning, 2014), CT Self Efficacy scale, and using convergence (combination of many assessment method), among others. The variety of assessment reflected different contextual requirement and understanding CT concepts, CT elements and are based on their educational curriculum objectives especially in computing or information technology related subjects.

4. Proposed methodology

The researcher will apply the sequential explanatory design, which will involve a quantitative, followed by a qualitative phase (Ivankova, Creswell, & Stick, 2006). In the first phase, quantitative data will be collected via Delphi technique. During the first phase, panel of experts will be invited and consulted through a series of questionnaire (and follow up for few rounds) to get a consensus on the constructs to be included in the instrument development for CT skills for lower secondary school students. The experts consist of related national agency officers, CT trainers, expert teachers and subject matter experts from the industry. In the second phase, the points taken from the Delphi consensus will be triangulated with interviews, where different panelists giving their opinions on certain criteria, which

emerge from the Delphi rounds, in order to better understand why certain construct, tested in the first phase, were significant or not for measuring students' CT skills, at lower secondary schools in Malaysia.

5. Proposed contribution

The study has its own strength and significance as it aims to develop a measurement tool for CT skills in the Malaysian context. The study would contribute significantly by focusing on the assessment of CT skills for lower secondary school students.

References

Dagienė, V., & Stupurienė, G. (2016). *Bebras – a Sustainable Community Building Model for the Concept Based Learning of Informatics and Computational Thinking*. *15*(1), 25–44. https://doi.org/10.15388/infedu.2016.02

Eickelmann, B. (2019). Measuring Secondary School Students' Competence in Computational Thinking in ICILS 2018-Challenges, Concepts, and Potential Implications for School Systems Around the World. In S.-C. Kong & H. Abelson (Eds.), *Computational Thinking Education* (pp. 53–64). https://doi.org/10.1007/978-981-13-6528-7_4

Fraillon, J., Ainley, J., Schulz, W., Friedman, T., & Duckworth, D. (2018). *Information Literacy Study 2018 Assessment Framework*. Amsterdam: International Association for the Evaluation of Educational Achievement (IEA) 2019.

Ioannidou, A., Bennett, V., & Repenning, V. (2011). Computational Thinking Patterns. *2011 Annual Meeting of the American Educational Research Association (AERA)*, *2*.

Ivankova, N. V., Creswell, J. W., & Stick, S. L. (2006). Using Mixed-Methods Sequential Explanatory Design: From Theory to Practice. *Field Methods*, *18*(1), 3–20. https://doi.org/10.1177/1525822X05282260

Kafai, Y. B. (2016). From computational thinking to computational participation in K--12 education. *Communications of the ACM*, *59*(8), 26–27. https://doi.org/10.1145/2955114

Koh, K. H., Basawapatna, A., Nickerson, H., & Repenning, A. (2014). Real Time Assessment of Computational Thinking. *IEEE Symposium on Visual Languages and Human-Centric Computing (VL/HCC)*, (July). https://doi.org/10.1109/VLHCC.2014.6883021

Kotsopoulos, D., Floyd, L., Khan, S., Namukasa, I. K., Somanath, S., Weber, J., & Yiu, C. (2017). A Pedagogical Framework for Computational Thinking. *Digital Experiences in Mathematics Education*, *3*(2), 154–171. https://doi.org/10.1007/s40751-017-0031-2

Liz, A., Araujo, S. O., Andrade, W. L., & Guerrero, D. D. S. (2019). *How Many Abilities Can We Measure in Computational Thinking ? A Study on Bebras Challenge*. 545–551.

Mohamed Shuhidan, S., Mohamed Shuhidan, S., Abu Bakar, S. A., & Abd Hakim, A. A. (2016). Digital Competency Standard at School. *International Information Institute (Tokyo). Information*, *19*(78), 6.

National Research Council. (2010). *Report of a Workshop on the Scope and Nature of Computational Thinking*. https://doi.org/10.17226/12840

Papert, S., & Harel, I. (1991). Situating constructionism. In *Constructionism* (Vol. 36, pp. 1–11).

Rich, P. J., Jones, B. L., Yoshikawa, E., & Perkins, M. (2017). Computing and Engineering in Elementary School : The Effect of Year- long Training on Elementary Teacher Self-efficacy and Beliefs About Teaching Computing and Engineering. *International Journal of Computer Science Education in Schools*, *1*(1). https://doi.org/10.21585/ijcses.v1i1.6

Román-gonzález, M. (2015). Computational Thinking Test : Design Guidelines and Content Validation. *Proceedings of EDULEARN15 Conference*, (July), 2436–2444. https://doi.org/10.13140/RG.2.1.4203.4329

Román-González, M., Pérez-González, J. C., & Jiménez-Fernández, C. (2017). Which cognitive abilities underlie computational thinking? Criterion validity of the Computational Thinking Test. *Computers in Human Behavior*, *72*. https://doi.org/10.1016/j.chb.2016.08.047

Wing, J. (2011). Research notebook: Computational thinking -What and why? *The Link Magazine*. Retrieved from http://www.cs.cmu.edu/link/research-notebook-computational-thinking-what-and-why

Zainudin, F., & Educational Technology Division, M. of E. M. (2016). Developing Digital Competency Standards (DCS) as a Tool to Measure Students ' Digital Skills Delivery of Century Skills: Focusing on the Fundamentals. *36th APEC E-Learning Training Program*, (July). Seoul.

Can "Stag-and-Hare Hunt" Behavior be Modeled using Interaction Data from a Mobile-Supported Collaborative Learning Application?

Rex BRINGULA[a*], Ma. Mercedes RODRIGO[a]

[a]*Ateneo Laboratory for the Learning Sciences, Ateneo de Manila University, Philippines*
*rexbringula@gmail.com

Abstract: Despite the call to develop culturally-aware educational technologies, very few studies were conducted in the Philippines. In order to contribute to this body of literature, this study has been conceived. This paper intends to model the "stag-and-hare" hunt behavior of students in the light of cultural orientation of the participants. It will use the interaction data that will be gathered through *Ibigkas! Math* – a mobile-supported collaborative learning application. Based on the developed model, the mobile application will be revised to make it more adaptive to students' academic needs. The proposed methodology and future works are discussed.

Keywords: behavior, collaborative learning, cooperation, mobile application, mobile game

1. Introduction

Computer-supported cooperative learning (CSCL) environment intends to instill cooperation among learners. Through this learning model, students are able to work together towards a common academic work, and, consequently, learn in a social group (Gillies, 2016; Gokhale,1995). However, it has to account that learners' cultural orientation influences their interactions within a group (King, Ganotice, & Watkins, 2014). Blanchard and Frasson (2005), and Blanchard and Ogan (2010) agree that there is a need to develop culturally-aware educational technologies. For instance, Bringula et al. (2018) found that students exhibited different degrees of engagement in a participatory design workshop: at one end, students were very competitive and outspoken, while on the other end, students were timid, shy, and afraid to commit mistakes.

One of the behaviors underrepresented in the CSCL literature is the stag-and-hare hunting behavior. Stag-and-hare hunting behavior refers to the tendency of learners to choose either a high-risk game mode but with higher payoffs (i.e., the stag) or a low-risk game mode but with lesser points (i.e., the hare) in a game-based mobile-supported collaborative learning environment. Since learners are in a collaborative learning environment, their cultural orientation (e.g., concept of shame and shyness) and personality types may influence their interactions with the system. A student, who is not ashamed to commit mistakes, may passively choose an answer for the sake to contribute to the group points. On one hand, a student, who avoids to be blamed when his/her answer is wrong, may select a question with lesser point. These types of student may not necessarily contribute to the overall welfare of the group, and ultimately, do not achieve learning. In order to fill-in this research gap, this study intends to

1. determine the features that could be utilized to model the "stag-and-hare" hunt behaviors of learners in a game-based mobile-supported collaborative learning environment, and
2. use the model in developing an automatic detector of stag-and-hare behavior in a CSCL.

2. Theoretical Framework

Students' cultural orientation influences their academic life (Jarvis, Holford, & Griffin, 1998). Understanding students' cultural orientation is important since bad assumptions about their learning behaviors could be avoided (Blanchard & Frasson, 2005). Furthermore, it enables teachers provide

relevant pedagogical approaches to the students from a culturally different background. For instance, several studies found that test anxiety (Cassady, Mohammed, & Mathieu, 2004), reward allocations (Fischer & Smith, 2003), and achievement (mastery and performance) and social goals (affiliation, approval, concern, and status) (King, Ganotice, & Watkins, 2014) vary among cultures.

As a collectivist society (Hofstede, 1980), students tend to find belongingness outside their family. They perceive that there is a need to be part of a group (Bernardo & Ismail, 2010) and to be able to establish a secure connection with that group (Mesurado, Richaud, & Jose Mateo, 2016). For Filipino students, engagement has different eight different levels (Santiago & Enriquez, 1976). These levels of interaction include: *pakikitungo* (transaction/civility with), *pakikisalamuha* (interaction with), *pakikilahok* (joinining/participating with), *pakikibagay* (in conformity with/in accord with), *pakikisama* (getting along with)*, pakikipag-palagayang-loob* (having rapport with)*, pakikisangkot* (getting involved with)*,* and *pakikiisa* (being one with). It is apparent that learning in the Philippine context is more grounded on social features (Mesurado et al., 2016). Deviating from the expected roles in these social interactions may result to "*hiya*" (shame) (Lasquety-Reyes, 2016). Shame is a mechanism for social and individual control in a collectivist culture. It guides the actions of a person since he/she would seek to meet the expectations of the group (Pattison, 2000). Thus, in a collaborative environment, teachers must explicitly set the expectations on which level/s of engagement is/are desired.

Filipinos use "*hiya*" to control or regulate social behavior. It is defined as "a feeling of inferiority, embarrassment, shyness, and alienation, which is experienced as acutely distressing" (Guthrie 1968, p. 62). This perception of "*hiya*" has a negative connotation (Jocano, 1999). When applied in educational context, students exclude themselves in academic and extra-curricular participations (see Page & Zarco, 2001; Ordonez & Gandeza, 2004). Because of "*hiya*", students are not comfortable asking their teachers valid questions; instead, they ask their classmates when clarifying ideas or instructions (Ordonez & Gandeza, 2004).

In a recent study of Bringula et al. (2018), it was observed that Filipino students exhibited shyness and varying degrees of engagement in a participatory design workshop to elicit design guidelines for an educational game. There were six groups of students consisting of six members on each group with different academic abilities. The content of the game is about the English language. As a collaborative game, the scores of the team depend on group efforts and individual competency. While students were eager to participate in the game, students had varying degrees of engagement and exhibited shyness. The relationship between different personalities and sources of shyness, and their impact of group participation ("*pakikilahok*") in a mobile-supported collaborative learning environment and learning, are still untested hypotheses in the Philippine context. Furthermore, the impact of different personalities of Filipino learners on collaboration and learning is still unknown.

Considering the collectivist culture of the Filipinos, researchers are informed that learners may be more comfortable learning as a group. This can only be achieved if "*hiya*" (shyness) could be overcome by the participants. It is still not understood how shame and shyness influence the behavior of the students in a collaborative learning environment. The personalities of Filipino learners have to be understood in order to carry out successful interventions and achieve optimum learning experiences in a mobile-supported collaborative learning (MSCL) environment. Thus, this study aims to investigate the influence of cultural values of the students in the context of "*hiya*" and their personalities on their behaviors in a MSCL environment.

3. Proposed Methodology

3.1 Software to be Utilized

Ibigkas! Math will be utilized in the study. It is a mobile-based learning application for grades 1 to 6 students. It is a collaborative game that covers arithmetic problems (addition, subtraction, multiplication, and division of whole numbers). The application generates the arithmetic problems and it will be displayed in one of the team members' mobile device (see Figure 1). It will be read aloud by the player. The answers are presented in multiple choice. The correct answer will appear in one of the team members' device. This is the first version of the game.
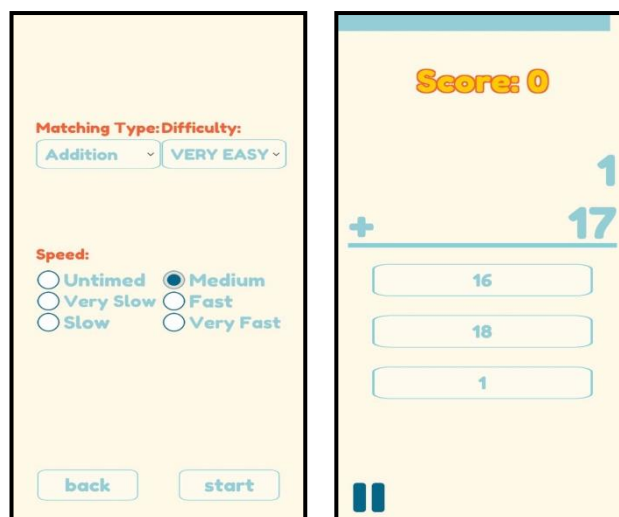
Figure 1. Ibigkas! Math

3.2 Experimentations

The study will consist of two experiments. In the first experiment, students of the same grade level from schools A (public school in Quezon City) and B (private university in Manila) will be grouped in teams of three members. Students of different mathematical competencies (struggling/low-, average-, and high-performing) will form a team. Teachers will be requested to select students based on these categories. Students will use the game for 20 minutes without any interventions from the software and facilitators. The first version of the game will be utilized in this experiment. The same sets of participants will be carried out both versions of the game throughout the succeeding two experiments where students will answer a demographic questionnaire (grade level, age, gender, and mathematics self-efficacy) and personality type inventory. During this process, interactions with the applications will be tracked and automatically recorded into a file. The feature selection and data analysis will be discussed in the next section.

A model will be developed based on the selected features. Based on the developed model, the application will be revised. This version of the application will be used in the second experiment. In the second experiment, the application will intervene if a student is passively choosing an answer or if a student is not solving more challenging questions. Individual textual feedback such as "*Refrain from guessing.*" or "*Would you like to try to answer a harder problem?*" will be incorporated in the application. A pretest and posttest will be administered during this experiment to determine the educational impact of the game.

3.3 Data Collection, Preparation, Feature Selection, and Data Analysis

The interaction logs will have 11 parameters (i.e., timestamp, types of problem solved, grade levels, difficulty levels, speed, choices, target problem, correct answer, incorrect answers, scores, and game ended). From these parameters, features will be selected. Incomplete records (e.g., incomplete or invalid data, outliers) will be removed from the dataset. Forward feature selection method using k-NN 10-fold cross validation will be employed using RapidMiner. Using the results of the feature selection, the dataset will be subjected to modeling. Decision tree modeling with accuracy criterion will be employed to determine the behaviour of the students in using the application. The results of the decision tree modelling will serve as basis in the development of an adaptive application.

4. Future Work

Although this study does not claim that Filipino cultural characteristics are unique, it intends to believe that the interactions of the students may vary depending on the context of the study. Students from a highly competitive class environment (e.g., Science High Schools) may display different learning

behaviors during the game. Hence, future research works in a western cultural setting and conducting the study with a different set of participants are desirable.

Acknowledgements

References

Bernardo, A. B. I., & Ismail, R. (2010). Social perceptions of achieving students and achievement goals of students in Malaysia and the Philippines. *Social Psychology of Education, 13* , 385–407.

Blanchard, E. G., & Frasson, C. (2005, June). Making intelligent tutoring systems culturally aware: The Use of Hofstede's cultural dimensions. In paper presented in *IC-AI* (pp. 644-649).

Blanchard, E. G., & Ogan, A. (2010). Infusing cultural awareness into intelligent tutoring systems for a globalized world. In *Advances in Intelligent Tutoring Systems* (pp. 485-505). Springer, Berlin, Heidelberg.

Bringula, R., Rodrigo, M. M. T., Ocumpaugh, J. L., Porayska-Pomsta, K., Olatunji, I., & Luckin, R. (2018). Towards the Development of a Computer-based Game for Phonemic Awareness. In *Proceedings of the 26th International Conference on Computers in Education* (pp. 657-662). Asia-Pacific Society for Computers in Education.

Cassady, J. C., Mohammed A., & Mathieu, L. (2004). Crosscultural differences in test perceptions: Women in Kuwait and the United States. *Journal of Cross-Cultural Psychology, 35*(6), 713-718.

Fischer, R., & Smith, P. (2003). Reward allocation and culture: a meta-analysis. *Journal of cross-cultural psychology*, *34*(3), 251-268.

Gillies, R.(2016). Cooperative learning: Review of research and practice. *Australian Journal of Teacher Education*, *41*(3), 39–51. doi:10.14221/ajte.2016v41n3.3

Gokhale,A.A.(1995).Collaborative learning enhances critical thinking. *Journal of Technology Education*, *7*(1).doi: https://doi.org/10.21061/jte.v7i1.a.2

Guthrie, G.(1968). The Philippine temperament. In G. Guthrie (editor), *Six perspectives on the Philippines* (pp.49–84). Manila: The Bookmark, Inc.

Hofstede, G. (1980). *Culture's consequences: International differences in work-related values*. Beverly Hills, CA: Sage.

Jarvis, P., Holford, J., & Griffin, C. (1998). *The theory and practice of learning*. London: Kogan Page, Limited.

Jocano, F. L. (1999). *Management by culture: Fine-tuning modern management to Filipino culture (revised edition)*. Quezon City, Philippines: Punlad Research House, Inc.

King, R. B., Ganotice, F. A. J., Watkins, D. A.(2014).A cross-cultural analysis of achievement and social goals among Chinese and Filipino students. *Social Psychology Education, 17*,439-455. doi:10.1007/s11218-014-9251-0

Lasquety-Reyes, J. (2016). In defense of hiya as a Filipino virtue. *Asian Philosophy*, *26*(1), 66-78.

Mesurado, B., Cristina Richaud, M., & José Mateo, N. (2016). Engagement, flow, self-efficacy, and Eustress of University Students: a cross-national comparison between the Philippines and Argentina. *The Journal of psychology*, *150*(3), 281-299.

Ordonez, R. V., & Gandeza, N. (2004). Integrating traditional beliefs and modern medicine: Filipino nurses' health beliefs, behaviors, and practices. *Home Health Care Management & Practice*, *17*(1),22-27.doi: 10.1177/1084822304268152

Page, R. M., & Zarco, E. P. (2001). Shyness, physical activity, and sports team participation among Philippine high school students. *Child Study Journal*, *31*(3), 193-204.

Pattison, S. (2000). *Shame: Theory, therapy, theology*. Cambridge, England: Cambridge University Press.

Santiago, C., & Enriquez, V. (1976). Tungo sa makapilipinong pananaliksik. *Sikolohiyang Pilipino: Mga Ulat at Balita, 1*(4), 3-10.

The Effect of Digital Game-Base Learning on Primary School Students' Critical Thinking Skills and Environmental Literacy

Szu-Kai TSAI [a*] & Tsung-Yen CHUANG [b]
[a]*Szu-Kai TSAI, National University Of Tainan, Taiwan*
[b]*Tsung-Yen CHUANG, National University Of Tainan, Taiwan*
*tim2680320@gmail.com

Abstract: Over the past few decades, many countries are doing everything they can to develop the young generation's critical and systematic thinking, to help them become independent thinkers with the capacity to engage in higher-order thinking or policy promotion. This study aims to examine the way that digital game-based learning (DGBL) exerts an effect on critical thinking and environmental literacy. The fifth-and-sixth graders will participate in the study. Participants will finish the questionnaire survey and interviewed regarding environmental protection and participants' behavior and attitudes, revealing the effect of digital game-based learning upon their critical thinking skills, and the students' environmental literacy.

Keywords: critical thinking skills, environmental literacy, digital game-based learning

1. Introduction

1.1 Motivation

Environmental issues have long been a grave concern of modern society, as the scope and variety of such problems will change as time passes. Some new issues might emerge after a period of accumulation of old issues. In Taiwan, the "go green with nuclear" initiative and the Air Pollution Control Act were recently conceived to solve the electricity and air pollution problems. Take the green-nuclear vote in 2018 as an example. Although the development of nuclear power helps to reduce air pollution and mitigate power shortage, nuclear power produces radioactive waste, which is difficult to dispose of, and the development of green energy might be neglected. As linear thinking fails to address such complicated problems, many countries are doing everything they can to develop the younger generation's critical and systematic thinking, to help them become independent thinkers with the capacity to engage in higher-order or critical thinking. This has become an important agenda for most advanced countries. Environmental education offers opportunities to consider these issues and try to present possible solutions to many heated disputes. Thus, students learn to examine current conditions from a more diversified perspective.

Technological advances have contributed to the spread of digital education. Compared with traditional classroom-based teaching, the advantage of digital learning is its lack of temporal-spatial constraints. Take the Taiwan Environmental Information Association for example. As the largest environmental information media, it holds contests employing children's picture books or games, with the hope of helping players come to realize the importance of environmental education; most of these are card games or board games. Some researchers argue that by introducing digital games into the classroom, learners may be more motivated, willing to cope with challenges and resolve problems at hand. This study intends to use digital games as a medium, in order that students may learn to collect and analyze information, while actively exercising their judgment and reasoning skills. All this may hopefully increase young learners' critical thinking and reasoning skills, as well as their environmental literacy. In terms of the importance of critical thinking in education, this study proffers a research study plan with relevant literature on how to use DGBL as a strategy to improve students' environmental literacy and critical thinking skills. In addition, this study intends to explore the efficacy in using simulations of environmental episodes in game-based learning to develop students' mastery of critical

thinking and achieve better environmental literacy, and determine whether they will continue to put their enthusiasm and sense of participation in environmental protection into practice in their life after the course ends.

2. Literature review

Environmental education

How humans interact with the environment is an issue that needs to be addressed by the whole world. When modern people formed an awareness of environmental issues decades ago, they started to see the importance of environmental education and related issues, and decided to think of ways to preserve the natural environment's sustainability into the future. The dissemination of environmental education and related issues started in the 1970s when international communities took initiatives to promote a series of actions. UNESCO presented the Declaration of Tbilisi in 1977, whereby the role and objectives of environmental education were put into a complete context (Karama, 2016). The above Declaration proffered a number of key points as follows: 1.To help learners identify the real causes underlying environmental issues. 2. To stress the complexity of environmental issues, and the need to develop the younger generations' ability to engage in critical thinking and employ problem-solving skills. 3. To employ a diversified learning environment and wide range of teaching strategies in environmental education. 4. To inspire learners to exert their abilities when they are immersed in a learning experience, and take responsibility for their decision-making outcomes. Taylor (1985) explored ways of game simulation in an instructional setting aimed at environmental education in order to simplify actual situations while still presenting the complexity of real environmental problems. Meanwhile, the discussions, Q&As, and role-playing may all help to improve students' environmental literacy because they tend to exercise stronger participation when told stories that occurred in the real world (Arslan, Moseley & Cigdemoglu, 2011). Considering that teaching methods are associated with learners' level of participation, we employed various learning strategies to help them better immerse in the scenarios (in which current events happening in Taiwan will be described), to which they are exposed via games. During the process, teachers may encourage them to weigh in different factors and values by asking questions. This helps to enhance their critical thinking skills and problem-solving strategies regarding environmental issues.

Previous studies regarding game-based learning and critical thinking skills

In the education field, the development of game-based learning has so far shown a certain positive effect in keeping students motivated in their learning process. Norman (2014) indicates that games help to achieve the basic requirements of, and add fascinating elements to, a learning setting. When it comes to environmental education, we may take advantage of game-playing that is both educational and entertaining to increase motivation in learners. Currently, relatively few domestic and foreign studies have been dedicated to exploring the correlation between digital games as a learning aid and environmental literacy. In the Literature Review section, a few research papers are cited for discussion on the relationship between game-based learning and one's higher-order thinking ability. They include Sousa and Rocha's (2019) study on the virtual world created by games that might develop and increase the leadership skills possessed by players. Also, Lee et al.'s (2016) study focuses on company executives' decision-making capabilities, as these gamers need to analyze and conjecture the real meanings beneath a large amount of conflicting and contradictory messages within a company.

As the games mentioned in the above literature combine scenarios and question-asking strategies to inspire learners to think, it is clear that "questions" are the starting point of the critical thinking process. According to Hsu and Wang (2018), the act of forming questions cannot direct learners to achieve further understanding, but may help them to partake in analyzing the learning content and form basic concepts in their minds, while integrating these messages when doing so. The design of games involves a mechanism of opposites, so that students may learn to develop a range of abilities, including analytical, integrational, and assessing skills via the mechanisms of challenges and interactions, and ultimately learn to be critical thinkers who know how to solve problems, and become enthusiastic learners with high motivation.

What is critical thinking?

Since its inception, the development of "critical thinking" has undergone several phases; a large number of scholars have proffered very different ideas and rationales for it because critical thinking involves philosophy and psychology, two different academic disciplines (Ab Kadir, 2017). Yet some similarities can still be found in these academic explorations. The first scholar who presented a definition of "critical thinking" was Glaser (1941); he suggested three attributes for critical thinking: 1. A tendency to consider issues and solve problems. 2. Having an understanding of rational exploration and logical reasoning. 3. Having the skills to employ the above-mentioned strategies. Afterward, the American Philosophical Association developed the Delphi method, and declared: "We believe critical thinking is a purpose-oriented, self-regulated judgment, which involves an objective judgment by a series of steps: interpretation, analysis, evaluation, estimation, and explaining a matter from a variety of factors related to evidence, concepts, methodologies, standards, and background information" (Facione, 1990). Of these, the six core critical thinking skills are: inference, explanation, evaluation, self-regulation, interpretation, and analysis (Facione, 1992).

From the above literature, it is clear that a majority of scholars are convinced that developing critical thinking means one has the ability to discover and clarify a problem, to form a judgment of messages and conduct self-regulation. Also, it is vital that one be sure of one's hypothesis-forming process and learn to reflect on the hypothesis and convictions in the process (Braman, 1999). The capacity to reflect on, and regulate, one's own thinking is the key to forming higher-order thinking and developing critical thinking. In other words, it is reflection, not judgment, that makes it possible to perform a "rational analysis", develop the ability for "logical reasoning", and ultimately "make assessments and judgments" during the process. Some studies also reveal the importance of self-regulation and reflective judgment in developing critical thinking, as these would determine an individual's evaluation (Dwyer, Hogan & Stewart, 2015). Some researchers believe that the cultivation of critical thinking involves the development of skills and images, constantly asking questions, reflecting, regulating, and learning to examine one's reflection process. This also helps to maintain higher-order thinking, which aids in clarifying a problem and rectifying it.

3. Research methodology

This study explores Taiwan's environmental education by employing critical thinking strategies and digital game-based learning methods. Previous literature has shown that games are beneficial in breaking free of temporal-spatial constraints in order to help learners immediately experience the environmental problems. The fifth-and-sixth graders of a primary school located in Southern Taiwan were used as the research subjects in this study, while some "protection areas" were used in the game design. The game was designed from the angle of animals, so students might be able to interpret environmental issues from different perspectives, such as survival and data collection, and gain an opportunity to think about the environmental issues in a critical way.

Gamers were given a world view, a description of stories, and an explanation of questions before they started the game. This helped gamers to take on missions in the context of the story. The question design was coupled with assessment tools for critical thinking. The environmental issues included the conservation of indigenous species, pollution, and pesticide sprays. Thus, learners learned to consider and identify the complexity of environmental issues. Although surveys and evaluation tools compiled by domestic and foreign scholars are numerous, they cannot be readily added into our survey because of socio-cultural barriers and gaps in translation (Kuo, 2008). To help learners better understand the questions, the game was designed in accordance with the "first-level critical thinking" developed by Taiwanese scholars, in the hope of achieving a more satisfactory outcome in evaluating the environmental literacy of these young respondents in Taiwan (Yeh, 2003).

Furthermore, it is advised to design the evaluation scale in accordance with the syllabus of the 12-year Basic Education, to thoroughly evaluate students' awareness, comprehension, system of values, skills, and practices regarding environmental protection. The core competencies comprise "systematic thinking and problem- solving" and "moral practices and civic consciousness" (Ministry of Education, 2014). All of the above indicate that a curriculum with environmental issues added may lead to a

transfer of learning, which proves helpful to increase awareness of environmental protection as well as critical thinking habits. Therefore, it is advised to provide a questionnaire survey and interviews regarding environmental protection and participants' behavior and attitudes before and after the course, thus revealing the effect of digital game-base learning upon the critical thinking skills, and the students' environmental literacy. The experimental procedures are illustrated in Fig 1.

Figure 1. The experimental procedures.

References

Ab Kadir, M. A. (2017). What teacher knowledge matters in effectively developing critical thinkers in the 21 st century curriculum? *Thinking Skills and Creativity, 23*, 79-90.

Arslan, H. O., Moseley, C., & Cigdemoglu, C. (2011). Taking attention on environmental issues by an attractive educational game: enviropoly. *Procedia - Social and Behavioral Sciences, 28*, 801-806. doi:https://doi.org/10.1016/j.sbspro.2011.11.146

Braman, O. R. (1999). Teaching peace to adults: Using critical thinking to improve conflict resolution. *Adult Learning, 10*(2), 30-32.

Dwyer, C. P., Hogan, M. J., & Stewart, I. (2015). The effects of argument mapping-infused critical thinking instruction on reflective judgement performance. *Thinking Skills and Creativity, 16*, 11-26. doi:https://doi.org/10.1016/j.tsc.2014.12.002

Facione, P. (1990). Critical thinking: A statement of expert consensus for purposes of educational assessment and instruction (The Delphi Report).

Glaser, E. M. (1941). *An experiment in the development of critical thinking*: Teachers College, Columbia University.

Hsu, C.-C., & Wang, T.-I. (2018). Applying game mechanics and student-generated questions to an online puzzle-based game learning system to promote algorithmic thinking skills. *Computers & Education, 121*, 73-88. doi:https://doi.org/10.1016/j.compedu.2018.02.002

Karama, M. J. (2016). A Comparative Survey of Environmental Education Goals Between the UNESCO Framework and 10th Grade Palestine Curriculum. *International Journal of Curriculum and Instruction, 8*(2), 1-17.

Lee, H., Parsons, D., Kwon, G., Kim, J., Petrova, K., Jeong, E., & Ryu, H. (2016). Cooperation begins: Encouraging critical thinking skills through cooperative reciprocity using a mobile learning game. *Computers & Education, 97*, 97-115.

Norman, D. (2014). *Things that make us smart: Defending human attributes in the age of the machine*: Diversion Books.

Sousa, M. J., & Rocha, Á. (2019). Leadership styles and skills developed through game-based learning. *Journal of Business Research, 94*, 360-366. doi:https://doi.org/10.1016/j.jbusres.2018.01.057

Taylor, J. (1985). *Guide on Simulation and Gaming for Environmental Education*: ERIC.

The Ministry of Education (2014). *The 12-Year Basic Education Curriculum Guidelines:* the Ministry of Education.

Kuo, J. M., L, J. P & Yu, C. J. (2008). The Validity and Revision of Cornell Critical Thinking Test Level I. *Journal of Educational Research and Development.*

Yeh, Y. C. (2003). *Critical Thinking Test - Level I.* Taipei City: Psychological Publishing Co., Ltd.

Game-based Learning: Students' Critical Thinking Performance while Playing "Callisto Summit"

Kung-Hou LIN [a]*, Tsung-Yen CHUANG [a] & Ju-Ling SHIH [b]
[a]**Department of Information and Learning Technology, National University of Tainan, Taiwan*
[b]*Graduate Institute of Network Learning Technology, National Central University, Taiwan*
*Sabrinalin@tn.edu.tw

Abstract: This study investigates students' gaming decisions while playing the robotic game "Callisto Summit" and analyzes their critical thinking performance based on the gaming decisions. "Callisto Summit" is designed for the players to use block codinge to move the robots on a large game map to negotiate and solve inter-group conflicts and issues, such as city development, environmental pollution, and population. Forty-eight American students aged 8-12 participated in the game-based learning activity. In this study, qualitative research methods are used to document and observe how players made gaming decisions, then further analyze their behaviors to understand their critical thinking performance.

Keywords: game-based learning, decision making, critical thinking, robotic game

1. Introduction

Over the past few decades, global educational reform has been focused on the need of the emerging models of economic and social development to equip students with new skills and competencies included the social values and attitudes as well as with the constructive experiences. Tony Wagner (2014) asserts that the ability to think critically and solve problems, communicate effectively through speaking and writing, and collaboration with others are the top three survival skills in the 21st century. Decision-making process requires critical thinking competence, such as the ability to ask a series of good questions during the process of decision making. In general, games have great potential to support learning experiences, and Hogle (1996) showed that the benefits of games can help with learning, increase interest, provide exercise and feedback, preserve memories, as well as improve higher order thinking and reasoning skills.

Game-based learning (GBL) can provide students the opportunities for experiment and exploration. Yien et al. (2011) shows that students are more immersed in exploring the learning scenarios during the experiential activities so that they enhance learning effectiveness and get wider and deeper knowledge and skills. When the students become players in games, they explore the issues actively through interpreting information, analyzing data, implementing actions, and thinking critically for adjusting strategies to make better decisions. This study focuses on critical thinking performance and decision-making in game-based learning activity, and to demonstrate that decision making is more like an intermediary between critical thinking and problem solving.

2. Literature review

2.1 Game-based learning

Game-Based Learning (GBL) is defined as a learning strategy by Kim, Park and Baek (2009) which focuses on giving educational content through game play to reach particular objectives. With numerous studies supporting the positive effects of games on learning (Prensky, 2003), using games as a means to transfer learning content in schools and skills in workplaces has become more and more pervasive. GBL provides a challenging opportunity for players to broaden their competencies regardless of the proficiencies they began with. For instance, normally game players are repeatedly confronted with a similar type of problem at the beginning, until they find a method and master certain skills.

Moreover, game-based learning stimulates deeper thinking in players, more diversified problem solving, as well as closer teamwork through differing learning strategies and mediums than traditional classrooms (Gee, 2003). The value of game-based learning is to allow learners to be fully engaged in exploring the rules and exercisinge decision makings without taking risks in the real world. Bogost (2011) stresses that games treat topics and ideas as rules, actions, decisions and consequences, not as content to be taught. The spirit of game-based learning is allowing learning to happen in the fun process (Perrotta, Featherstone, Aston, & Houghton, 2013).

2.2 Decision Making

There are many fundamentals associated with the decision making, such as perception, resources, priority, benefits, acceptability and risks (Armistead, 2010). A better decision-making approach can help decision makers in solving problems (Mardani et al.2015). The challenge of decision-making is to maximize the value of outcomes to the decision maker and minimize the risk, which means making the most appropriate choice under an uncertain environment and in several imperfect scenarios.

Making good decisions needs competencies including personal expertise, structured high-level thinking skills, interpersonal interaction such as influence, communication, and conflict resolution skills. In fact, critical thinking improves decision making and enhances understanding of the general principles of the domain (Helsdingen, Bosch, Gog, & Van, 2010). When decision makers break down a problem according to the fact to analyze information, they are using critical thinking skills, a structured high-level thinking, to get a better decision. Clearly, critical thinking can provide the learners with a proper method to facilitate better decision making, and further to solve problems efficiently.

2.3 Critical Thinking

Critical thinking has been developing in the last 2,500 years and its definition vary. Ennis' (1996) defined it as reasonably reflective thinking that is focused on deciding what to believe and do. Scriven and Paul (1987) stated that critical thinking is the disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and evaluating information generated by observation, experience, reflection, reasoning, or communication, as a guide to belief and action. In recent years, educational reform around the world have been trended by critical thinking competences and actually has been spread from university to high school and even elementary school levels (Lipman, 1993). Critical thinking is not only memory and understanding, but also a form of higher-order cognitive processes. Students learn to use rational analysis and evaluation. Facione (2011) offered the core of critical thinking as the higher-order cognitive skills including interpretation, analysis, evaluation, inference, explanation, and self-regulation.

King (1995) and Taba (1966) suggested that students' thinking level are strongly influenced by the level of teachers' questions. Investigation of Yang et al. (2005) showed that students' critical thinking skills can be enhanced by Socratic questionings interactions between the instructors and students. The format emphasizes higher level cognitive processes, rather than asking students to remember facts and details. Socratic questions method is more likely to encourage students the analysis, synthesis, and evaluation of different sources of information. Hannel (1998) proposed seven steps to critical thinking with the information-processing steps to increase students' understanding: (1) Observation message: classification, identification (2) Looking for similarities and differences: comparison, identification of correlation, analogy (3) Identifying comprehensive topics or relationships: classification, integration, pre-summary (4) What we know: decoding, speculation (5) Correctly answering: coding (6) Applied to similar situations: inferences, plans, applications (7) What we learned: Summarize.

In this study we use the seven steps as the tool to analyze the game design and explain students' critical thinking performance in terms of their decision making processes in the game.

3. Game Design

"Callisto Summit" is a robotic game designed to embed STEM and interdisciplinary concepts. The gaming context is about Robot Beings being overpopulated in space and the base stations are in

competition for development and limited resources. Forty-eight American students aged 8-12 participated in the game-based learning activity. The students were divided into two sessions, two hours each with 24 students in each session divided into six groups.

In the game, a big map in the size of 600 x 400 cm showed the imaginary context of the planet Callisto in the 2050 (Figure1). Student groups role-play the six basic stations, including Metal, Water, Wood, Earth, Fire, and Air. Each station has different initial condition and different goals to achieve. The groups take turns to move their robots by block coding to achieve their tasks. Earth and Wood Base Stations are facing external forces for planet, development, environmental pollution, and alien trespass. Water and Metal Base Stations face economic declination and increase of chaos and safety problems due to continuous incoming robot transfers. Fire Base Station devotes in planet development which cause space pollutions. Air Base Station, in contrast, devotes to space environmental protection. The beginning set up are 7 developed areas (Red Circles), 7 adjacent polluted areas (Black Circles), 3 robot immigrants (Green Triangles), and some un-discovered areas and existing space diamonds.
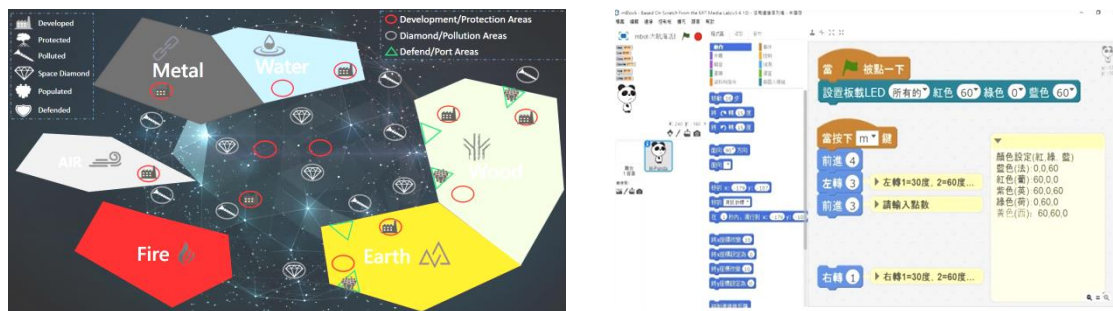

Figure 1. Map of "Callisto Summit" (left) ; the block coding software for robot action (right)

The activity starts with 5 to 10 minutes game background and rules introduction. Then all groups take 4 minutes for internal affairs to setup 3 goals in terms of the areas to move the robots to; and 4 minutes for diplomatic actions to negotiate with other groups. After then, all groups take 4 minute to write programming and 1 minutes for each group to move robots. All group do the robot movements for three rounds in a game. The whole process matches the critical thinking 7 steps (Figure 2).The winning condition is when all stations complete three tasks, and all stations are satisfied with the end results. Two games are expected for the same group of students to experiment the various gaming results that are brought about by different decision makings; and why.

Figure 2. Gaming process with critical thinking 7 steps

The winning condition is when all stations complete three tasks, and all stations are satisfied with the end results. Two games are expected for the same group of students to experiment the various gaming results that are 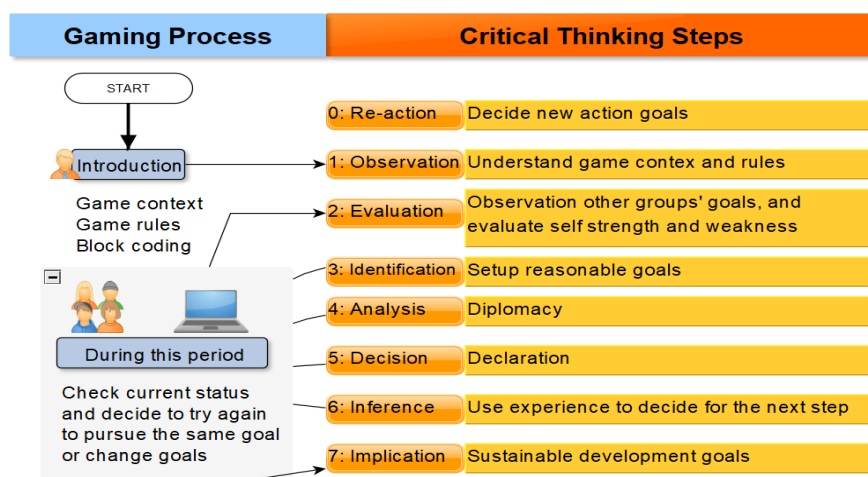brought about by different decision makings; and why. All gaming movements and decision-making process are documented for analysis. After the game, evaluate the status of the planet with the students, and relate to the issues of sustainable development goals.

4. Conclusion

The study is to observe what, how, and why students would do different gaming decisions in the game. At the same time, students' coding skills and negotiating strategies will be observed to cross-analyze to identify their critical thinking performances.

Detail analysis would include how the new and better decisions can be possibly triggered by the previous action's success or failure, and how group members would affect their decisions, either by the changing conditions of the game, their sensory perceptions to the dynamic verbal or non-verbal social interactions.

Overall speaking, the students had positive feedbacks to the game. They liked the activities and they enjoyed thinking, communicating, coding in the game. They can relate what they experience in the game to the social situations in the real life. They hoped to have similar interdisciplinary activities in the future.

Acknowledgement

References

Armistead, L.(2010). Sharing Leadership Responsibilities Results in Achievement Gains. *Education Partnerships, Inc*.

Bogost, I. (2011). How to do things with videogames. University of Minnesota Press.

Ennis, R. H. (1996). Critical thinking dispositions: Their nature and assessability. *Informal logic*, 18(2).

Facione, P. A. (2011). Critical thinking: What it is and why it counts. *Insight assessment*, 2007(1), 1-23.

Hannel, G. I., & Hannel, L. (1998). The seven steps to critical thinking: a practical application of critical thinking skills. *NASSP bulletin*, 82(598), 87-93.

Helsdingen, A. S., Van den Bosch, K., Van Gog, T., & van Merriënboer, J. J. (2010). The effects of critical thinking instruction on training complex decision making. *Human factors*, 52(4), 537-545.

HogleJ. G., (1996). Considering games as cognitive tools: In search of effective" edutainment.". ERIC Clearinghouse.

Kim, B., Park, H. & Baek, Y. (2009). Not just fun, but serious strategies: Using meta-cognitive strategies in game-based learning. *Computers and Education*, 52(4), 800-810.

King, A. (1995). Designing the instructional process to enhance critical thinking across the curriculum. *Teaching of Psychology*, 22(1), 13–17. http://dx.doi.org/10.1207/s15328023top2201_5

Gee, J. P. (2003). What video games have to teach us about learning and literacy. *Computers in Entertainment* (CIE), 1(1), 20-20.

Lipman, M. (Ed.). (1993). Thinking children and education. Kendall-Hunt.

Mardani, A., Jusoh, A., Zavadskas, E., Cavallaro, F., & Khalifah, Z. (2015). Sustainable and renewable energy: An overview of the application of multiple criteria decision making techniques and approaches. *Sustainability*, 7(10), 13947-13984.

Perrotta, C., Featherstone, G., Aston, H., & Houghton, E. (2013). Game-based learning: Latest evidence and Future Directions (NFER Research Programme: Innovation in Education). Slough: NFER.

Prensky, M. (2003). Digital game-based learning. *Computers in Entertainment* (CIE), 1(1), 21-21.

Scriven, M., & Paul, R. (1987). Critical thinking. In The 8th Annual International Conference on Critical Thinking and Education Reform, CA.

Taba, H. (1966). Teaching strategies and cognitive functioning in elementary school children. Cooperative Research Project, No. 2404. San Francisco: San Francisco State College.

Wagner, T. (2014). The global achievement gap: Why even our best schools don't teach the new survival skills our children need-and what we can do about it. *Basic Books*.

Yang, Y. T. C., Newby, T. J., & Bill, R. L. (2005). Using Socratic questioning to promote critical thinking skills through asynchronous discussion forums in distance learning environments. *The American Journal of Distance Education*, 19(3), 163-181.

Yien, J. M., Hung, C. M., Hwang, G. J., & Lin, Y. C. (2011). A game-based learning approach to improving students' learning achievements in a Nutrition course. *Turkish Online Journal of Educational Technology-TOJET*, 10(2), 1-10.

Using Gamification to Effect Learning Behaviors in Intelligent Tutoring System

Faiza TAHIR[a*], Antonija MITROVIC[a] & Valerie SOTARDI[b]
[a]*Intelligent Computer Tutoring Group, Department of Computer Science and Software Engineering, University of Canterbury, New Zealand*
[b]*School of Educational Studies and Leadership, University of Canterbury, New Zealand*
*faiza.tahir@pg.canterbury.ac.nz

Abstract: Engagement and motivation is always a challenge in online learning environments. The benefits of learning environments have proven its history for many years, but effectively engaging users with these environments and motivating them is an active and important research problem. In this work, I will investigate the potential of gamification on motivation and user engagement in an intelligent tutoring system SQL-Tutor. This work is inspired by the growing trend of gamification and its positive effects in various domains.

Keywords: intelligent tutoring system, problem solving, gamification, self-regulation

1.   Introduction and Literature Review

The goal of Intelligent Tutoring Systems (ITSs) is to provide individual support to learners according to their needs and abilities. Research shows that learning can be affected by boredom and frustration which lead to low performance for both low and high achievers (Munshi et al., 2018), and abandoned learning activities (Baker et al., 2010). Engagement and motivation are crucial for learning with ITSs (D`Mello et al., 2007). Gamification was introduced as a term with the definition "the use of game design elements in non-game contexts" (Deterding et al., 2011). It is considered as less expensive in contrast to standalone games (Landers et al., 2017). As games are originally intended for enjoyment, gamification is also defined as motivational information systems which combine the efficiency of utilitarian systems and enjoyment of hedonic systems (Koivisto et al., 2019). Adoption of gamification is reported in many fields, particularly in education, health science and crowdsourcing. Hamari and colleagues conducted surveys on gamification research in 2014 and 2019. These analysis revealed that education is an area where gamification is applied mostly and accompanied with positive results. Detailed analysis of these studies showed that they are focusing on behavioural change of learners through the use of gamification and focused only on psychological changes which are engagement, enjoyment and motivation. According to these surveys, most popular gamification elements are points, badges and leader boards and there is a huge lack of empirical evidence in gamification studies.

The theory of gamified learning presented by Landers (2014) specified the two mechanisms of introducing gamification in learning process. One is mediator, which adds game elements to affect learner's behaviour, which in turn increases/decreases learning outcomes. The other is moderator, where game intervention affects learner behaviour (psychologically) which affects the relation between instructional content and learning outcome. In subsequent work of Lander (2017), he provided the mapping of different game elements to psychological theories in order to emphasise that gamification will improve learning outcome if carefully applied with the help of psychological behaviours. On the basis of this theory, Landers and colleagues (2014) conducted an experiment by selecting time-on-task as mediating psychological behaviour and leader board as game intervention and the results were significantly improved learning.

Gamification has been applied mostly to web-based learning environments such as Code academy, Khan academy and Stack Overflow (Marder, 2015; van Roy et al., 2018) but its application in ITSs in not much explored. Few studies conducted are worth mentioning here. Denny and colleagues (2018) conducted a study on Peerwise, a system for peer learning, with points and badges added as gamification intervention. The targeted behaviours were engagement, motivation and self-testing. The

results showed positive effects of gamification, particularly for badges. In another study, Long and colleagues (2014) explored the effects of adding badges to an ITS and mediate the process with re-practising behaviour. The results show partial success, and they figured out that re-practising is not an optimal mediating behaviour to improve learning. In the subsequent study, Long and colleagues (2015) explored the effects of gamification with self-regulating strategies in the ITS. The results showed the positive attitude of students towards achieving badges and other game elements (Long, Aman, & Aleven, 2015). Starting from the mixed findings about the effectiveness of gamification in ITSs, this research project will move forward the debate by empirically investigating the impact of gamification in SQL-Tutor, a mature ITS for teaching Structured Query language (Mitrovic, 2003). Many versions of SQL-Tutor have been released, providing new features and more support such as probabilistic student model (Mayo & Mitrovic, 2000), various problem selection strategies (Mayo, 2001; Mitrovic & Martin, 2004; Mathews, 2012), an animated pedagogical agent (Mitrovic & Suraweera, 2000), positive feedback (Barrow, Mitrovic, Ohlsson, & Grimley, 2008), worked examples (Shareghi Najar, Mitrovic, & McLaren, 2014) and erroneous examples support (Chen, Mitrovic, & Mathews, 2016).

This PhD project will make a number of contributions. First, we will analyse the literature to identify the psychological behaviours that work as mediators or moderators and have effect on learning performance of learners when working with ITS. On the basis of the identified learning behaviours, a gamified learning intervention will be designed and implemented in SQL-Tutor. Second, we will examine the effects of gamification on students' learning outcomes. The last contribution of this research will be to explore the relationship between enjoyment, engagement and motivation of learners with the gamified ITS.

2. Proposed Work

From the brief literature review it is evident that gamification can be promising if applied within correct context. In this project I will focus on *the impact of gamified SQL-Tutor on students' learning behaviours and subsequently their learning outcomes.* Figure 1 shows the overview of this project's theoretical framework.
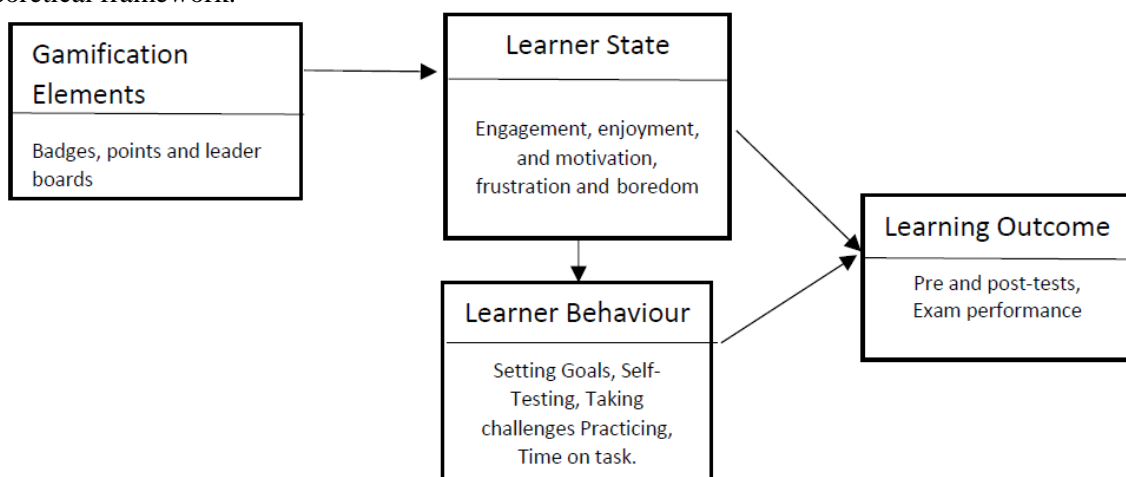

Figure 1. Theoretical framework of the project

This project will be conducted in three phases. The initial phase includes a pilot study which was conducted and I collected data about the students' affective states, their engagement and attention levels while working with SQL-Tutor and its impact on students' performance. The results showed that affect states (enjoyment, frustration, boredom) and psychological behaviours (motivation, engagement and attention) are affecting student's performance while learning from SQL-Tutor. It also revealed that students became frustrated and their engagement reduced while attempting to solve complex problems and in the absence of motivation intervention they left the problem solving. Along with identification, I will further analyse the results to find the required levels of these behaviours for achieving high performance. The learning behaviours are selected on the basis of these learner's psychological states

and will be gamified in SQL-Tutor in next phase. The research question addressed in the pilot study are following:

RQ 1: To what extent do engagement, enjoyment, frustration and boredom affect students' performance while working with SQL-Tutor?

In phase two, I will design and implement badges as a gamification intervention, select learning behaviours to target through gamification and measure the learning outcomes. Badges will act as motivational affordance to increase motivation, engagement, excitement and help learners to keep going in case of negative affective states. On the basis of these psychological behaviours, I will focus on five learning behaviours: goal-setting behaviour, self-testing behaviour, taking conflict/challenge behaviour, practising and time-on-task behaviour. These behaviours will implement in SQL-Tutor with gamification techniques. For example, the goal-setting behaviour will be supported by implementing a badge that will be given when the learner completes five problems in a day, or completes five problems every day for five consecutive days. Self-testing behaviour will be supported by providing badges when students attempt optional quizzes. The conflict/challenge behaviour will be supported by providing badges for solving complex problems and daily challenges. Badges will also be provided on completing problems daily, for completing more difficult problems (e.g., problems requiring the Group by clause) or completing a specific number of problems in one session. These learning behaviours act as mediators between gamification and learning outcomes as suggested by the Landers theory of gamified learning. The research questions addressed in this phase are following:

RQ 2: Do badges influence students to complete more problems, and remain motivated, enjoyed and engaged for longer?

RQ 3: Which learning behaviours act as optimal mediators to increase students' performance in the presence of badge interventions? (This RQ will be investigated in five subquestions, each focusing on a specific learning behaviour)?

On the basis of the finding from the study, I plan to introduce other gamification interventions in the last phase of my project. Leader boards and points are other two popular gaming intervention as mentioned by Hamari, (2019). I will conduct another study in order to compare the effects of various types of gaming interventions along with their gaming attributes and learning behaviours. The research questions addressed in this phase are:

RQ 4: Is a combination of points, badges and leader boards more effective than when those elements are used individually?

RQ 5: Which learning behaviours best combine with points, badges and leader board and yields optimal result in terms of student performance?

3.   Research Methodology

To answer the research questions above, I will conduct exploratory research to determine the main aspects of gamification in SQL-Tutor, and develop techniques and procedures to apply gamification effectively. This project will consist of three experiments based on three phases mentioned above and system in context is SQL-Tutor. Phase one consist of pilot study focused on RQ1 started with the demographic questionnaire and then identify and analyse student's affective states and psychological behaviours with the help of iMotions (https://imotions.com) software package. Phase 2 and 3 focusing on RQ2-RQ5, a classroom study will be conducted in each phase which will provide the modified version of SQL-Tutor to one group of randomly selected students (experimental) and standard version of SQL-Tutor to other group of students (control). The data will be quantitative in nature in all three phases and collected through the student logs of SQL-Tutor and exported from iMotions. The effects or learning outcome/performances of students will be measured via pre-/post-tests. This data will be analysed with the help of correlation and regression analysis. At the end of phase 2 and 3 a questionnaire will be provided to get the opinion and future intentions of students on using gamification interventions and learning behaviours. Motivation will analyse both by student interaction with the SQL-Tutor and through the questionnaire provided at the end of each experiment.

References

Baker, R. S., D'Mello, S. K., Rodrigo, M. M. T., & Graesser, A. C. (2010). Better to be frustrated than bored: The incidence, persistence, and impact of learners' cognitive–affective states during interactions with three different computer-based learning environments. *Human-Computer Studies, 68*(4), 223-241.

Barrow, D., Mitrovic, A., Ohlsson, S., & Grimley, M. (2008). Assessing the impact of positive feedback in constraint-based tutors. In International Conference on Intelligent Tutoring Systems (pp. 250-259). Springer, Berlin, Heidelberg.

Chen, X., Mitrovic, A., & Mathews, M. (2016). Do Erroneous Examples Improve Learning in Addition to Problem Solving and Worked Examples?. In International Conference on Intelligent Tutoring Systems (pp. 13-22). Springer, Cham.

D'Mello, S., Picard, R. W., & Graesser, A. (2007). Toward an affect-sensitive AutoTutor. *IEEE Intelligent Systems, 22*(4), 53-61.

Denny, P., McDonald, F., Empson, R., Kelly, P., & Petersen, A. (2018). Empirical Support for a Causal Relationship Between Gamification and Learning Outcomes. Proc. CHI Conference on Human Factors in Computing Systems, Montreal, Canada (p. 311). ACM.

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: defining "gamification". Proc. 15th Int. Academic MindTrek Conference: Envisioning Future Media Environments, Tampere, Finland (pp. 9-15). ACM.

Hamari, J., Koivisto, J., & Sarsa, H. (2014). *Does gamification work?--a literature review of empirical studies on gamification.* Proc. 47th Hawaii Int. Conf. on System Sciences, 14, pp. 3025-3034.

Koivisto, J., & Hamari, J. (2019). The rise of motivational information systems: A review of gamification research. *International Journal of Information Management, 45*, 191-210.

Landers, R. N. (2014). Developing a theory of gamified learning: Linking serious games and gamification of learning. *Simulation & Gaming, 45*(6), 752-768.

Landers, R. N., Armstrong, M. B., & Collmus, A. B. (2017). How to use game elements to enhance learning: Applications of the theory of gamified learning. *Serious Games and Edutainment Applications* (pp. 457-483): Springer.

Landers, R. N., & Landers, A. K. (2014). An empirical test of the theory of gamified learning: The effect of leaderboards on time-on-task and academic performance. *Simulation & Gaming, 45*(6), 769-785.

Long, Y., & Aleven, V. (2014). Gamification of joint student/system control over problem selection in a linear equation tutor. Proc. Int. Conf. Intelligent Tutoring Systems (pp. 378-387). Springer, Cham.

Long, Y., Aman, Z., & Aleven, V. (2015). Motivational design in an intelligent tutoring system that helps students make good task selection decisions. Proc. Int. Conf. Artificial Intelligence in Education (pp. 226-236). Springer, Cham..

Marder, A. (2015). Stack overflow badges and user behavior: an econometric approach. Proc. IEEE/ACM 12th Working Conference on Mining Software Repositories (pp. 450-453). IEEE.

Mathews, M. M. (2012). "A Framework for Multiple Adaptable Pedagogical Strategies in Intelligent Tutoring Systems."

Mayo, M., & Mitrovic, A. (2000). Using a probabilistic student model to control problem difficulty. In International Conference on Intelligent Tutoring Systems (pp. 524-533). Springer, Berlin, Heidelberg.

Mayo, M., & Mitrovic, A. (2001) Optimising ITS Behaviour with Bayesian Networks and Decision Theory. *Artificial Intelligence in Education*, 12(2), 124-153.

Mitrovic, A., & Suraweera, P. (2000). Evaluating an animated pedagogical agent. In International Conference on Intelligent Tutoring Systems (pp. 73-82). Springer, Berlin, Heidelberg.

Mitrovic, A. (2003). An intelligent SQL tutor on the web. International Journal of Artificial Intelligence in Education, 13(2-4), 173-197.

Mitrovic, A., & Martin, B. (2004). Evaluating adaptive problem selection. In International Conference on Adaptive Hypermedia and Adaptive Web-Based Systems (pp. 185-194). Springer, Berlin, Heidelberg.

Munshi, A., Rajendran, R., Ocumpaugh, J., Biswas, G., Baker, R. S., & Paquette, L. (2018). Modeling Learners' Cognitive and Affective States to Scaffold SRL in Open-Ended Learning Environments. Proc. 26th Conf. User Modeling, Adaptation and Personalization, Singapore, Singapore (pp. 131-138). ACM.

Shareghi Najar, A., Mitrovic, A., & McLaren, B. M. (2014). Adaptive Support versus Alternating Worked Examples and Tutored Problems: Which Leads to Better Learning?. In International Conference on User Modeling, Adaptation, and Personalization (pp. 171-182). Springer, Cham.

van Roy, R., Deterding, S., & Zaman, B. (2018). Uses and Gratifications of Initiating Use of Gamified Learning Platforms. Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems (p. LBW565). ACM.

Reciprocal Kit Build Concept Map: An Activity Designed to Encourage Learning at Boundary in Collaborative Situation

Lia SADITA*, Tsukasa HIRASHIMA, & Yusuke HAYASHI
Department of Information Engineering, Hiroshima University, Japan
*lia@lel.hiroshima-u.ac.jp

Abstract: In a collaborative situation, learners must actively interact with their peers to have meaningful discourse, not only co-present. Researchers have shown that employing a concept map as a representation tool was useful to construct and maintain group shared knowledge, rather than a dialogue only communication setting. The use of concept map positively affected students' learning outcomes as well as their attitudes. Moreover, prior studies have extended the collaborative concept map activity with individual externalization, concept map sharing and reviewing activity to trigger cognitive change through conflicts. The current study introduces a new extension of collaborative concept mapping activity with Reciprocal Kit Build (RKB). The RKB allows learners in pair to create an individual and collaborative concept map, exchange ideas through reconstruction, and discuss it facilitated by shared and difference maps. Unlike existing studies, our design activity is aimed to promote learning mechanism at boundaries, by boundary-crossing and utilizing boundary objects. This paper explains how the RKB may potentially provoke conceptual changes during collaboration.

Keywords: collaborative learning, concept map, boundary-crossing, boundary objects

1. Introduction

Researches highlight that interaction between learners plays a key role during peer-to-peer collaboration. Scripts, scenarios, or representational tools have been designed to assist students while interacting in a collaborative situation. Productive discussion requires learners' active participation and awareness of each other's knowledge (Fischer & Mandl, 2002). A concept map, which has been popularly used as "external representation" of individual thinking, plays an important role in the sophistication of internal representation. Concept map also can be used to communicate ideas and maintain shared focus during a discussion. Various studies were conducted to employ a concept map for computer-aided collaborative learning (Fischer & Mandl, 2002; Gracia-Moreno, Cerisier, Devauchelle, Gamboa, & Pierrot, 2017). Employing concept map during discourse has positively affected students learning outcomes as well as their attitudes (Gracia-Moreno et al., 2017; van Boxtel, van der Linden, Roelofs, & Erkens, 2002).

Previous works have extended the collaborative concept map activity with the externalization of individual prior knowledge and concept map sharing and reviewing to trigger active inquiry (Basque & Lavoie, 2006; Engelmann & Hesse, 2010; Roschelle & Teasley, 1995). The creation of individual maps before collaboration and knowledge awareness of group members have affected the knowledge acquisition process and results. The individual phase has influenced learners to explain their ideas better during a discourse. The students have elicited more information that is relevant to their uncertainties. Awareness of collaborator's knowledge can reduce miscommunication and help them to collaborate more efficiently (Engelmann & Hesse, 2010). Reviewing other individual maps have also positively influenced the broadness of the collaborative map (Stoyanova & Kommers, 2002). However, the externalization of individual thinking in own private space did not necessarily enable knowledge exchange and elaboration during collaborative construction of a concept map. Learners have faced difficulty to integrate different perspectives over a shared problem (Gracia-Moreno et al., 2017).

To promote productive discussion where individual knowledge is acknowledged and elaborated during concept map sharing and reviewing, we introduce a learning activity at the boundary. Boundaries are socio-cultural differences leading to a discontinuity in action or interaction (Sanne F.

Akkerman & Bakker, 2011). Boundaries are not seen as barriers to learning, but also "spaces" with potential for learning (Sanne F. Akkerman & Bakker, 2011). The boundaries can be crossed by people, or by objects or by interactions between actors of different practices. Boundary crossing refers to the process of "negotiating and combining ingredients from different contexts to achieve hybrid situations" (Engeström, Engeström, & Kärkkäinen, 1995). Objects that cross boundaries are often referred to as boundary objects. Some potential learning mechanisms at boundaries are identification, coordination, reflection, and transformation (S. F. Akkerman, 2011).

Boundary objects can be abstract or concrete things, such as repositories, rules, forms, or maps. A map represented one's perspective is a type of boundary artifacts used for communication among different community of practices. Moreover, the map components such as nodes or links can also be boundary objects to help students to get started. By providing the same map components, individuals can create concept maps with different structures to illustrate own thoughts. These components serve as a reference point to identify similarities and differences in understanding. Coordination and reflection of those components are potential to promote mediation and negotiation of meaning during the discourse, further trigger the transformation of knowledge.

A Kit-Build (KB) approach is a type of re-constructional concept mapping activity where students are requested to build a concept map based on the specified components (i.e. nodes and linking words) defined by a teacher (Hirashima, 2018; Hirashima, Yamasaki, Fukuda, & Funaoi, 2015). Students need to find the map structure by themselves, then those of reconstructed map structures will be compared with their peer's map or with the teacher's map. KB system will display similar propositions as a shared map, as well as dissimilar propositions composed only by students or a teacher as a difference map. Hence, the teacher can assess students' understanding of learning materials instantaneously and provide prompt feedback.

Our proposed activity, named as RKB, exemplifies the KB approach for peer-to-peer communication. Predefined nodes or linking words will play a role as a boundary object to encourage boundary-crossing. We aim to evaluate whether our proposed activity can support potential learning mechanism at the boundary during collaboration. The following research questions guided our study:
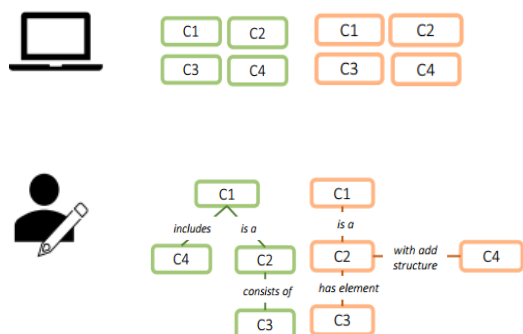a) Whether and to what extent do the RKB approach improve students' learning achievements after collaborative concept mapping activity?
b) Whether and to what extent do the RKB approach affect the quality of the collaborative product?
c) Whether and to what extent do the RKB approach affect students' metacognition on the group level, specifically, group regulation of cognition?
d) How is the knowledge convergence between members in a group prior to, during, and after collaboration following the RKB?
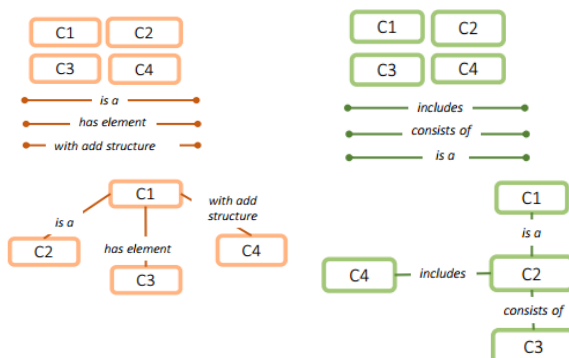
2. Research Methodology

2.1 The Learning Activity: Reciprocal Kit Build

We design a learning environment for dyads to co-construct a concept map with two different phases, i.e. individual and collaborative phase.
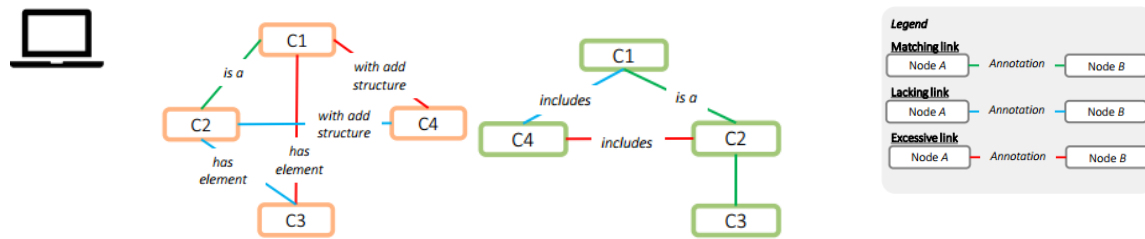

(1) Initial map construction (individual)   *(2) Re-constructional map building (individual)*

(3) Visualization of map differences and group discussion (collaboration)

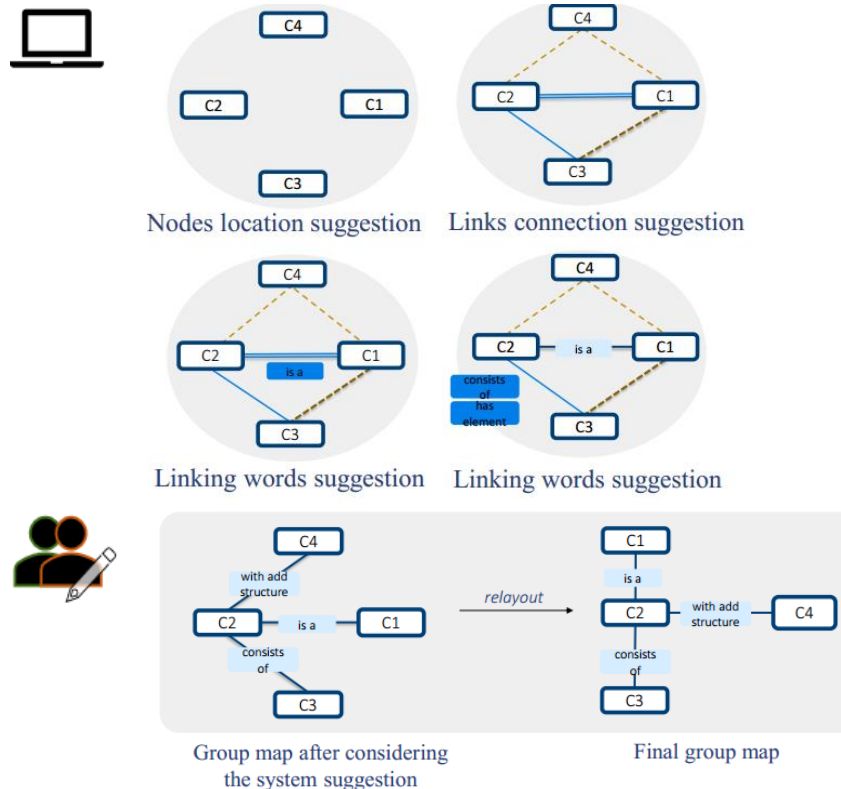*(4) Group map construction (collaboration)*

Figure 1. The Reciprocal Kit Build Design Activity in collaborative settings.

2.2 Data Collection Procedures

The collected data consist of concept maps, activity logs, questionnaires, and audio discussion. The concept maps and learners' activity data will be collected through a web-based RKB system. The constructed concept maps during individual and collaborative phase are continuously recorded while learners are progressing throughout the activities. We will also gather individual post-collaboration maps a week after the experiment session. The sequence of activities and the discussion while building the maps will be recorded and analyzed to investigate the process of collaborative knowledge construction. After the collaboration, we conduct a survey on group metacognition scale for online collaborative learning proposed by Biasutti and Frate (2018).

Based on the data, we will measure students' learning outcomes and the knowledge transfer from individual-to-group and from group-to-individual (during and after collaboration). There are two types of learning outcomes; at a group and individual level. The group learning outcomes will be measured from the collaborative map, while the individual learning outcomes will be evaluated based on the score gain from initial maps to the post-collaboration maps. Knowledge convergence prior to, during, and after collaboration are assessed based on the similarity of group members' initial maps, the individuals' maps with the group's map, and the group's map with post-collaboration maps. The

similarity of maps may represent two types of knowledge convergence measures, i.e. knowledge equivalence and shared knowledge (Weinberger, Stegmann, & Fischer, 2007). As a process, the knowledge convergence within a group will be analyzed from the discourse and the log data. We will investigate students' metacognition on the group, specifically, we are interested to analyze items related to the group regulation of cognition (Biasutti & Frate, 2018).

3. Conclusion

We propose a Reciprocal Kit Build approach to extend the collaborative concept map construction in a pair. We also describe the system design and how it potentially supports the creation and evolution of active boundary objects during collaboration, i.e.: afford individual reflection and exploration, create awareness of each other's work, enable co-creation, and allow participants to build on the work of others. Our approach is unique since we are integrating some best practices on collaborative concept mapping activities and situate the learning process with different types of boundary objects, e.g. maps, nodes, and links. Further, we need to realize the system design, conduct some experiments, and evaluate the results.

Acknowledgments

References
Akkerman, S. F. (2011). Learning at boundaries. International Journal of Educational Research, 50(1), 21–25. https://doi.org/10.1016/j.ijer.2011.04.005
Akkerman, Sanne F., & Bakker, A. (2011). Learning at the boundary: An introduction. International Journal of Educational Research, 50(1), 1–5. https://doi.org/10.1016/j.ijer.2011.04.002
Basque, J., & Lavoie, M.-C.-. C. (2006). Collaborative concept mapping in education: Major research trends. Concept Maps: Theory, Methodology, Technology. Proc. of the Second Int. Conference on Concept Mapping., 1, 79–86. Retrieved from http://eprint.ihmc.us/119/
Biasutti, M., & Frate, S. (2018). Group metacognition in online collaborative learning: validity and reliability of the group metacognition scale (GMS). Educational Technology Research and Development. https://doi.org/10.1007/s11423-018-9583-0
Engelmann, T., & Hesse, F. W. (2010). How digital concept maps about the collaborators' knowledge and information influence computer-supported collaborative problem solving. International Journal of Computer-Supported Collaborative Learning, 5(3), 299–319. https://doi.org/10.1007/s11412-010-9089-1
Engeström, Y., Engeström, R., & Kärkkäinen, M. (1995). Polycontextuality and boundary crossing in expert cognition: Learning and problem solving in complex work activities. Learning and Instruction. https://doi.org/10.1016/0959-4752(95)00021-6
Fischer, F., & Mandl, H. (2002). Facilitating knowledge convergence in videoconferencing environments: the role of external representation tools. Proceedings of the Conference on Computer Support for Collaborative Learning: Foundations for a CSCL Community, (Cscl), 623–624.
Gracia-Moreno, C., Cerisier, J.-F., Devauchelle, B., Gamboa, F., & Pierrot, L. (2017). Collaborative knowledge building through simultaneous private and public workspaces. Data Driven Approaches in Digital Education, 10474, 553–556. https://doi.org/10.1007/978-3-319-66610-5
Hirashima, T. (2018). Reconstructional Concept Map: Automatic Assessment and Reciprocal Reconstruction. The 2nd Annual International Conference Learning Innovation.
Hirashima, T., Yamasaki, K., Fukuda, H., & Funaoi, H. (2015). Framework of kit-build concept map for automatic diagnosis and its preliminary use. Research and Practice in Technology Enhanced Learning, 10(1), 17. https://doi.org/10.1186/s41039-015-0018-9
Roschelle, J., & Teasley, S. D. (1995). The construction of shared knowledge in collaborative problem solving. In Computer Supported Collaborative Learning. https://doi.org/10.1007/978-3-642-85098-1_5
Stoyanova, N., & Kommers, P. (2002). Concept mapping as a medium of shared cognition in computer-supported collaborative problem solving. Journal of Interactive Learning Research. https://doi.org/10.1161/CIRCOUTCOMES.110.942318
van Boxtel, C., van der Linden, J., Roelofs, E., & Erkens, G. (2002). Collaborative concept mapping: Provoking and supporting meaningful discourse. Theory Into Practice, 41(1), 40–46. https://doi.org/10.1207/s15430421tip4101_7
Weinberger, A., Stegmann, K., & Fischer, F. (2007). Knowledge convergence in collaborative learning: Concepts and assessment. Learning and Instruction. https://doi.org/10.1016/j.learninstruc.2007.03.007

Examining the Effects of Leaderboards in Gamified Learning Environment

Shurui BAI

Faculty of Education, The University of Hong Kong, Hong Kong SAR

shurui18@hku.hk

Abstract: Gamification is widely defined as the use of game design elements in non-game contexts. Recent years have witnessed a significant growth of gamification studies, and the most commonly used game elements among the studies are the leaderboards. Research findings on the effects of leaderboards so far have been mixed. On one hand, previous studies have shown that leaderboards can motivate participants to perform more tasks and improve their learning performance. On the other hand, leaderboards can also demotivate participants in completing their learning activities. This study aims to systematically investigate the effects of different variations of leaderboards using experimental designs in the higher education context. More specifically, this study will manipulate three main independent variables-anonymity of learners' identity, learners' ranking position, and learners' group size on a leaderboard. The dependent variables include participant academic performance, course engagement, participant intrinsic motivation and participant perception. Three hypotheses will be proposed and tested.

Keywords: Leaderboards, gamification, academic performance, motivation

1. Introduction and Previous Study

In recent years, gamification has become a buzzword across various academic disciplines. It is often defined as the application of digital game elements in non-gaming contexts to motivate user behavior (Deterding et al., 2011). It has been proposed that gamified practices will become a key element in motivating people to complete certain tasks such as improving their fitness (Nike+), answering other people's questions (Yahoo! Answers), or completing learning activities.

It is important to note that findings from previous comparison studies are limited because they usually included more than one game mechanics. This makes it impossible to parse out the effects and pinpoint a specific causal factor. For example, Hew et al. (2016) conducted two experiments to examine whether a digital points-badge-leaderboard system (Experiment groups) would promote superior quality of student work when compared to students without any digital game mechanics (Control groups). Results found that a gamified system positively motivated students to engage with more difficult tasks and produced better student artifacts than the control condition.

This study focuses only on one specific game element – the leaderboard, which is one of the most commonly used game elements in previous gamification studies (Sailer et al., 2014). Leaderboard is a high-score reputation table which rank users by their performance. Leaderboards satisfy a person's need for achievement by comparing his or her own abilities against others'. By displaying a list of players' ranks upward or downward, an order of competition against success criteria are available. However, in most cases, only learners on the top of leaderboards get satisfied and engaged, those at the bottom leave off comparison (Sailer et al., 2014).

In this study, we aim to investigate the effects of different variations of leaderboards on participant academic performance, course engagement, participant intrinsic motivation and participant perception. This study will manipulate three main independent variables – learners' identity, learners' ranking position, and learners' group size on a leaderboard. Three hypotheses will be proposed and tested.

2. Hypotheses

2.1 Hypothesis about Anonymous Information for Comparison

According to *Social Comparison Theory*, people have the tendency to use attained information to evaluate their opinions or abilities with others to obtain accurate appraisal when objective criteria are absent (Festinger, 1954). Public information about people's relative position helps increase their motivation effects (Webster et al., 2003). People will be motivated more if his rank is high, and is also known by others, but the motivation will be diminished if no one knows (Mcleod, 2011). Based on the social comparison theory, we propose the first hypothesis about the anonymity of personal identification on leaderboards setting: *H1: Non-anonymous personal identification on leaderboard setting enhances individual academic performance, engagement, intrinsic motivation; and students hold a positive perception towards it than the anonymous counterpart.*
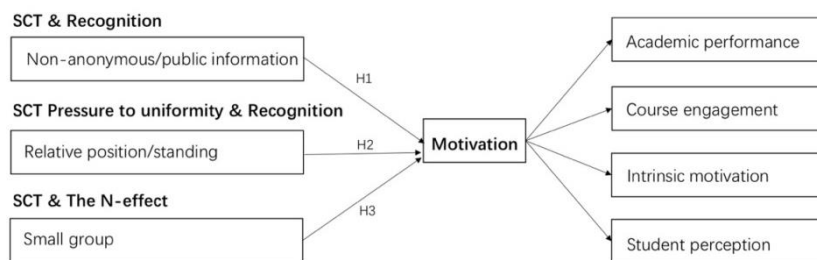
Note: SCT Social comparison theory
Figure 1. Theories underpinning hypotheses of motivation

2.2 Hypothesis about Positioning Scheme

Leaderboards type can be divided based on positioning scheme: the relative positioning (also named no-disincentive leaderboards) and the absolute positioning (also named as infinite leaderboards). Relative leaderboards only present players above or below him/her. The absolute leaderboards display the literal ranks of every player. Players are always under threats of being beaten and falling off. The absolute leaderboards are commonplace in gamified learning (e.g., Özdener, 2018). According to the *pressure to uniformity* under *social comparison theory*, the effect is strong when people make comparison with those who are close to their abilities or opinions (Festinger, 1954). For example, learners prefer to compare their course assessment scores with competitors with similar levels. Therefore, relative leaderboards are assumed to perform better. The hypothesis is: *H2: Relative positioning scheme enhances individual academic performance, engagement, intrinsic motivation; and students hold a positive perception towards it in comparison to the absolute positioning scheme.*

2.3 Hypothesis about Group Size

The N-effect under social comparison theory manifests the negative relationship between the number of competitors (N) and a person's competitive motivation on individual tasks (Garcia & Tor, 2009). Social comparison becomes weak and competitive motivation diminishes under the environment of a large number of competitors. In one of Garcia's empirical study (2009), individuals completed a quiz significantly faster when they believed they competed with 10 rather than 100 other participants. Group sizes mediate the user's contribution to a community. Leung (2019) manipulated group sizes in three levels (10, 20 and 50) to compare user's response to different scores of their peer groups. In the educational field, group size is often confined to class size. Given the N-effect, we hypothesize that larger group size dampens individual motivation on student learning tasks. This leads to the third hypothesis: *H3: Small group size enhances individual academic performance, engagement, intrinsic motivation; and students hold a positive perception towards it.*

3. Methods

3.1 Participants

Participants will be recruited from a university in an Asian region. After consent forms are signed by individuals; demographic information will be collected for further data analysis. Gender is not presumed to be one influential factor, but the gender ratio will be reported for educational implication. The intervention duration for each sub-experiment is assumed as one semester (8-12 weeks).

3.2 Experiment Design

We will gamify our intervention by incorporating a plugin module called Level Up! to Moodle. This module enables learners to earn experience points in their courses. Level Up! can grant students a corresponding rank and badge automatically when they collect enough points. It is a user-friendly module which allows educators to manually display students' personal identity or not, so we can make comparison between anonymous and non-anonymous groups for the sake of the first hypothesis. As for the second hypothesis testing, we can activate the relative ranking or the absolute ranking by clicking a button "ranking" in setting. In the third experiment, we will recruit three classes (i.e., small, medium and large group sizes) to examine the effects of different group sizes.

3.2.1 Experiment One for H1

One class in a university will take part in this experiment within one semester to test the first hypothesis. We apply group sequential study, which means the treatment class will expose to multiple interventions in a set order (Thompson & Panacek, 2006). This design helps lead to a conclusion much earlier and allow a near-perfect match of participants. Internal validity of group sequential study does not depend on random assignment and has a higher statistical power (Charness et al., 2011), but the carryover effects may occur. We will completely counterbalance the effects by making the treatment order an independent variable. So different participants are exposed to different orders of treatments. There are two interventions in the treatment class: anonymous leaderboards (AL) and non-anonymous leaderboards (NAL). It is to say, participants in the treatment class will be divided into two groups by random draw, we apply AL-NAL order to half of the students and NAL-AL order to the rest of students at the same time.

3.2.2 Experiment Two for H2

A two-arm study is conducted: the relative positioning group and the absolute positioning scheme group. We administrate this experiment in a postgraduate course by randomly dividing a class of students into two groups of an equal number. The experiment will last for one semester and the pre-tests are conducted at the beginning of the intervention. We videotape every class activity and transfer the

in-class points into the learning management platform Moodle. The measurement of intrinsic motivation and engagement will be conducted after the intervention by two scales. Whether to use anonymous or non-anonymous leaderboards depends on the result of the first experiment.

3.2.3 Experiment Three for H3

Finally, we set up a favorable dashboard based on results from experiment one and two. Then we apply those leaderboards into three group sizes (i.e., small, medium and large). We have no pre-knowledge about the sample size, so we assign the large group size five times more than the small group size and twice more than the medium group size to maximize statistical power (Leung, 2019). For example, Leung (2019) manipulated group sizes in three levels (10, 20 and 50). Students initial levels, prior knowledge will be tested and measurement on intrinsic motivation and engagement will be conducted after the intervention.

3.3 Measurement of the Research Outcomes

As for individual achievement performance, we measure student academic performance partially through in-class and out-of-class activities. The preliminary points-adding criteria are designed based on teaching objectives. We also measure individual student academic performance via academic tests (e.g., final test scores, midterm test scores, and standardized test scores). Exams or assignments developed by instructors are common in the higher education context.

With regards to course engagement, two instruments were consulted: a) the Student Course Engagement Questionnaire (SCEQ) proposed by Handelsman, Briggs, Sullivan, and Towler (2005) and b) the self-developed points-adding criteria, by which we can measure student obvious participation engagement. Since emotional engagement is hard to measure by observation, and we know little about students who fail a certain assignment or test; therefore, SCEQ scale can complement our measurement by taking account of skills, participation/interaction, emotion, and performance engagement. We use Intrinsic Motivation Inventory (IMI) to measure the intrinsic motivation of individual students. After the intervention of three experiments, an interview will be held to understand student perception towards leaderboards in terms of anonymity, positioning scheme and group size.

References

Charness, G., Gneezy, U., & Kuhn, M. A. (2011). Experimental methods: Between-subject and within-subject design. *Journal of Economic Behavior and Organization*. Doi:10.1016/j.jebo.2011.08.009.

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). *From game design elements to gamefulness: defining "gamification"*. Paper presented at the Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments, Tampere, Finland.

Festinger, L. (1954). A Theory of Social Comparison Processes. *7*(2), 117-140. Doi:10.1177/001872675400700202.

Garcia, S. M., & Tor, A. (2009). The N-Effect: More Competitors, Less Competition. *Psychological Science, 20*(7), 871-877. Doi:10.1111/j.1467-9280.2009.02385.x.

Handelsman, M. M., Briggs, W. L., Sullivan, N., & Towler, A. (2005). A Measure of College Student Course Engagement. *The Journal of Educational Research, 98*(3), 184-192. Doi:10.3200/JOER.98.3.184-192.

Leung, W. (2019). *How Do One's Peers on a Leaderboard Affect Oneself?* Paper presented at the Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, Glasgow, Scotland Uk.

Mcleod, P. L. (2011). Effects of Anonymity and Social Comparison of Rewards on Computer-Mediated Group Brainstorming. *42*(4), 475-503. Doi:10.1177/1046496410397381.

Özdener, N. (2018). Gamification for enhancing Web 2.0 based educational activities: The case of pre-service grade school teachers using educational Wiki pages. *Telematics and Informatics, 35*(3), 564-578. Doi:10.1016/j.tele.2017.04.003.

Sailer, M., Hense, J., Mandl, H., & Klevers, M. (2014). Psychological perspectives on motivation through gamification. *Interaction Design and Architecture(s), 19*(1), 28-37.

Thompson, C. B., & Panacek, E. A. (2006). Research study designs: Experimental and quasi-experimental. *Air Medical Journal, 25*(6), 242-246. Doi:10.1016/j.amj.2006.09.001.

Webster, J. M., Duvall, J., Gaines, L. M., & Smith, R. H. (2003). The Roles of Praise and Social Comparison Information in the Experience of Pride. *The Journal of Social Psychology, 143*(2), 209-232. Doi:10.1080/00224540309598441.

Mining Student Experience and Feedback in Social and Professional Issues in IT: Basis for Understanding Blended Learning

Arlene Mae CELESTIAL-VALDERAMA[ab*]
[a]*College Faculty, Jose Rizal University, Mandaluyong City, Philippines*
[b]*Graduate Student, University of the East, Manila, Philippines*
*arlene.valderama@jru.edu

Abstract: In most organizations, surveys are conducted for copious objectives. Surveys are traditions of collecting data that has become the voice of the customer relayed and conveyed anonymously or blatantly. Various learning institutions, mostly universities at large, has made it customary to allow students answer surveys intended to collect views on their overall assessment covering their satisfaction in the entire course as the semester concludes. In Jose Rizal University, student feedback is collected in various survey formats. One of which is called the Canvas Learning Experience survey that provides opportunity to the learners to comment on the proficiency of the implementation of the blended learning course. It seeks student comments on specific areas for improvement in the teaching and learning process. The conveyance of whether these students are immensely satisfied with their learning environment and experience matters mostly to the university treating them as customers and partners. One of the significant objectives of this research is to develop a blended learning feedback mining system that empowers the educational institution administration to inspect at the reproaches of their clients' learning experience in the blended learning course and thus upgrade them accordingly. The conceptual framework of this research centers on catching and investigating criticism information from students' perceptions basing from their qualitative comments using text mining. In turn, the framework will give the fundamental structure in the implementation of the feedback mining system that the university may utilize for addressing the results of the Canvas Experience survey.

Keywords: feedback mining system, student feedback, student learning experience, text mining, blended learning experience

1. Introduction

In most organizations, surveys are conducted for copious objectives. Surveys are traditions of collecting data that has become the voice of the customer relayed and conveyed anonymously or blatantly. In universities and learning institutions, it has become a practice that students answer surveys intended to collect their views of their overall assessment covering their satisfaction as customer in the entire course that has concluded or is about to conclude. Likely, the conveyance of whether these students are immensely satisfied with their learning environment and experience, treating them as customers of the university has always been of vital importance to the academic division of the university following on the mission and vision of the institution. These surveys contain Likert-scale questions considered to be quantitative as well as qualitative ones. In its likelihood, the results of these surveys are measured and analyzed. Items with low results are then subjected to an action plan for addressing and progressive disposition.

One of the significant objectives of this research is to develop a blended learning feedback mining system that empowers the educational institution administration to inspect at the reproaches of their clients' learning experience in the blended learning course and thus upgrade them accordingly. As many educational institutions pay a ton of consideration to quantitative input, measurable correlations are processed and presented to school administrators. In any case, the subjective remarks given by students are not completely intercepted. In this paper, the conceptual framework of the study centers on catching and investigating criticism information from students' perceptions basing from their

qualitative comments using text mining. In turn, the framework will give the fundamental structure in the implementation of the feedback mining system that the university may utilize for addressing the results of the Canvas Experience survey.

1.1 Blended Learning

According to Thorne et al. (2003) as mentioned by Irawan et al. (2017), blended learning gives an opportunity to integrate the innovative and technological advances in online learning with the interaction and participation toward traditional learning. Blended Learning is a learning that combines the technology and traditional instructor-led training in the room (Bersin, 2004, p. 56). Blended Learning has four characteristics, namely: (1) learning which combines technology; (2) combination of face-to-face learning, independent, and online; (3) the combination of effective learning, and (4) teachers and parents as facilitators and supporters (Husamah, 2014, p. 16).

Jose Rizal University has long since ventured the utilization of blended learning. The institution has coined the term Course Redesign Program (CRP) to selected courses under the General Education curriculum. In the CRP, face-to-face class meetings were reduced, and online interactive set of learning activities awaited the enrolled students from the various general education courses. Learners enjoy the independence of accomplishing their online activities and assignments in their own free time inside or outside the campus. For the time being, the university has set a separate institute, called the Institute of Technology-Based Learning (ITBL) who is responsible for the management of blended learning courses. ITBL is under the authority of the University Vice President for Quality, Linkages, and Technology Enabled Learning. At present, ITBL caters courses from the different colleges in the university. JRU students have long been owning to the benefits of blended learning to their advantage and the academic divisions have increased the learning outcomes through this deployment. ITBL utilizes the Canvas Learning Management System as the medium in catering distance learning mode for the courses.

This paper focuses on one of the most recent additions of blended courses from the Information Technology department under the College of Computer Science and Engineering, it is called ITC C203, Social and Professional Issues in IT. This course is offered to Bachelor of Science in Information Technology majors in their second-year level. ITC C203 as a blended learning course allows a once a week 1.5 hours face-to-face meeting with an instructor. The rest of their learning activities are done online in the convenience of both students and faculty. The learning experience and feedback of the students enrolled in this course are the focal points of this study as these comments will be mined using text analytics.

2. Conceptual Framework

The target of this proposal paper is grounded in gaging the student qualitative feedback and stage a range of topics exhibited affirmative and adverse. The core of the data collection is the student experience in the course redesign program of the university, the conduct of the blended learning course. The most recent addition from the Information Technology department is the course, Social and Professional Issues in IT. This blended learning course includes 1.5 weekly face to face meetings.

In the blended learning approach, Alontaga et al (2013) has mentioned the community of inquiry framework (CoI) as applied in the same university's course redesign program. The CoI framework served as the evaluation framework for the study to determine the blended learning experience of the students and to improve the blended learning program. For the course as the nub of the student learning experience, ascertained in the teaching, social, and cognitive presence allows the course to progress accordingly. The student feedback will then substantiate the community of inquiry framework (CoI) applied to the course.

The conceptual framework of the study is depicted in Figure 1. The comments of the students in ITC C203 (Social and Professional Issues in IT) serves as input to the architectural concept of the framework. The comments will be grouped based on a common topic, using a clustering algorithm. The sentiment of the topic shall then be obtained. The topics along with the sentiment polarity score will then be amassed to be reported visually.
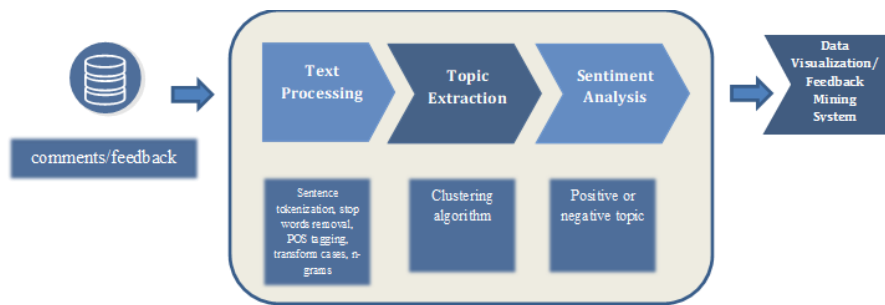
Figure 10. Conceptual Framework of the Study

The summative report will include a demonstration on the significant clusters of the comments and words for the topic extraction task. The topics along with its sentiment polarity scores will be depicted. The negative topic result will be paralleled to an aligned business rule presented through key result areas with regards to course improvement.

3. Problem Statement and Objectives

With the aim to reckon numerous comment feedback from students in a blended learning course, the faculty must read unstructured comments and act upon these to improve the student learning experience. In this lieu, this paper intends to examine and unravel the research question of how unstructured student feedback comments be mined to prescribe course improvements in a blended learning course. The qualitative feedback process shall aid the ITBL in making decisions in the aspects of teaching and learning course improvement to shove the continuance of providing the student stakeholders in caring about good education. Further, the research will develop a business intelligence feedback mining system with a user-interface that implements the conceptual framework of the study. The research question individualizes sub-questions as follows:

- Research Question 1: How the blended learning course student feedback via numerous unstructured comments be identified and categorized?
- Research Question 2: Identify a data mining technique to group the comments based on key topics.
- Research Question 3: How can clustered topics be classified into the nature of its positivity or negativity?
- Research Question 4: How can the clustered group be aligned leading to course improvement suggestions and be presented into a web interface?

The aim of this work is to examine the student comments relating to their experience in a blended learning course. It aims to utilize various types of actionable information called topic sentiment to facilitate the improvement of the course in the teaching and learning process and provide students with a more buildable learning experience. The research objectives in alignment to the research questions are as described:

- Research Objective 1: Perform a feedback mining process to extract topics based on top frequency words from the comments.
- Research Objective 2: Run a clustering technique that generates the key topics into clusters.
- Research Objective 3: Implementing a sentiment analysis technique to suggest target solutions in the improvement of the blended learning course.
- Research Objective 4: Develop a business intelligence feedback mining system that prescribes key components of the blended learning course in terms of its improvements in the teaching and learning process.

4. Scope, Delimitation, and Significance of the Study

The focus of this research is to employ a text mining approach to mine student comments from a blended learning course that highlights their learning experience. It shall develop a blended learning feedback mining system that implements its conceptual framework. The proposal is demarcated in one blended learning course under ITBL managed by the office of the vice president for quality, linkages, and technology enabled learning. Data from the students enrolled in the blended learning course shall

be the source of input. The location of this intended study is under the IT department of the institution. The Canvas experience survey contains Likert-scale questions and qualitative questions for the from which the commentary part of students' suggestions for improvement is. It shall provide the necessary structure for implementing a prototype tool to be tested for mining student comments from the qualitative responses of the students. As the relationship between quantitative and qualitative feedback may provide further results, the presentation of the correlational aspects of both feedbacks and the quantification of the qualitative comments will remain a recommendation. In the text analytics approach, comments with multiple topic generation will be left for future work.

JRU has been at par in the maintenance quality standards as to institutional and program accreditations. The research goals allow the university administrators to adjust to necessary improvements from which suggested by one of their most important customers, the students. Leckey, J., & Neill, N. (2001) signified that student feedback is not only important for course improvement. In this case, student learning experiences are not an exception. To maintain the accreditation level in the areas of faculty, instruction and laboratories (FIL), student feedback must be taken in serious context.

5. Research Design and Methodology

The university's Canvas learning experience survey is the tool to be used in the data collection of this study. The manner from which students will answer the survey is through an anonymized online survey. The students' input data will come from one blended learning course in the university's ITBL managed courses. In the first phase, data collection is executed. Comments function as the input as the pre-processed data. The second phase is to extract individual sentences and phrases using tokenizers. Tokenization deals with the splitting of text into units during data preprocessing. Text can be tokenized into paragraphs, sentences, phrases and single words. The delimiters used in this process vary with data sets (GI Nitin et al, 2015). In the stop word removal, the most frequently used words in English are useless in text mining as they will be removed. Stop words are language specific functional words which carry no information and therefore removed from the documents during data preprocessing stage (GI Nitin et al, 2015). POS tagging, transform cases, n-grams will also be applied to the process. The third phase will be extracting topics and their sentiments using clustering techniques. The last stage is the visualization. The goal of text analytics is to derive high-quality information from text. Typical text mining tasks include; text categorization, text clustering, concept or entity extraction, production of granular taxonomies, sentiment analysis, document summarization, correlations, and entity relation modelling (Gottipati, S., Shankararaman, V. & Gan, S, 2017).

References

Thorne, K. (2003). Blended learning: How to integrate online and traditional learning. London: Kogan Page.

Irawan et al. (2017). Blended learning based on schoology: Effort of improvement learning outcome and practicum chance in vocational high school Cogent Education (2017), 4: 1282031 http://dx.doi.org/10.1080/2331186X.2017.1282031

Bersin, J. (2004). The blended learning book: Best practices, proven methodologies, and lesson learned. San Fransisco, CA: Pfeiffer Publishing.

Husamah. (2014). Pembelajaran Bauran [Blended learning]. Jakarta: Prestasi Pustaka

Alontaga, J., Valderama, A. et.al (2013). Examining Blended Learning Experiences of Higher Education Students, Paper presented in the International Congress in E-Learning 2013, The Heritage Hotel December 6-7, 2013.

Leckey, Janet & Neill, Neville. (2001). Quantifying Quality: The importance of student feedback. Quality in Higher Education. 7. 19-32. 10.1080/13538320120045058.

G. I. Nitin, G. Swapna and V. Shankararaman, "Analyzing educational comments for topics and sentiments: A text analytics approach," 2015 IEEE Frontiers in Education Conference (FIE), El Paso, TX, 2015, pp. 1-9. doi: 10.1109/FIE.2015.7344296

S. Gottipati, V. Shankararaman and S. Gan, "A conceptual framework for analyzing students' feedback," 2017 IEEE Frontiers in Education Conference (FIE), Indianapolis, IN, 2017, pp. 1-8. doi: 10.1109/FIE.2017.8190703.

Promoting Students' Self-Direction Skills through Scaffolding with Learning and Physical Activity Data

Huiyong LI[a]*
[a]*Graduate School of Informatics, Kyoto University, Japan*
*lihuiyong123@gmail.com

1. Introduction

With the growing trend of preparing students for lifelong learning, the theories of self-directed learning have been increasingly applied in the context of K12 and higher education. Being self-directed would help students to prepare them for success in their future careers, and enables them to engage in lifelong learning. Since it is a cognitively and behaviorally complex task to execute self-direction, it's crucial to create a data-rich environment where students are given more opportunities to engage in self-direction.

Self-direction Skills (SDS) are acquired through experience, training, and effort. The benefits of experience and training will depend on the degree to which people engage through volitionally initiated thought processes. It is becoming a trend to utilize technologies in education, and students' learning behaviors in an online learning environment can be automatically recorded by learning systems. Such learning records provide new opportunities to model students' learning process. On the other hand, the increased availability of the activity tracking data gives individuals more opportunities for establishing benchmarks in objective metrics and improving achievements through the experience of reality (Swan, 2013). The research and design of data quantification have grown as an interest area in information and learning sciences (Lee, 2019).

Therefore, this research focuses on developing a seamless technology platform that supports SDS in students' day to day context, especially building an adaptive scaffolding in the execution and acquisition of SDS. Students' learning and physical activities are chosen as context and the interactions between students and the platform are also recorded as indicators of the development of SDS.

2. Research Goals

This research aims to build an adaptive scaffolding in the execution and acquisition of SDS themselves under the context of learning and physical activities. Three major areas must be investigated for the research.

- What is SDS and its sub-skills acquisition in a data-rich environment?
- How to leverage learning and physical activity data to develop SDS?
- How to design an adaptive scaffolding for the acquisition of SDS in a data-rich environment?

To achieve the research goal, the Goal Oriented Active Learner (GOAL) system is designed and implemented to integrate learning and physical activity data, concretize the process of self-direction and embed the adaptive scaffolding. Students are expected to gradually enhance their SDS in the GOAL system during the daily cycle of data collection, self-analysis, self-planning, monitoring, and self-reflection.

3. Related Work

3.1 Self-Direction Skills

According to P21 (Partnership for 21st Century Skills, 2016) framework, Initiative and Self-Direction requires monitoring one's understanding and learning needs, demonstrating initiative to advance professional skill levels, defining, prioritizing and completing tasks without direct oversight and

demonstrating commitment to lifelong learning. It requires learners to handle multiple environments, goals, tasks, and inputs while understanding and adhering to organizational or technological constraints of time, resources, and systems. The conceptual framework gives a general criterion for a self-directed learner.

Self-directed learning (SDL) and self-regulated learning (SRL) are two most frequently used terms in today's educational discourse on the learning process (Brockett & Hiemstra, 2018; Candy, 1991; Winne et al., 2006; Zimmerman, 2008). Literature highlights their commonality and differences (Saks & Leijen, 2014). Both SDL and SRL have 4 key phases: Task definition – Setting goals and Planning – Enacting strategies – Monitoring and Reflecting. SDL due to its adult education roots is mostly used for describing the learning activities outside the traditional school environment. SRL, on the other hand, is mostly studied in the school environment.

Technological innovation in the field of data logging and rapidly increasing digital world have expanded the intersection of SDL and SRL. The processes of executing and developing SDL and SRL can be captured. For this research, I adopted a five-phase process model, DAPER which synthesizes the SDL and SRL models to conceptualize data-driven SDS execution and acquisition (Majumdar et al., 2018). It has five phases, the initial phase of data collection which gives learners the initiative, followed by the other four phases: data analysis, planning, execution monitoring, and reflection. Figure 1 provides an overview of the DAPER phases with example from the context of learning and physical activities.
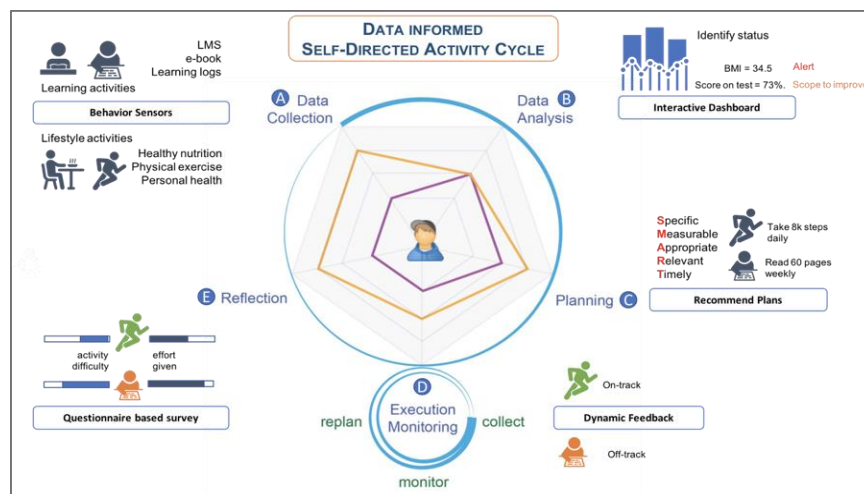

Figure 1. DAPER Model of Self-Direction Skills Execution (Majumdar et al., 2018)

3.2 Quantified-Self

Quantified-Self movement emphasizes the importance of the regular collection, processing, and presentation of data on behavioral indicators, environmental indicators or biological indicators as measures to evaluate personal performance so that individuals can better achieve progress in their areas of interest (Choe et al., 2014). Individuals with focus on the setting process-oriented goals are often interested in the stream of data regarding their own activities during that process to monitor goal accomplishment and if necessary re-plan. The research and design of quantified-self have grown as an interest area in information and learning sciences (Lee, 2019). The quantified resources and technology begin to be used for educational purposes. But keeping track of variables of interest is often time-consuming as data collection is not unified in one application.

3.3 Adaptive Scaffolding

Scaffolds are tools, strategies, and guides that can be designed to support students in directing their learning. Scaffolds can be provided by human and computer tutors, teachers, peers, and animated pedagogical agents during learning to enable students to develop understandings beyond their immediate grasp (Chi et al., 2001). Adaptive scaffolding requires a teacher or tutor to continuously diagnose the student's emerging understanding and provide timely support during learning (Azevedo et

al., 2004). Adaptive scaffolding may be more beneficial for supporting students' self-directed learning because it adjusts to meet students' learning needs. However, there is a lack of empirical evidence regarding the effectiveness of adaptive scaffolding to support the acquisition of SDS.

4. Methods

The Design and implementation of GOAL system is shown in Figure 2. The GOAL system integrates data during learners' learning and physical activities, tracks the interactions between learners and system, and implements the DAPER model with the functionalities required in each phase. Learners can link automatically their learning activity data from the LMS and other linked e-learning tools. For physical activity data, students authenticate to synchronize that data directly from mobile health apps or platforms for wearable devices. This system grounds the theory of SDS and enables learners to develop the skills in the context of learning and physical activities, like e-book reading, walking, running.
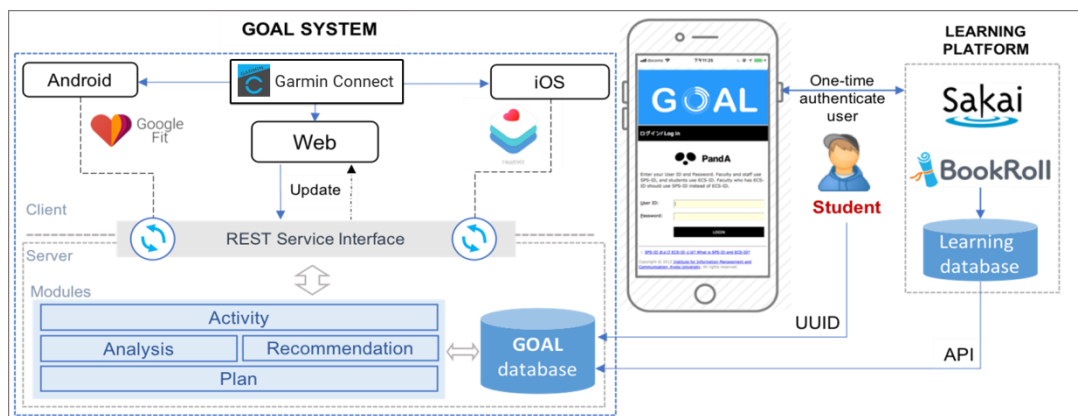

Figure 2. The Design and Implementation of GOAL System

The framework of scaffolding for self-direction skills acquisition in a data-rich environment is given in Figure 3. It contains activities, scaffolding in GOAL, and self-direction skills. The learners' activity data is the records of learning systems and physical activity platforms. During the learners execute their own learning or physical activity, the scaffolding will be provided to execute and acquire SDS. Two components of scaffolding are required: tasks and interface features. The tasks would be given to demonstrate the SDS sub-skills and the interface features are used to execute these tasks. Finally, five SDS sub-skills are measured and promoted based on the interactions between the learners and GOAL system: data sufficiency in data collection phase, status identification in data analysis phase, SMART (Specific, Measurable, Appropriate, Relevant, Timely) planning in planning phase, regular tracking in execution monitoring phase, and self-evaluation in reflection phase.
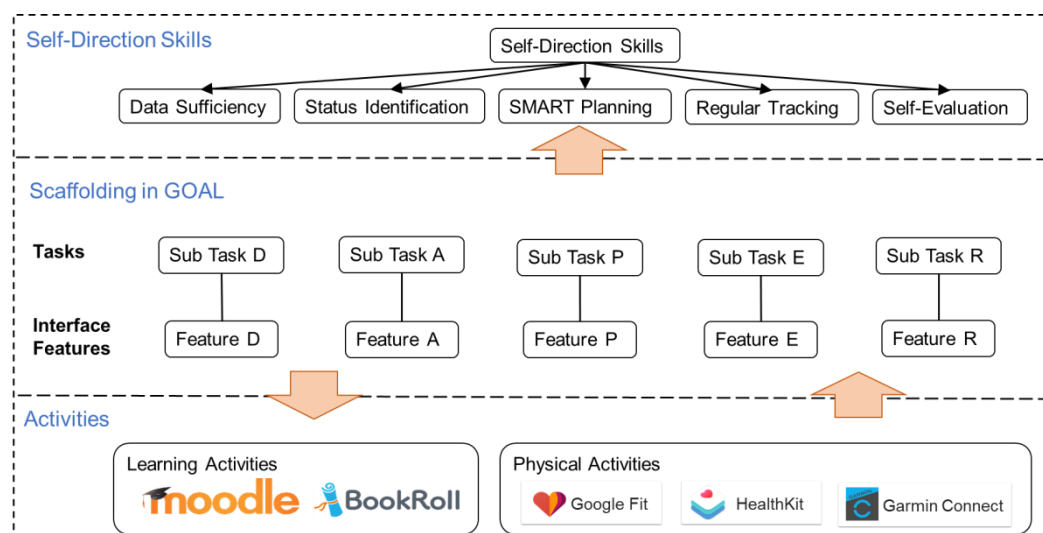

Figure 3. Scaffolding for Self-Direction Skills Acquisition in a Data-Rich Environment

5. Expected Academic Contributions

SDS are considered as a necessary 21st century skills (Partnership for 21st Century Skills, 2016). For learners, SDS is crucial to maintain academic performance as well as a healthy lifestyle while they have multiple activities to carry out. There is limited work which connects both the learning and physical data of learners and provides a holistic perspective to develop their SDS. Hence, this research explores to leverage learning and physical activity data to develop SDS in learners' day to day context.

Furthermore, there is a lack of empirical evidence of scaffolding for the acquisition of SDS. This research attempts to support learners being self-directed through adaptive scaffolding in a data-rich environment. The scaffolding is triggered in a data-driven manner and decomposed into actionable sub-tasks, which contributes to exploring a data-driven paradigm to develop such meta-cognitive skills in the current data-informed world.

References

Azevedo, R., Cromley, J. G., & Seibert, D. (2004). Does adaptive scaffolding facilitate students' ability to regulate their learning with hypermedia?. *Contemporary educational psychology, 29*(3), 344-370.

Brockett, R. G., & Hiemstra, R. (2018). *Self-direction in adult learning: Perspectives on theory, research and practice*. New York: Routledge.

Candy, P. C. (1991). Self-Direction for Lifelong Learning. *A Comprehensive Guide to Theory and Practice*. Jossey-Bass, 350 Sansome Street, San Francisco, CA 94104-1310.

Cheng, S. F., Kuo, C. L., Lin, K. C., & Lee-Hsieh, J. (2010). Development and preliminary testing of a self-rating instrument to measure self-directed learning ability of nursing students. *International journal of nursing studies, 47*(9), 1152-1158.

Chi, M. T., Siler, S. A., Jeong, H., Yamauchi, T., & Hausmann, R. G. (2001). Learning from human tutoring. *Cognitive Science, 25*(4), 471-533.

Choe, E. K., Lee, N. B., Lee, B., Pratt, W., & Kientz, J. A. (2014). Understanding quantified-selfers' practices in collecting and exploring personal data. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1143-1152). ACM.

Flanagan, B., & Ogata, H. (2017). Integration of learning analytics research and production systems while protecting privacy. *Proceedings of the 25th International Conference on Computers in Education (ICCE2017)*, pp. 333-338.

Greene, J. A., & Azevedo, R. (2007). A theoretical review of Winne and Hadwin's model of self-regulated learning: New perspectives and directions. *Review of Educational Research, 77*(3), 54–372.

Lee, V. R. (2019). On researching activity tracking to support learning: a retrospective. *Information and Learning Sciences, 120*(1/2), 133-154.

Majumdar R., Yang Y.Y., Li H., Akçapınar G., Flanagan B., & Ogata H. (2018). GOAL: Supporting Learner's Development of Self-Direction Skills using Health and Learning Data. *Proceedings of the 26th International Conference on Computers in Education (ICCE2018)*, pp. 406-415.

Partnership for 21st Century Skills. (2016). A state leader's action guide to 21st century skills: A new vision for education. Tucson, AZ: Partnership for 21st Century Skills.

Saks, K., & Leijen, Ä. (2014). Distinguishing self-directed and self-regulated learning and measuring them in the e-learning context. *Procedia-Social and Behavioral Sciences, 112*, 190-198.

Stockdale, S. L., & Brockett, R. G. (2011). Development of the PRO-SDLS: A measure of self-direction in learning based on the personal responsibility orientation model. *Adult Education Quarterly, 61*(2), 161-180.

Swan, M. (2013). The quantified self: Fundamental disruption in big data science and biological discovery. *Big data, 1*(2), 85-99.

Winne, P. H., Nesbit, J. C., Kumar, V., Hadwin, A. F., Lajoie, S. P., Azevedo, R., & Perry, N. E. (2006). Supporting self-regulated learning with gstudy software: The learning kit project. *Technology Instruction Cognition and Learning, 3*(1/2), 105.

Zimmerman, B. J. (2008). Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects. *American educational research journal, 45*(1), 166-183.

Developing a Model for Effective Cascaded School Teacher Training on ICT Integration in Tanzania

Lucian Vumilia NGEZE
Indian Institute of Technology Bombay, India
lucianngeze@iitb.ac.in

Abstract: Training school teachers has been one of the key developments that lead to improved teaching practices leading to overall student learning gains. In many cases, teacher training programme in different topics (Assessment, Lesson Planning, ICT integration, Curriculum planning, etc.) involves inviting teachers at a training centre, training them on selected modules for a specified number of days and letting them go back to their schools, with a hope that they will be able to share the experiences and learning with others. Even though no impact evaluation is conducted, teachers do not share what they learned with other teachers. The Align Attain Integrate Teach Train (A2IT2) model is developed to improve the effectiveness of such cascaded training programmes on technology integration in teaching and learning. Its different phases give the competences needed by the teacher to effectively train other teachers at school level on technology integration. Based on refinements of the methodology used, the model will help planners of teacher workshops to plan efficient and sustainable programmes.

Keywords: Teacher professional development, teacher training models, secondary trainers, cascade model, ICT in teaching and learning.

1. Introduction

Teacher professional development (TPD) has been defined as all activities that develop teacher's skills, knowledge and expertise (OECD, 2009). TPD involves structured professional learning activities that improve the teaching practice, leading to improved student outcomes (Darling-Hammond, Hyler, & Gardner, 2017). To improve the teaching quality and hence raising students' performance, several methods are involved. These can come in many forms including formal and informal settings. In the formal setting, teachers attend short courses, workshops, seminars, conferences or even longer qualification programmes. Informal teacher professional development involves activities such as mentoring, coaching, sharing of good practices, collaborative planning and teaching and informal dialogues on the ways that can best be used to improve teaching.

In Tanzania, for the past 8 years, we have been training teachers on integrating technology in their teaching and learning in using cascade mode of TPD. Cascade model of TPD involves training of teachers at different levels. At the top level, you have a number of trainers who are selected to meet the training demands. These are called primary trainers. The first level involves participants selected from a pool of teachers normally from different schools. These selected teachers are then trained by the primary trainers based on the content to be covered. This training may be for several days depending on the needs at that particular time. The trained teachers are called 'multipliers' or master trainers – here referred to as secondary trainers. The secondary trainers then have to go and train other teachers on the same content they have been trained on. Even though the cascade model has advantages such as use of existing teachers as trainers (Kennedy, 2005) leading to cost effectiveness. The model involves shorter periods out of schools (Gilpin, 1997). In this case, a large number of teachers is trained (Hayes, 2000). Apart from the mentioned advantages, the model is also associated with challenges such as one-way transmission with no feedback (McDevitt, 1998), lack of trainers confidence to execute the training curriculum (Box, 2002), curriculum misinterpretation (Suzuki, 2011), dilution of the teaching content at different levels (Hayes, 2000), longer periods between cascades (Dichaba, 2013) and lack of emphasis

on the instructional practices (Hooker, 2008). In this case, the cascaded training programmes were not successful as it was expected.

We developed the Attain Align Integrate Teach Train (A2IT2) model to improve the cascading effect by ensuring confidence of the master trainers while training other teachers on how to integrate technology in teaching and learning.

2. Research Goals

Broadly, the research aims at improving the effectiveness of cascaded teacher training on ICT integration in teaching and learning. The specific research goals are:
  i. Developing a solution to improve effectiveness and sustainability of cascaded in-service teacher training programmes; and
  ii. Implementation of the solution in different in-service teacher training programmes to evaluate its effectiveness.

3. Research Methodology

This research will follow a Design Based Implementation Research (DBIR) methodology (Fishman et al., 2013). DBIR is a suitable methodology because it involves a series refinements and iterations while implementing the solution to the persistent problems of cascaded teacher training programmes. In the first phase, we identified and defined the problem by collaborating with teachers who were involved in ICT teacher training sessions before and the trainers who were involved in those sessions. Designing of the solution (workshop on ICT integration) based on A2I2 model, was done during phase 2. An extension to A2I2 model was done by adding two phases: Teach and Train. We have completed the first iteration of Phase 3 which involved the implementation of A2IT2 model involved the implementing the solution by training teachers on selected ICT topics. Data were collected and analysed to evaluate and reflect on the refinements of the previous phases. Figure 1 shows the different phases and actions.
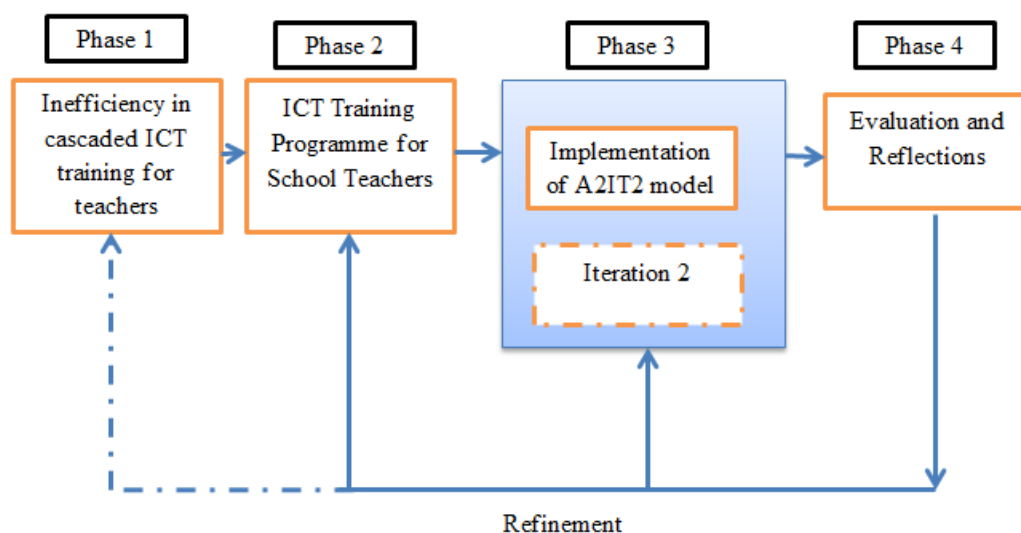

Figure 1: Phases of the Research Methodology

4. A2IT2 Model and its Phases

This model has five phases, each with its function. The different functions of each of the phases and their focus and outputs of the model are shown in Table 1.

Table 1

 Focus and output at each phase of the A2IT2 Model

Phase	Focus	Output
Attain	Introduces the teachers to student-centred design	Ability to create measurable learning objectives, assessment strategies
Align	Aligning instructional strategies and assessment strategies to the learning objectives	Knowledge of constructive alignment
Integrate	Creating technology-enhanced lesson plans	A lesson plan with a technology integration plan
Teach	Immediate practice: teachers micro-teach a lesson of their preference to the rest of the training participants	A fully technology integrated lesson as taught in the class.
Train	Trained teachers train other teachers in their respective schools	Teacher trainers

5. Research Studies

I conducted two studies with different teachers. Six (6) topics were selected for the 4 days' workshop for teachers. These topics included: Internet Searching for educational Content; YouTube in Teaching and Learning; Mentimeter for classroom engagement; Padlet for classroom collaboration; MS PowerPoint Presentation and Windows Movie Maker. Preliminary study was done during a workshop with college teachers to determine the features and roles of primary and secondary trainers. Two other studies (study 1 and Study 2) were completed with school teachers in Tanzania. Next research studies are planned to start in December 2018 to determine effectiveness of the teacher training sessions and the role of primary trainers in the cascade process.

Table 2
Research Plan and Activities

Studies	Research Goal	Research Question	Data Collection tools	Analysis	Results
Preliminary study (N=6)	Characteristics of secondary trainers	What is expected of teachers selected as secondary trainers?	Semi structured Interview	Thematic analysis	Knowledge of workshop, experience and personal skills
	Role of primary trainer to secondary trainers	What kind of support do secondary trainers need from primary trainers?	Semi structured Interview	Thematic analysis	Support during the sessions, mentoring
Study 1 (N= 19)	To determine the confidence levels to use technology tools in teaching and learning?	What are the teachers' confidence levels to use technology tools in their teaching and learning?	5 point Likert Scale Pre-post survey, Feedback survey	Man-Whitney U test, frequency analysis	*High perceived confidence to use technology tools*
	To identify the factors that hinder teacher training on ICT in schools	What are the factors that hinder effective teacher training on ICT in schools?	3 semi-structured interviews	Thematic analysis	Infrastructure, time limitation, motivation,

					attitude to change
Study 2 (N=24)	To measure the level of ICT integration by teachers	1. How well are teachers aligning technology to the learning objectives during microteaching? 2. What is the perceived content knowledge gained for transfer of training?	Classroom observation protocol, Microteaching assessment rubric, Group Reflection summary	Observation, rubric evaluation	Improved integration of technology, challenge in setting up technology tools
	To identify workshop design considerations to improve transfer of training	What are the workshop design considerations for effective transfer of training?	Focus group interviews, semi-structured interviews	Thematic analysis	Software knowledge, computer basics, device connections

6. Research Contribution

This research will generate a model to improve effectiveness of cascaded school teacher training programmes on ICT integration in Tanzania. TPD planners can use this model while planning to ensure effectiveness. Teachers who will participate in teacher training workshops will develop their professional career. On the other hand, use of technology in teaching and learning will increase and hence improving performance (Higgins, 2003).

Acknowledgements

References

Box, S. (2002). The Social and Cultural Dimensions of Trainer Training, Journal of Education for Teaching: International Research and Pedagogy, 28:2, 165-178.

Darling-Hammond, L., Hyler, M. E., Gardner, M. (2017). Effective Teacher Professional Development. Palo Alto, CA: Learning Policy Institute

Dichaba, M.M, (2013).The Perspectives of In-service Trainers on the Challenges of the Cascade Model (2013). Anthropologist, 15(3): 265-275.

Fishman, et al., (2013). Design-based implementation research: An emerging model for transforming the relationship of research and practice. National society for the study of education, 112(2), 136-156.

Gilpin, A. (1997). Cascade training: Sustainability or dilution. Learning to train: Perspectives on the development of language teacher trainers, 185-195.

Hayes, D. (2000). Cascade training and teachers' professional development. ELT journal, 54(2), 135-145. Hooker, M. (2008). Models and best practices in teacher professional development.

Higgins, S. J. (2003). Does ICT improve learning and teaching in schools?. BERA, British Educational Research Association.

Kennedy, A. (2005). Models of continuing professional development: A framework for analysis. Journal of in-service education, 31(2), 235-250.

McDevitt, D. (1998). How effective is the cascade as a method for disseminating ideas? A case study in Botswana. International journal of educational development, 18(5), 425-428.

OECD. (2009). Creating Effective Teaching and Learning Environments: First Results from TALIS – ISBN 978-92-64-05605-3

Suzuki, T. (2011). Cascade model for teacher training in Nepal. Studies in Languages and Cultures, No.27.

Warriem, J.M. and Iyer, S. (2018). A model for large-scale, in-service teacher training on effective technology integration in engineering education

Understanding and Improving Learners' Feedback Seeking Behavior

Narasimha SWAMY
Indian Institute of Technology Bombay, India
klnswamy@iitb.ac.in

Abstract: Feedback in education is predominantly a teacher initiated practice. Even when peers exchange feedback, it is the teacher who initiates and manages it. The same is reflected in the design of online learning environments. But this idea is incompatible with the real world challenges, where individuals are often required to proactively elicit and judge feedback from multiple sources for accomplishing their goals. Interventions to nurture such learner agency in feedback seeking are rare. My study investigates learners' proactive feedback seeking behavior during a chemistry representational task. Using microgenetic analysis, I examine how the factors related to the learner, task, feedback sources and the tools influence the learners' feedback seeking behavior. In the preliminary findings, I describe how these factors interact in determining the variables such as timing, purpose, choice of feedback source, mode of seeking and using the feedback received. Ultimately, my thesis objective is to arrive at guidelines that can inform the design of learning environments to better facilitate and improve learners' feedback seeking behavior.

Keywords: Feedback seeking behavior, cost-value framework of feedback seeking, feedback as dialogue, social constructivism, stereochemistry

1. Rationale

Major reviews of feedback interventions report that the effects of feedback can be negative, inconsistent and highly variable due to numerous interfering factors (Hattie & Timperley, 2007; Kluger & DeNisi, 1996; Shute, 2008). Those factors include the characteristics of the learner, task, feedback source along with the nature, mode, timing and frequency of the feedback messages provided (Ruiz-Primo & Li, 2013). Further considering the actual classroom complexities like student diversity, class size and teacher workload, conditions that can make the given feedback to work exactly as expected are said to be difficult to obtain (Boud & Molloy, 2013). Hence understanding learners' feedback seeking behavior might better inform us regarding the effective feedback practices.

 'Feedback Seeking Behavior' (FSB) is a well-developed construct in the fields of organizational behavior, social and occupational psychology. FSB is defined as an individual's proactive search for feedback information in one's environment for accomplishing the goal directed activities (Crommelinck & Anseel, 2013). A dominant theoretical model used for studying FSB is the cost-value framework (Anseel, Beatty, Shen, Lievens, & Sackett, 2015). As per this framework, characteristics of the task, individual, feedback source and the context interact in generating perceptions of cost and value in seeking feedback. These cost-value perceptions in turn determine the timing, purpose, choice of feedback source, mode of seeking and using the feedback received. I use this framework for examining the learners' feedback seeking episodes.

2. Research Questions

- How the characteristics of task, learner, feedback sources and the tools in the environment interact in determining the variables of feedback seeking such as timing, purpose, choice of feedback source, mode of seeking and using the feedback received?

- How the answer to the above question informs the design of learning environments that can better facilitate and improve the learners' feedback seeking behavior?

3. Study Design

3.1 Theoretical Perspective

As per Thurlings, Vermeulen, Bastiaens, and Stijnen (2013) our notion of feedback is largely influenced by our notion of learning. I adhere to social constructivist perspective of learning. As per this perspective, feedback often comes from multiple sources in the form of dialogue and occurs as a result of interaction with an individual's internal or self-generated feedback (Askew, 2000; Boud & Molloy, 2013). Social constructivist perspective also informs the many decisions of my study design (Palincsar, 1998). The choice of learning task is an authentic real world problem. The learning environment includes domain specific cultural tools such as molecular models and software applications. The task requires making sense of symbolic representations and conventions employed by the chemists. My unit of analysis is a social unit which involves learner interaction with the feedback source mediated by tools and representations. My analysis does not see cognitive, emotions, motivation and identity aspects in isolation, instead examines how they are intertwined in determining the feedback effects. I employ microgenetic method of analysis which is suggested to be appropriate for studying processes having highly variable effects on learning (Chinn & Sherin, 2014).

3.2 Domain Context, Nature of Task and Participants

Participants in my study are undergraduate chemistry students who had recently completed an introductory stereochemistry course. Learning task requires students to interpret 2D symbolic representations of chemical reaction and then determine the relationship between spatial orientation of the catalyst used and the particular pharmaceutical drug formed (adapted from Wong, Sultana, & Vosburg, 2010a). Spatial arrangements in the drug formed is critical here since its effectiveness is tied to the spatial arrangements of its constituent atomic groups. Nature of the task demands learners to go beyond simple verbal feedback seeking to build complex molecular models and sketch their multi perspective symbolic diagrams for eliciting feedback from peers.
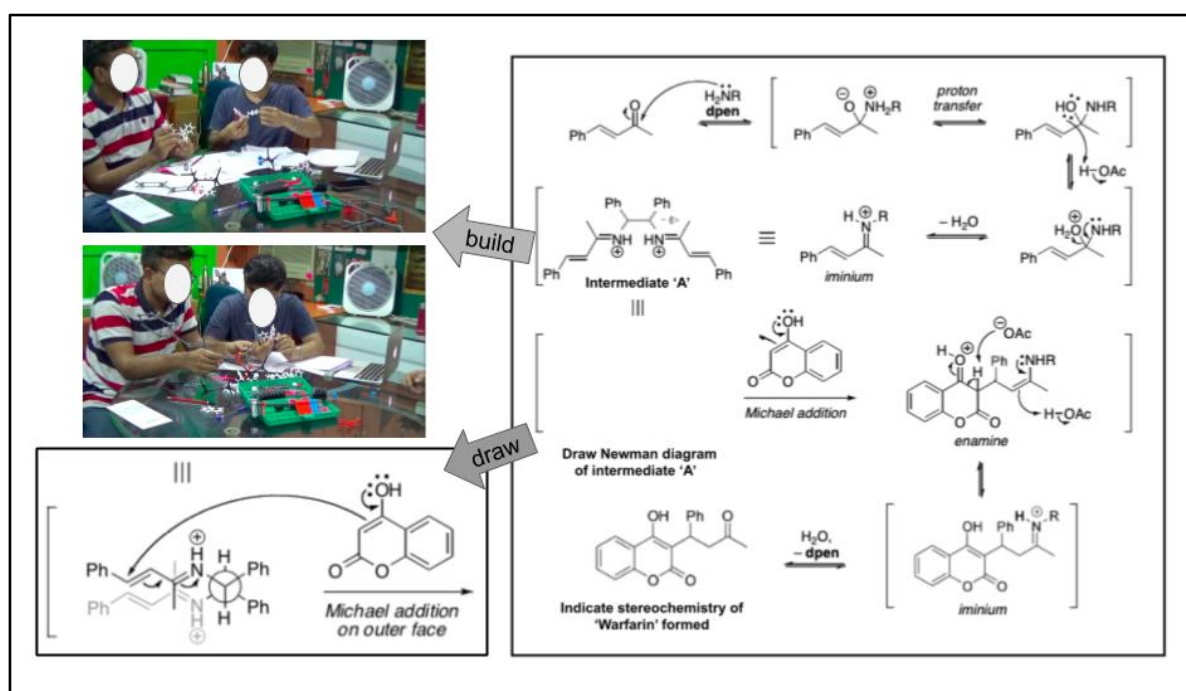

Figure 1. A Green, Enantioselective Synthesis of Warfarin (Wong et al., 2010).

3.3 Study Procedure, Method of Data Collection and Analysis

A pilot study was done with two participants. It was an hour long activity. Participants were informed both verbally and in written instruction that they were free to discuss if needed. They were also told to consider researcher as their last resort for any discussion. Researcher would provide them with a series of subtasks in sequence. Participants had to report themselves after completion. Overarching strategy was to delay final answer for each subtask until participants had tried different possibilities.

Data collection involved video recording of participant interaction. Other data sources were participant sketches, comments on worksheets and instructional material. Data analysis involved identifying episodes of learner's proactive feedback seeking from peers. By proactive I mean that decisions such as timing of feedback seeking, purpose for which feedback was sought, choice of feedback source, method of feedback seeking were all made by learner himself or herself. I distinguished one feedback episode from another by determining the change in purpose. I also consider the episode of dialogue as feedback dialogue if and only if it meets the purpose for which the learner initiated it. For examining the role of factors related to task, learner and feedback source in feedback seeking I would go back and forth a few seconds before and after the start and end of feedback seeking episode respectively. I employed competitive argumentation with colleagues for drawing inferences (Chinn & Sherin, 2014).

4.   Discussion

Given below is a learner's feedback seeking episode while performing an analogical mapping of 3D models with the given 2D representations of a reaction mechanism. Duration of the episode was around 3.33 minutes.
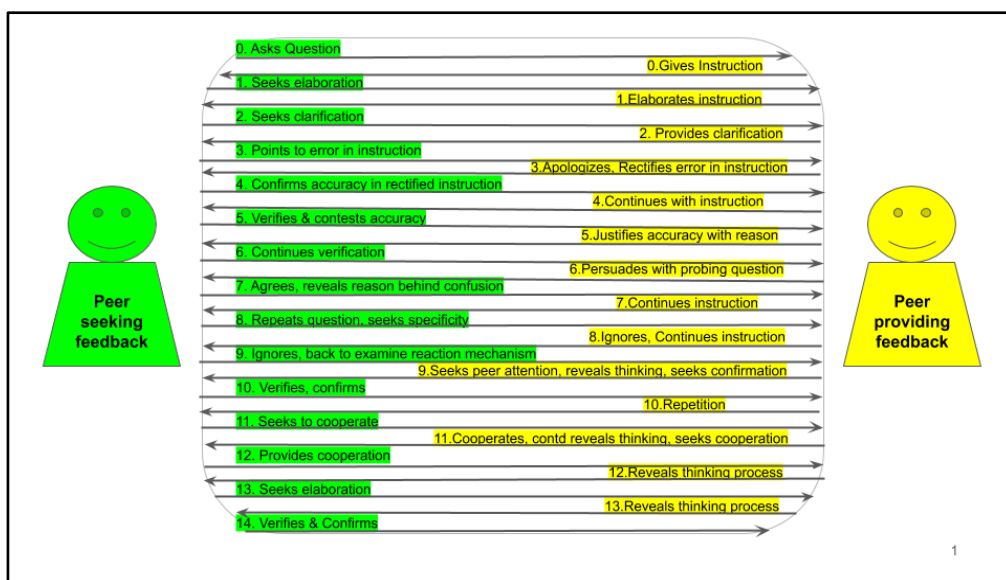

Figure 2. Proficiency of Learner, Feedback Source and the Nature of Feedback Seeking

In the above feedback seeking episode it took 14 conversational turns for the feedback to occur. In another episode, where the current peer providing feedback was in the seeking position the conversational turns that took the feedback to occur was around 70 turns. But that episode occurred while the seeker was trying to perform a mental simulation of the rotation of the intermediate molecule around a bond and determine the probable direction of the attack in the chemical reaction. Both the complexity of the task element and the proficiency of the individuals seeking and giving feedback in relation to the task element influence the extent and nature of the feedback dialogue.

Using the cost-value framework, I examine each feedback seeking episode in detail. Consider for example the process of seeking feedback as mentioned in Figure 2. Here the learner seeking feedback has to continuously monitor the feedback information received from the source, judge it against one's own requirements and then decide how to use or respond to it. The cost involved in the process might reduce if the feedback source is more proficient peers. In a collaborating group since the perceived value of feedback from more proficient peers would be more, they might be the preferred choice of feedback source but it might not contribute towards improving feedback seeking behavior. Further the time gap between the conversational turns was observed to be crucial for both the feedback seeker and feedback provider to interpret what each said to the other and construct the appropriate response. Time between conversational turns negotiated between similar proficiency peers would probably be more since both may experience similar difficulty levels. While this is just about the cognitive aspects in the feedback seeking dialogue then there are desirable and undesirable costs involved with regard to motivational, emotional and identity aspects. For instance, the act of seeking feedback also involves the risk of revealing one's ignorance. If the learners perceived threat to self is high then he or she might be embarrassed to indulge in feedback seeking behavior. The individual's perceived threat to self also might increase or reduce depending on the characteristics of the feedback source.

By identifying the desirable and undesirable costs related to cognitive, emotional, motivational and identity aspects during a feedback dialogue and how they interact with each other, my study aims towards arriving at guidelines that can inform the design of learning environments where we can intentionally introduce certain desirable costs and mitigate undesirable costs to facilitate and improve learner feedback seeking behavior.

References

Anseel, F., Beatty, A. S., Shen, W., Lievens, F., & Sackett, P. R. (2015). How Are We Doing After 30 Years? A Meta-Analytic Review of the Antecedents and Outcomes of Feedback-Seeking Behavior. *Journal of Management*, *41*(1), 318–348.

Askew, S., University of London, Institute of Education, & Assessment, G. and E. L. (2000). *Feedback for learning*.

Boud, D., & Molloy, E. (2013). Rethinking models of feedback for learning: The challenge of design. *Assessment & Evaluation in Higher Education*, *38*(6), 698–712.

Chinn, C. A., & Sherin, B. L. (2014). Microgenetic Methods. In R. K. Sawyer (Ed.), *The Cambridge Handbook of the Learning Sciences* (2nd ed., pp. 171–190).

Crommelinck, M., & Anseel, F. (2013). Understanding and encouraging feedback-seeking behaviour: A literature review: Feedback-seeking behaviour: a review. *Medical Education*, *47*(3), 232–241.

Fernyhough, C. (2008). Getting Vygotskian about theory of mind: Mediation, dialogue, and the development of social understanding. *Developmental Review*, *28*(2), 225–262.

Hattie, J., & Timperley, H. (2007). The Power of Feedback. *Review of Educational Research*, *77*(1), 81–112.

Kluger, A. N., & DeNisi, A. (1996). The effects of feedback interventions on performance: A historical review, a meta-analysis, and a preliminary feedback intervention theory. *Psychological Bulletin*, *119*(2), 254–284.

Palincsar, A. S. (1998). SOCIAL CONSTRUCTIVIST PERSPECTIVES ON TEACHING AND LEARNING. *Annual Review of Psychology*, *49*(1), 345–375.

Ruiz-Primo, M. A., & Li, M. (2013). Examining Formative Feedback in the Classroom Context: New Research Perspectives. In *SAGE Handbook of Research on Classroom Assessment* (pp. 215–232).

Shute, V. J. (2008). Focus on Formative Feedback. *Review of Educational Research*, *78*(1), 153–189.

Thurlings, M., Vermeulen, M., Bastiaens, T., & Stijnen, S. (2013). Understanding feedback: A learning theory perspective. *Educational Research Review*, *9*, 1–15.

Wong, T. C., Sultana, C. M., & Vosburg, D. A. (2010). A Green, Enantioselective Synthesis of Warfarin for the Undergraduate Organic Laboratory. *Journal of Chemical Education*, *87*(2), 194–195.

KB-Mixed: A Reconstruction and Improvable Concept Map to Enhance Meaningful Learning and Knowledge Structure

Didik Dwi PRASETYA[ab*], Tsukasa HIRASHIMA[a], & Yusuke HAYASHI[a]
[a]*Department of Information Engineering, Hiroshima University, Japan*
[b]*Department of Electrical Engineering, Universitas Negeri Malang, Indonesia*
*didik@lel.hiroshima-u.ac.jp, didikdwi@um.ac.id

Abstract: Kit Build (KB) is a closed-ended and reconstruction concept map that proven positive effects in assessment and learning regarding learners' knowledge understanding. The KB design emphasizes the centralization of teacher understanding that would be reconstructed by learners and ignores their knowledge structure itself. This study focused on a new extension of the KB concept map reconstruction, which is combined with the open-ended style called KB-Mixed. KB-Mixed does not only aim to increase knowledge understanding, but also enhance meaningful learning and facilitate knowledge structure. This study involved university students as participants who were divided into two groups, experimental and control. Students in the experimental group were requested to construct concept maps using the KB-Mixed method, while those in the control group used the open-ended concept map which called Extended Scratch-Build (ESB). The experiment results indicated that KB-Mixed outperformed the control group in terms of knowledge understanding and knowledge structure.

Keywords: Concept map, reconstruction, improvable, meaningful learning, knowledge structure

1. Introduction and Motivation

Concept maps are flexible tools for teaching, learning, organizing, and representing knowledge that can be implemented in various fields and education levels, starting from preschool to higher education and corporate training (Novak and Gowin 1984). Concept maps were developed by Novak and Gowin based on the meaningful theory proposed by Ausubel (1963). Meaningful learning occurs when a student chooses to relate new knowledge to prior knowledge. Meaningful learning requires individuals to have a well-organized relevant knowledge structure in a particular area and strong emotional commitment to integrating further with existing knowledge (Novak, 2008). In the context of construction style, concept maps can be classified into two categories: (1) open-ended; and (2) closed-ended (Taricani, 2006). In the open-ended concept maps, learners may use any concepts and any linking words in their maps. The main advantage of open-ended style is the possibility to capture learner's knowledge structure (Ruiz-Primo, 2001; Hirashima, 2018) and facilitate knowledge building, although it will be more challenging to assess and provide feedback. In the other side, a closed-ended style contains finite concepts and links provided beforehand. In this case, learners must use provided components to construct their maps by connecting one concept to another. The main advantage of closed-ended style is offering a well-structured concept map to promote knowledge understanding, although it will be less facilitate the knowledge building situation.

Kit-Build (KB) is a closed-ended style concept map framework introduced by Hirashima (2015). In KB, a learner is provided to nodes and links that are composed of teacher's concept map, and the learner is required to make a concept map by combining them. Thus, the workings of KB consist of three main stages. First, a teacher creates a concept map that will become a goal map. Second, the KB system will decompose the goal map into concepts and links called "kit". Third, the students will be asked to reconstruct the concept map from the provided kit. Therefore, KB map requests a learner to reconstruct the original map by using provided components, and it can be called "reconstructional concept map" (Hirashima, 2018). Some previous studies have revealed many positive effects on the KB concept map to improve learning outcomes, both individually and in groups. The KB design is a

promising method to capture the learner's knowledge understanding in particular material based on the teacher's understanding. However, this concept of map building would be not suitable for capturing learner's knowledge structure itself. From here, we can see the potential work to extend the KB system to facilitate knowledge building and enhance meaningful learning.

2. Proposed Method

The present study focused on a new extension of a closed-ended KB map that calls KB-Mixed. KB-Mixed extends the existing KB framework by integrating the open-ended method to facilitate meaningful learning well. In KB-Mixed, learners will be requested to construct a concept map using a KB approach, and then they continue to extend or improve their previous concept map using an open-ended approach. The main purpose of KB-Mixed is to examine whether the KB extension with the open-ended approach can facilitate learner's comprehension of new knowledge based on their prior knowledge. KB-Mixed also promotes knowledge building, which is usually difficult to obtain either using KB or open-ended concept maps.

KB-Mixed offers two interconnected phases concept map construction, as shown in Figure 1. In the first stage, the use of the KB method that provides kits to be reconstructed by learners is to give learners' knowledge structure and support for meaningful learning. Furthermore, the second stage that allows learners to improve the concept map by adding new concepts and links is to expand existing structures and support knowledge building. Two phases of concept map construction are the main characteristic of KB-Mixed to increase meaningful learning and promote learners' knowledge understanding and knowledge structure.
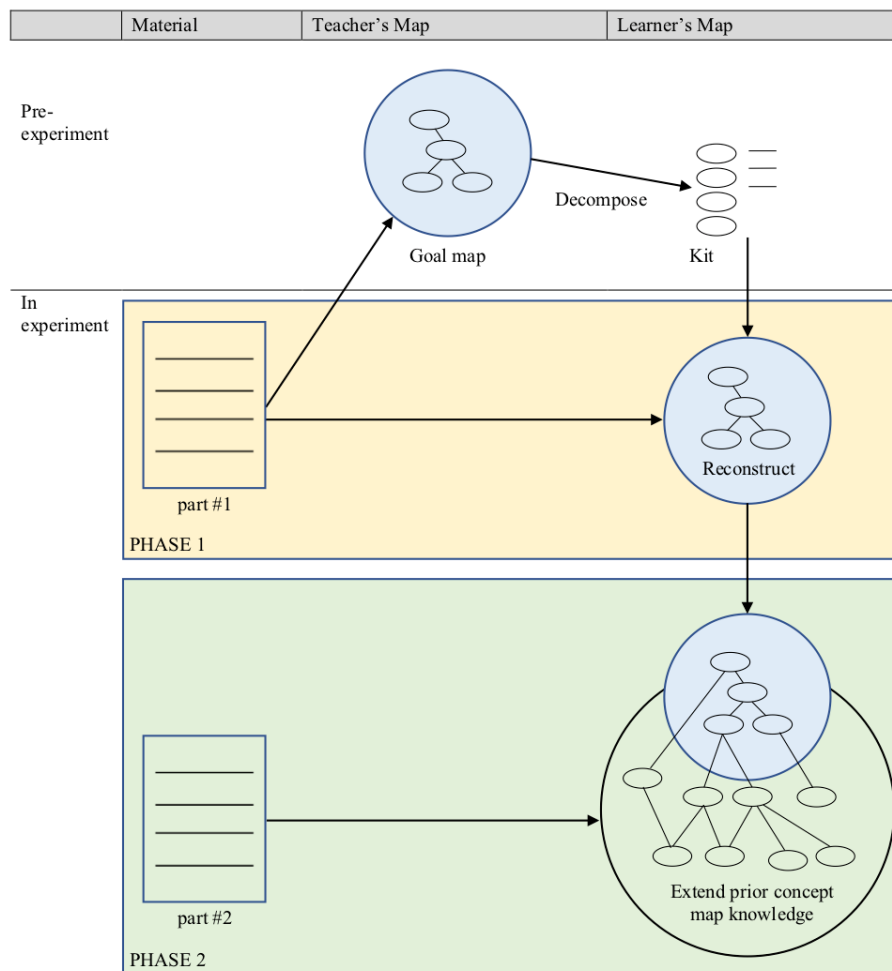

Figure 1. The practical flow of KB-Mixed concept map

Three measurements analysis will be involved to investigate the KB-Mixed performances, including (1) analysis of students' learning comprehend; (2) analysis of knowledge-building through the knowledge structure; and (3) analysis of students' creative thinking. Analysis of students' learning

understanding involved pre-test and post-test design. In the context of this concept mapping, we define knowledge-building as the ability to visualize learners' ideas related to a particular topic. The assessment of the concept map is based on propositions by adopting the quality rating of propositions introduced by Osmundson (1999). To measure the learners' creativity, the Novak & Gowin's (1984) structural method was adopted.

3. Experiment

The first experiment involved 55 students from the State University of Malang, Indonesia, majoring of informatics engineering. Based on their major, participants are familiar with using a computer and the Internet for learning. The participants were divided into two groups randomly, which consists of 27 students for the control group and 28 students for the experimental group. Students in the control group were requested to create concept maps using an open-ended and then extend it using the same method which called extended open-ended, while the experimental group using KB-Mixed approach. In this comparison, we focus on a concept map that provides extensibility through two-phase construction.

This study was conducted in the "Basis Data 1" (Database 1) subject which was delivered in Indonesian. The material used here was "Basis Data Relasional" (Relational Database). The experienced lecturer was involved in conducting theoretical learning in both control and experiment classes. The control and experimental group used the same learning environment, including classrooms, personal computers specifications, and Internet connection. This experiment was conducted in a computer laboratory during one lecture session. Before the investigation was conducted, at the previous course meeting, participants had been given an introduction to concept maps. Table 1 shows the experimental procedure of the control and experimental group. Both groups had different lecture schedules, but they were held in the same 1st-course hours, with a total duration of 100 minutes.

Table 1

The experiments schedule

No	Control group's activity	Experimental group's activity	Duration
1	Pre-test		10 min
2	Teaching material part #1		25 min
3	Create a concept map using the ESB method	Create a concept map using the KB method	15 min
4	Teaching material part #2		25 min
5	Extend previous concept map using the open-ended method		15 min
6	Post-test		10 min

The first experiment involved pre-test and post-test design in identifying learners' performances. The pre-test was designed to examine whether students in the control group and the experimental group had equivalent knowledge regarding related instructional design. Pre-test and post-test design used the same multiple-choice questions, where the post-test is randomly presented. Pre-test and post-test evaluations were carried out by a class teacher because this study was in class experimental. The teacher who conducted the assessment here was also a teacher who taught in class, a senior teacher with more than ten years of teaching experience in database subjects.

4. Results

To identify students' learning performance, we involved post-test used multiple-choice questions. Descriptive statistics of the post-test results of the control group and experimental group can be shown in Table 2.

Table 2

Descriptive statistics of the post-test for both groups

Item	Control Group	Experimental Group
Mean	81.02	87.50
Standard Deviation	10.612	9.001
Minimum	62.50	75
Maximum	100	100

The results of the post-test of both control and experimental groups were analyzed by the Mann-Whitney U test and are shown in Table 3. The results revealed a statistically significant difference in learners' learning performance between the control group and the experimental group after the intervention ($U = 259.0$, $p = .030 < 0.05$). An evaluation of the effect size (ES) indicated a medium effect with Cohen's d value was 0.7.

Table 3

The Mann Whitney-U results of the post-test for both groups

Groups	N	Mean Rank	Sum of Ranks	U	Z	p
ntrol group	27	23.59	637.00	259.0	-2.164	.030
perimental group	28	32.25	903.00			

5. Discussion, Conclusion, and Future Work

This study proposed an idea to extend the existing KB map to promote learners' comprehension of new knowledge. The first experiment results revealed that the experimental group outperformed the control group in terms of students' learning performance indicated by the post-test score. The two phases of concept map construction offered by KB-Mixed has proven to be able to have a positive impact on learning outcomes. Nevertheless, further experiments are still needed to investigate the effects of knowledge building and creative thinking. The second experiment will focus on knowledge building and creative thinking analysis. Also, studies on the automatic scoring of KB-Mixed concept map results are necessary to facilitate the assessment. However, the result of the KB-Mixed concept map is an open-ended style that has too many variations and will make it difficult for the teacher. The future work should focus on automatic scoring in the concept map using novel methods such as machine learning and deep learning.

References

Ausubel, D. P. (1963). The Psychology of Meaningful Verbal Learning. New York, Grune, and Stratton.

Hirashima, T., Yamasaki, K., Fukuda, H., & Funaoi, H. (2015). Framework of kit-build concept map for automatic diagnosis and its preliminary use. Research and Practice in Technology Enhanced Learning, 10(1), 17.

Hirashima, T. (2018). Reconstructional concept map: automatic Assessment and reciprocal reconstruction.

Novak, J. D., & Gowin, D. B. (1984). Learning how to learn. Cambridge University Press.

Novak, J. D., & Cañas, A. J. (2008). The theory underlying concept maps and how to construct and use them. Florida Institute for Human and Machine Cognition, 2008.

Osmundson, E., Chung, G. K. W. K., Herl, H. E., & Klein, D. C. (1999). Knowledge mapping in the classroom: A tool for examining the development of students' conceptual understandings. Report: CSE-TR-507.

Taricani, E. M., & Clariana, R. B. (2006). A technique for automatically scoring open-ended concept maps. Educational Technology Research and Development, 54(1), 65-82.

Ruiz-Primo, M. A., Schultz, S. E., Li, M., & Shavelson, R. J. (2001). Comparison of the reliability and validity of scores from two concept-mapping techniques. Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching, 38(2), 260-278.

Digital Multi-Grade One-room Schoolhouses for underprivileged communities in rural Pakistan

Faisal BADAR
Charles Darwin University, Australia
*faisal.badar@students.cdu.edu.au

Abstract: Despite extensive global efforts to make education accessible for all, one out of every five children are out-of-school. The situation demands re-thinking of learning strategies, particularly in underprivileged context. Continued advancements in learning technologies may offer novel solutions. The one-room schoolhouse is a centuries-old proven educational system, which has yielded promising results for rural areas. Using a multi-grade teaching method, the one-room schoolhouse provides a resilient model for educating children at locations that lack quality teachers and resources. This paper outlines doctoral research focused on identifying ways to develop adaptable and sustainable approaches to educate underprivileged out-of-school children in rural and remote areas of Pakistan through digital one-room schoolhouses, and suited to their local dynamics.

Keywords: Rural Education, Out-of-school children, ICT, one-room schoolhouse, Multi-grade teaching, underprivileged

1. Introduction

The development of any society can be determined by assessing the measures taken to provide quality education to every child, and to eradicate educational inequality that may be prevalent. Global initiatives such as 'Education for All' (EFA) and 'Sustainable Development Goal-4' (SDG-4) focus on this (UNESCO, 2015). Despite such initiatives, global statistics show that one out of five children is out-of-school. Furthermore, a decline in efforts from participating governments, progress in decreasing the number of out-of-school children, adolescents, and youth has significantly reduced in recent years (Statistics U. I., 2018). The Gender Gap Report also indicates significant difference in the average attainment of education by girls in South Asian Countries such as Pakistan, India, Afghanistan and Bangladesh (Forum, 2017).

Mobile and ubiquitous Information and Communication Technology (ICT) tools have enabled new ways to teach and learn where they are no more dependent on a specific time, place, or teachers (Hussain, Wang, & Rahim, 2013). Innovative e-learning solutions are also emerging in remote and rural areas in developing countries; however, the sustainability of sometimes-disruptive innovations create a challenge for governments and policy makers (Badar, Mason, & Khan, 2018). The one-room schoolhouse offers a practical and adaptable approach for 21st-century learning where student-centric learning is focused within a multi-grade student class (Goodlad, 1996). They provide a positive alternative to social promotion, stigmatizing, a traditional form of ability grouping, and grade labelling while encouraging personalised learning (Bennet, Hare, & Lee, 1983; Pratt, 1986; Veenman, 1995).

2. Out-of-school children and contribution of digital technology for education

263 million children and youth are out-of-school from primary to upper secondary (UNESCO, 2015). Children from economically and educationally disadvantaged families tend to have weaker educational base compared to their advantaged counterparts within the society, and the gap only widens during the school years (Hutchinson, et al., 2017). There are several factors leading to this gap including learning environment at home, opportunities to hear and read more words, and access learning activities outside the home (Smees & Sammons, 2017). The gap often leads to a higher number of dropouts. The main

reasons behind out-of-school secondary level children are poverty, location, and gender, and learning models based on mobile technology can provide access to "people who live in a remote location where there are no schools, teachers and libraries" (Ally, 2009).

2.1 Role of classroom, ubiquitous and mobile technologies in spreading education

Education in developing countries could be transformed by e-learning through mobile technology (Badar, et al., 2018). With mobile-learning, learners have more flexibility of what, when, where, why and how to learn, making it an individualized, personalized and highly interactive learning (Cobcraft, Towers, Smith, & Bruns, 2006). Ubiquitous technologies such as mobile phones are widely considered as the optimal solution for delivering education in developing countries, because of their usability, accessibility, and affordability (Grimus, et al., 2013; Ford & Leinonen, 2009). Mobile technology has the potential to shift the teaching focus to the learner (Grimus, et al., 2013).

2.2 Pakistan; education and out-of-school children status

Pakistan is the sixth most populated country in the world, with 63% population under the age of 25 years and has the fourth largest pool of out-of-school children (UNESCO, 2017). Most of the out-of-school children are residing in remote, rural or underprivileged city areas where prevailing challenges in providing quality education include a shortage of good teachers, the hidden child labour challenge, affordability and cultural barriers to pursuing educational goals (Titola-Meskanen, 2014). Education quality and standard are declining in rural areas and increasing urban/rural disparities and inequalities, which is creating a learning crisis in low-income rural areas (Agarwal, 2014). Funds granted by international funding agencies are not utilised effectively and hence the education sector is badly affected in the last few decades (Khan, Lurhathaiopat, & Matsushita, 2016).

3. One-room Schoolhouses

3.1 One-room Schoolhouses

One-room schoolhouses have been common all around the world and operating for the last 300 years (Williams, 2005). However, while these schoolhouses became popular in the nineteenth century, they were also used as community centres. In addition to being used for educational purposes, they were used for church services, Christmas parties, community suppers, lectures, etc. After completing the school year, students were examined orally covering their spelling, arithmetic problem-solving competence, and other subjects, based on which teachers determine the students' future level of studies.

The one-room schoolhouse has traditionally provided an integrated approach to the curriculum, often mixing age and aptitude. As a method for a 21st-century education, it is distinguished from conventional curriculum design because it revisits this older approach. Interestingly, recent research indicates it improves the non-cognitive abilities of students, giving them the opportunity to mentor relatively less advanced students (Cundra, Benzel, & Schwebach, 2017). The one-room schoolhouse encourages and supports peer-mentoring between relatively more and less experienced students. This pedagogical approach helps students to access challenging course material when someone among them has more relevant knowledge and provided the opportunity to educate the less knowledgeable ones (Bhuiyan, Supe, & Rege, 2015). Methods such as one-room schoolhouse integrate peer-mentorship into the curriculum design directly and provide a more conducive learning environment as compared to the traditional learning approach (Cundra, Benzel, & Schwebach, 2017).

4. Research Description (Research aim, question and significance/contribution)

4.1 Research Aim

The aim of this research is to explore and develop adaptable and sustainable approaches for providing digital education to out-of-home children through one-room schoolhouses in the underprivileged context in Pakistan, suited to their local dynamics and limitations.

4.2 Research Questions

- In what ways can approaches be developed for 'digital education through one-room schoolhouses' for children in underprivileged contexts in Pakistan?

- What factors are needed to be considered to test whether these approaches are adequate?

4.3 Significance/contribution of Research

This study aims to identify new ways to educate out-of-home children in underprivileged contexts using educational technology. Significantly, it will explore approaches capable of understanding local surroundings affecting the underprivileged children's educational opportunities and provide an acceptable and adaptable solution. The approaches will also be able to assess the varying needs based on their localized socio-cultural dynamics and can propose the optimally suited educational technology and pedagogy in that particular context. To develop such approaches, a significant understanding of the factors affecting the educational opportunities is required.

5. Research methodology and research progress

This research is supported by a mixed methods approach because the complexity of the problem suggests that disparate data may yield new insight. There are several components to this research:
1. Review of 'stand out' educational technology initiatives during the last two decades.
2. An exploratory study of 'One-room Multi-Grade Schools' operating in rural and remote areas of Pakistan along with the impact analysis of introducing education technology tools to students studying in these schools. Approximately 10 one-room schoolhouses will be visited.
3. Qualitative research (interviews/focus groups) involving relevant stakeholders of students studying in one-room schoolhouses in rural areas of Pakistan to understand local socio-cultural factors for not sending their children to school prior admitting them in one-room schoolhouses.
4. Quantitative research (survey questionnaire) involving secondary stakeholders of out-of-school children to understand their point-of-view regarding the socio-cultural drivers for out-of-school children and efficacy of one-room schoolhouses. These include parents of school-going children in remote and rural areas of Pakistan, principals, teachers and administration staff of schools operating in remote and rural areas of Pakistan, and local influencers in remote and rural areas in Pakistan.
5. Qualitative data analysis using NVivo software, and quantitative data analysis through SPSS software. Subsequently, comparative analysis of data related to the drivers for out-of-school children gathered from parents of out-of-school children through qualitative and that from other stakeholders through quantitative method
6. Developing adaptable approaches in light of the comparative analysis outcome and one-room schoolhouses study, for educating out-of-school children in remote and rural areas of Pakistan through educational technology tools, suited to their local dynamics.

6. Research findings and future directions

Field visits to one-room schoolhouses in rural areas of Sindh, Pakistan and discussion with the stakeholders of these schools including parents of students, the teachers and the management of these schools provided insight regarding the local dynamics of these schools and the challenges these schools are facing. One of the major challenges is availability of qualified and experienced teachers in these areas. The rooms for improvement surfaced during the visit and discussion provided an opportunity to

integrate the contemporary educational technology tools with the traditional learning methods presently in practice to educate the children studying in these schools according to global standards, and to help them overcome their challenge of attracting quality teachers for these schools. A pilot project to implement these technologies into their educational system is underway to observe the pathway and the efficacy of Digital One-room Schoolhouses in rural Pakistan.

Transcription of conducted interviews with the parents of out-of-school children is in progress. After transcription of data, the collected data will be analysed through NVivo. Afterward, quantitative data collection and analysis will be completed as mentioned in the previous section. These analyses are likely to reveal the local dynamics and challenges faced by thee underprivileged communities in educating their children, and subsequently provide adequate understanding to find ways to develop adaptable and sustainable solution for out-of-school children in the underprivileged children, suited to their circumstances.

Acknowledgements

References

Agarwal, T. (2014). Educational Inequality In Rural And Urban India. *International Journal Of Educational Development, 34*, 11-19.

Ally, M. (2009). *Mobile learning: Transforming the delivery of education and training.* Athabasca: Athabasca University Press.

Badar, F., Mason, J., & Khan, K. (2018). Re-thinking out-of-school learning in rural Pakistan. *Proceedings of the 26th International Conference on Computers in Education. Philippines: Asia-Pacific Society for Computers in Education.* 40-445

Bennet, N., Hare, E., & Lee, J. (1983). Mixed-age classes in primary schools: A survey of practice. *British Educational Research Journal, 9*(1), 41-56.

Bhuiyan, P., Supe, A., & Rege, N. (2015). *The art of teaching medical students.* Delhi: Elsevier India.

Cobcraft, R., Towers, S., Smith, J., & Bruns, A. (2006). Mobile learning in review: Opportunities and challenges for. *Proceedings. Online Learning and Teaching (OLT) Conference* (pp. 21-30). Brisbane: Queensland University of Technology.

Cundra, L. B., Benzel, C. A., & Schwebach, J. R. (2017). Using the one-room schoolhouse method: The design and teaching of a summer undergraduate research course in Phage Biology. *Perspectives on Undergraduate Research & Mentoring*.

Forum, W. E. (2017). *The Global Gender Gap Report.* World Economic Forum.

Goodlad, J. I. (1996). *Schools, curriculum and the individual.* Waltham MA: Blaisdell Publishing Company.

Grimus, M., Ebner, M., & Holzinger, A. (2013). Mobile Learning as a Chance to Enhance Education in Developing Countries-on the Example of Ghana. *CEUR Workshop Proceedings*, *955*, pp. 340-345. Helsinki.

Hussain, S., Wang, Z., & Rahim, S. (2013). E-learning services for rural communities. *International Journal of Computer Applications, 68*(5), 15-20.

Khan, S., Lurhathaiopat, P., & Matsushita, S. (2016). The Contribution of the international community and the dynamics of history in educational policies in Pakistan: The case of success or failure. *International Journal Of Current Research, 8*(2), 42150-42156.

Pratt, D. (1986). On the merits of multiage classrooms. *Research in rural education, 3*(3), 111-115.

Statistics, U. I. (2018). *UIS Fact Sheet No 48.* UNESCO.

Titola-Meskanen, T. (2014). A mobile school in the digital era: Learning environment ecosystem strategies for challenging locations and extreme poverty contexts. *Proceedings of 6th Annual Architectural Research Symposium*, (pp. 292-304). Finland.

UNESCO. (2015). *Global Monitoring Report 2015: Education for All 2000-2015: Achievements and Challenges.* UNESCO.

Veenman, S. (1995). Cognitive and noncognitive effects of multigrade and multi-age classes: the best evidence synthesis. *Review of education research, 65*(4), 319-381.

Williams, F. K. (2005). Inside the one-room schoolhouse: A look at nongraded classrooms from the inside out. *National forum of applied educational research Journal, 18*(3), 2.

AUTHOR INDEX

CHEN	SHIH-HSUN	314
CHEN	MEI-RONG ALICE	326
CHEN	JIA-JYUN	441
CHEN	SHERRY Y.	560
CHEN	KAI-PING	568
CHEN	GAOWEI	575
CHEN	MENGYUEN	575,599
CHEN	LING	651
CHEN	CHIAO-YI	688
CHENG	BO-YUAN	147
CHENG	HERCY N. H.	164
CHENG	WEN-WEN	399
CHIANG	FENG-KUANG	28
CHIANG	SHIH HSUN FAN	73
CHIANG	CHUAN-CHIH	548
CHICÓN	RAFAEL	66
CHIN	KAI-YI	628
CHIOU	GUO-LI	147
CHONGDARAKUL	WARALAK	258
CHOOKAEW	SASITHORN	134,139
CHOU	YI-SHIUAN	11
CHRISTIAN	CONDORI-MAMANI	724
CHU	CHIH-MING	2
CHU	HUI-CHUN	448
CHUANG	TSUNG-YEN	773,777
CLEMENTE	FÉLIX J. GARCÍA	66
CUESTA	JOSEPHINE DE LA	274

D

DAI	PENGCHENG	184
DAVE	KASHMIRA	752
DITCHAROEN	NADH	604
DIY	WALFRIDO DAVID	246
DONEN	TSUYOSHI	372
DU	JUAN	28
DUAN	SU-YING	514

E

EBARDO	RYAN	274,532
EDUARDO	DE-RIVERO	724
ERKENS	MELANIE	697,700
ESQUEMBRE	FRANCISCO	66
ESSALMI	FATHI	647

F

FERNANDEZ	MARIKA GIANINA	86,246
FLANAGAN	BRENDAN	326,341
FREESTONE	MELVIN	414

JEONG	HEISAWN	718
JIANG	YICHAO	575
JONG	MORRIS SIU-YUNG	575,599
JUAN	CHING-FANG	509
JULIO	VERA-SANCHI	724,7343
JUNUS	KASIYAH	581

K

KAMINISHI	HIDEKAZU	694
KANEHIRA	REN	721
KANEKO	KEIICHI	192
KANJUG	ISSARA	128
KANO	TOMOKI	675
KATCHAPAKIRIN	KANTINEE	362
KATO	TAKESHI	679
KATO	MASANAO	721
KHAMBARI	MAS NIDA MD	153,294,765
KHAN	KHALID	665
KHOO	KAY YONG	656
KLINGE	VILLALBA-CONDORI	724,734
KO	CHIH-HSIANG	483
KOBAYASHI	AYAME	703
KOH	ELIZABETH	643
KOIKE	KENTO	388
KONG	HYE RIN	184
KRISTENSEN	KASPER	47
KUMAR	VIVEKANANDAN	591,647
KUNG	HSU-YANG	647
KUO	WEN-JIA	568
KUO	RITA	591,647
KWAN	CHUNG LIM CHRISTOPHER	356
KWANG	LEONG TZE	66

L

LAM	JACKY CHUN KIT	184
LAN	CHENG-HSUAN	691
LEAÑO	CECILIA B.	237,274
LEE	SILVIA WEN-YU	79
LEE	MIN-HSIEN	471
LEE	CLAIRE	643
LI	LINGYU	178
LI	HUIYONG	341, 797
LI	SHIH-CHUNG	441
LI	BAO-PING	476
LIANG	JYH-CHONG	95,509
LIAO	CALVIN C. Y.	712
LIMPIN	LAIZA	274,532
LIN	HSUAN-YU	2

LIN	PAI-CHUAN	79
LIN	YI-HSUAN	326
LIN	LU-FANG	382
LIN	TZU-SHIN	525
LIN	GUAN-LIN	560
LIN	VIVIEN	612
LIN	KUNG-HOU	777
LIU	CHEN-CHUNG	58,73,79
LIU	WEN-YI	159,172
LIU	MEIQIN	217
LIU	GUAN-CHEN	483
LIU	HAO-ZE	622
LIU	YI CHUN	691
LOOI	CHEE-KIT	203
LU	CHUN	461
LU	ZHONG-XIU	591
LUMAPAS	RAUL VINCENT W.	539
LUSHIANNA	TEJADA	734

M

MAJUMDAR	RWITAJIT	341
MANAHAN	DOMINIQUE MARIE ANTOINETTE	86,246
MANSKE	SVEN	697
MARCHETTI	EMANUELA	38
MARTHA	ATI SUCI DIAN	581
MASON	JON	280,414,665
MATSUBARA	RISA	372
MATSUO	SHO	209
MERCEDES RODRIGO	MA.	769
MISHIMA	NOBUO	209
MITROVIC	ANTONIJA	781
MITSUHARA	HIROYUKI	217
MIWA	NAOKI	721
MOKHTAR	MAHANI	51
MORENO	MONICA	86,246
MORISHIMA	YUKI	422
MOSES	PRISCILLA	110
MOURI	KOUSUKE	178,192
MUROI	TAKUMI	672
MUROTA	MASAO	230
MURTHY	SAHANA	746

N

NAGAI	MASAHIRO	230
NAGATA	KATSUMI	225
NAKA	TOTSAPORN	604

SHEN	KUAN-MING	471
SHEU	FENG-RU	490,748
SHIH	JU-LING	95,448,777
SHIH	MEILUN	490
SHIHIBORI	MASAMI	217,225
SHIMADA	ATSUSHI	192
SILAWATCHANANAI	CHAIYAPORN	134
SMITH	GREGORY	665
SOH	HON-MUN	51
SONG	YANJIE	197
SONIA	CASTRO-CUBA-SAYCO	734
SOOTKANEUNG	WARIN	134
SOTARDI	VALERIE	781
SRISAWASDI	NIWAT	19,286
SU	CHIEN-LUN	11
SU	YOU	466
SUHARTANTO	HERU	581
SUMI	KAORU	332
SUN	DANER	203
SUN	JERRY CHIH-YUAN	622
SURESH	DHIVYA	643
SWAMY	NARASIMHA	805

T

TABLATIN	CHRISTINE LOURRINE	756
TAGUCHI	JUNICHI	682
TAHIR	FAIZA	781
TAKADA	HIDEYUKI	372
TAKEDA	YUKI	372
TAM	VINCENT	575
TAMURA	YASUHISA	638,682,761
TAN	DARREN	66
TAWONATIWAS	MULLIKA	119
TEE	YI HUAN	643
TEY	TINY CHIU YUEN	110
THEW	NANG CHIT SU	258
THUMTATHONG	APIRAPORN	286
TIAM-LEE	THOMAS JAMES	332
TLILI	AHMED	745
TOMOTO	TAKAHITO	388,432
TRAPERO	HAZEL A.	237,274
TSAI	MENG-JUNG	147
TSAI	SZU-KAI	773

U

UENO	URARA	432
UESAKA	YURI	694
UOSAKI	NORIKO	178,184,192

Z

ZAKI   FILZAH ZAHILAH MOHAMED   765
ZENDRATO   ROTUA   706
ZHANG   XIAOTONG   164
ZHENG   CHUNPING   466,496
ZHOU   XIAOHUA   599,715
ZHU   TING-TING   651

2019.12.2-12.6, Kenting, Taiwan

27th International Conference on Computers in Education

is organized by

The Asia-Pacific Society for
Computers in Education (APSCE)

National Cheng Kung University

National Central University

National University of Tainan

is sponsored by

MOST 科技部
Ministry of Science and Technology

National Cheng Kung University

邁克兄弟科技股份有限公司
Smart Robot Technology Co. Ltd.

智軒文化事業有限公司
Wisdom Win Distributor Co.