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PREFACE

This volume contains the Doctoral Student Consortium (DSC) proceedings of the 24th International Conference on Computers in Education (ICCE 2016). For this year, the DSC program brings together PhD students working in the broad research areas of computers in education in the following seven sub-themes: Artificial Intelligence in Education/Intelligent Tutoring System and Adaptive Learning (AIED/ITS/AL); Computer-supported Collaborative Learning and Learning Sciences (CSCL/LS); Advanced Learning Technologies, Learning Analytics and Digital Infrastructure (ALT/LA/DI); Classroom, Ubiquitous, and Mobile Technologies Enhanced Learning (CUMTEL); Digital Game and Digital Toy Enhanced Learning and Society (GTEL&S); Technology Enhanced Language Learning (TELL) and Practice-driven Research, Teacher Professional Development and Policy of ICT in Education (PTP).

The DSC program aims to provide an opportunity for a selected number of PhD students to present, discuss and receive feedbacks on their dissertation work-in-progress from a panel of established researchers with expertise in the same research area. The DSC program is meant for students to shape their research methodologies and analysis at the early stage of their PhD research with comments and guidance from invited mentors for future research directions. The DSC program also hopes to nurture a supportive learning community and promote interactions among young researchers from various institutions and different countries in the Asia-Pacific region and beyond.

The DSC program and the related social events are financially supported by the Asia-Pacific Society for Computers in Education (APSCE). We hope that the papers in the proceedings on various research topics will stimulate more research ideas and discussions among the young researchers, and we would like to thank all the invited mentors in making this year's DSC program a highly successful event.

On behalf of editors

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Learning payoff of ICT: What can make a difference from the perspective of students

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Abstract: This study evaluated the payoff of Information and Communications Technology (ICT) on learning in China using a multiple case study design. Cases of how students used ICT for learning in 2005 and 2015 were collected from Shanghai K-12 schools. Semi-structured interviews and scales were the main data collection techniques utilized in the study. By case coding, the results showed that ICT influenced learning practice and skills. Furthermore, individualized ICT devices, specific learning resources, and refined activity contributed to the payoff.

Key words: Information and Communication Technologies, payoff, learning, case study

1. Introduction

The Chinese government has invested a certain amount of money on Information and Communications Technology (ICT) for education. From the beginning of the 21st century, the ICT access of schools has been improved significantly owing to policies such as “The Tenth Five-year Plan of ICT in Education” and “The Plan for ICT in Education (2011–2020)” (Ministry of Education of China, 2016). However, the effect of ICT in Chinese education, which features rote memorization and exam preparation, remains unclear. This study aims to provide a holistic view of the effect of ICT on learning using a multiple case study design.

2. Literature Review

2.1 Learning payoff of ICT

The data supporting the effectiveness of ICT in schools is, at best, mixed (Kirkpatrick & Cuban, 1998). Standardized tests for students are cited as a primary measure for program success. Studies upholding this view started with Angrist and Lavy (2002), whose findings showed no evidence that computerization in education raised test scores. However, an increasing number of researchers are struggling to promote the understanding of ICT’s payoff from the perspective of learning practice and skills. The increasing diversity of technologies and ever-changing contexts in which ICT has been used makes the ICT impact more complex. Johnston and Baker (2002) provided two learning outcomes for ICT use; the cognitive and affective domains. Law, Kampylis, and Punie (2015) reported the outcome of using ICT included 21st century skills and learning motivation. Moreover, most studies reviewed are limited to America and Europe. Lee et al. (2009) studied 15–16 year-old learners in the US who indicated positive school behavior and literacy scores in relation to ICT use. Harrison et al. (2001) evaluated the ImpaCT2 project in the UK and showed a positive correlation between ICT use and academic attainment; a range of online social and communication skills were also improved using ICT.

Numerous international organizations have taken the initiative to form a framework to evaluate the payoff of ICT. The assessing framework established by Inter-American Development Bank (Cabrol & Severin, 2009) and the European Commission (Kikis, Scheuermann, & Villalba, 2009) shared similar features. They used “inputs,” “process,” and “impact” to monitor ICT integrated projects. Inputs referred to the project foundation, such as infrastructure, resources, support, and sustainability. Process

referred to the use of input elements in specific projects. Impact or payoff were measured based on learning practices and skills, as well as student involvement and achievement.

2.2 Theoretical framework

The theoretical framework formed for this study is shown in Figure 1. Cases of 2005 and 2015 are compared in terms of inputs, process, and outputs. The outputs represented the payoff of ICT. Inputs and ICT usage processes explained the final payoff. Each aspect is evaluated from the voice of students, including the perception and experience of ICT usage among students.

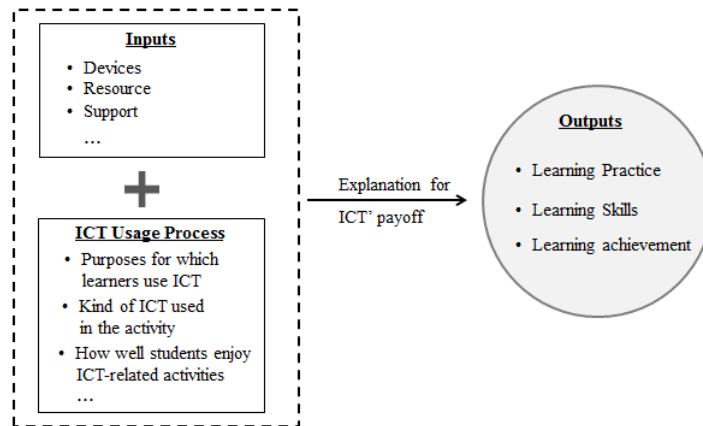


Figure 1. Theoretical framework of the ICT impact study

3. Methodology

3.1 Research questions

This research raises the following questions: (1) how different students perceived their learning being impacted by ICT between 2005 and 2015; and, (2) why differences existed and how could the differences be explained by ICT inputs and usage process.

3.2 Data collection process

Purposeful sampling strategies were applied in this study. For the 2015 cases, one primary school and one secondary school was respectively chosen from the 7 core districts in Shanghai. The criteria for school chosen were as follows. Firstly the school should be funded by government or other organizations for ICT. Secondly the school had been using ICT in most courses. 14 schools were determined after consulting the Shanghai Municipal Education Committee, who knew the ICT using status in each school well. In each school, approximately 10 students who were about to graduate were voluntarily recruited to recall their ICT using experience. For the 2005 cases, considering the difficulty of finding graduates from the same school as 2015 cases, college students in East China Normal University who graduated from ICT-funded schools in Shanghai were recruited. 120 students were interviewed in the preliminary investigation stage. Demographic information is listed in Table 1.

Table 1: Demographic information of participants

Case	School Level	Gender		Grade	Average Age
		Male	Female		
2005	Primary School	16	14	15 in 4th Grade, 15 in 5th Grade	19.0
	Secondary School	18	12	12 in 8th Grade, 18 in 9th Grade	24.5
2015	Primary School	15	15	14 in 4th Grade, 16 in 5th Grade	10.0
	Secondary School	13	17	16 in 8th Grade, 14 in 9th Grade	14.0

Semi-structured interview and 5-point Likert scale were used for data collection from March to July in 2016. An interview field guide with sample question probes such as “How did you use ICT in class” and “What activities were taken” was provided to two research assistants. Students’ perception on the ICT payoff was assessed by asking students to rate on scales of 1 to 5 in answering questions such as “How do you perceive engaging in learning with ICT” and “How do you perceive your problem solving ability”.

3.3 Data analysis

Independent T-test was conducted for the first research question. For the second question, the interview records were transcribed by two research assistants to form cases. There were respectively 3 cases for the primary school and secondary school for 2005 and 2015. Then the cases were coded by the assistants and the Cronbach’s Alpha was 0.84. Table 2 shows the coding scheme, which was adapted from the ICT indicators by international organizations, such as the UNESCO Institute for Statistics (UIS, 2009) and the European Union (Pelgrum & Doornekamp, 2009).

Table 2 Coding scheme for the cases

Category	Sub category
Input	<ol style="list-style-type: none"> 1) ICT devices availability: computer, Pad, whiteboard, ratio of learner-to-computer, Internet connection 2) Resource availability: digital learning materials, educational tools, and software developed for the learning process
Process	<ol style="list-style-type: none"> 1) Curriculum activities where students use ICT for learning (e.g., literacy, mathematics, science, and language) 2) Extent of ICT use among students for cooperation and/or communication 3) Kind of ICT (Web 2.0, LMS, Learning software) used in the activity 4) Enjoyment of students in ICT-related activities 5) Purposes of using ICT for learners: informative, functional, creating, and communication
Output	<ol style="list-style-type: none"> 1) Learning practice: attitude, motivation, engagement, and enthusiasm 2) Learning skills: critical thinking, problem-solving, collaboration, creativity 3) Learning achievement: homework performance and test scores

4. Preliminary results

For the first research question, the independent T-test results showed significant differences in learning practices ($t(118) = -3.65, p < .001$) and learning skills ($t(118) = -3.52, p < .001$) for 2005 and 2015. No significant difference was found in the learning achievement ($t(118) = -.58, p > .05$). Four subcategories, namely, learning motivation, learning engagement, critical thinking skills, and problem solving skills, of the year 2015 cases were significantly higher than that of the year 2005 cases. The results were $t(118) = -2.24, p < .05$; $t(118) = -2.20, p < .05$; $t(118) = -3.15, p < .005$; $t(118) = -2.34, p < .05$, respectively.

The coding results answered the second research question. Individualized ICT devices and available resources were revealed from the “inputs” coding. For the year 2005 cases, interviewees mostly mentioned image, flash, text, and the Internet. Secondary school students said “We use specific tools, such as geometer sketchpad for math learning.” In 2015, more than half of the students said, “My teachers teach using the Pad”, “the Pad has an electronic book, a foreign language app”, and “I have used Scratch, voice recognition software, and games on iPad”. The resource was rich and specific in the year 2015 cases. Secondary school students stated that, “We are allowed to use laboratory computers for some subjects” and “We used the online evaluation system to test our math performance”.

By reviewing ICT usage process transcription, the subjects, purpose, and organization for the activity were summarized. For the year 2005 cases, most students used ICT in “traditional” subjects, such as math and literacy for knowledge mastery. Interviewees indicated that “The flash presentations teachers showed helped me understand difficult contents.” About the activity, interviewees said that, “My teacher carried out a collaborative problem-solving activity, but..., I did not engage in the activity very much.” For the year 2015 cases, more ICTs were used for extracurricular learning to extend skill development. Students reported that, “On Friday afternoons, we can freely choose the ‘Computational Thinking’ course we are interested in.” The activity was much refined in 2015. Students mentioned that, “The teacher provides us a learning task list to guide us in the problem solving process.”

5. Research contribution

In conclusion, ICT has impacted learning practices and skills. More individualized ICT devices, specific learning resources, and refined activity have contributed to the payoff. The impact of ICT in education remains an open question considering the limited research found in East Asia. The proposed study contributed in enhancing our understanding of this topic and in developing propositions on the payoff of ICT.

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Improving effectiveness of MOOCs

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Abstract: Massive Open Online Courses (MOOCs) are trending education technology, delivering learning experience to worldwide students. Although some state that it has sound pedagogy, others are skeptical of its effectiveness and whether it assists to provide 21st century skills. Drop outs of the MOOCs keep remaining at higher percentages while the problems of isolated learning, less interactivity and less collaborative MOOC models are lasting.

Using survey methods, this doctoral research preliminarily explored whether MOOCs provide 21st century skills, and also identified what factors affects the effectiveness of MOOCs. Then we built an effectiveness framework for MOOCs where we can identify design interventions and evaluate improvements. MOOCs form a new phenomenon which needs more experiments and understanding to provide best learning models for the lifelong learning community. Therefore, as next steps, we further sought exploring learning interventions to improve the effectiveness of MOOCs using the dimensions we found in the framework.

In the preliminary stage we used Grounded Theory (GT) methodology in discovering the factors affecting the effectiveness of MOOCs. In next steps, this research needs practical understanding, design and application of learning theories in a new learning environment. We intend to incorporate Design Based Research (DBR) methodology and Human Computer Interaction (HCI) methodologies.

Our intention is to discover a novel pedagogical design which will enhance the learning experience in MOOCs, thus implement and evaluate a prototype of a learning intervention where MOOC platforms can be utilized to increase the effectiveness.

Keywords: MOOCs, effectiveness, design base research, grounded theory, 21st century skills

1. Introduction

E-Learning has been practiced for more than 10 years. The term “E-Learning” is described as the use of electronic medium to learn remotely. In practice, E-Learning was less followed and in-person classroom-based didactic lectures were identified as a major source of educating students. However, with the time, technological development and the trending sociological culture, E-Learning became a solution for the universities and institutions to deliver education effectively and efficiently. Yet it was facing major problems such as students often complaining the isolation, less interactivity and less collaboration which they used to have in face to face class room environments. However, in 2012, a new phenomenal educational technology was introduced as MOOCs (Massive Open Online Courses). MOOCs are trending because it opened educational opportunities for many who cannot afford education offered by elite universities for free of charge, resulting thousands of enrollments to online courses. In 2012, New York times pronounced the year of MOOCs since giant MOOC players were introduced, such as edX, Coursera and Udacity. However, by 2016, MOOCs trends were identified to be fading.

The pedagogy of the MOOC typically includes small chunks of video lectures, formative quizzes, self-graded and peer graded assignments and discussion forums. Many researchers have identified that MOOCs provides a sound pedagogy and enhances the opportunities to learn. However, with the time (4 years since its introduction), some researchers questioned the quality of actual learner experience. They are skeptical of the MOOCs and claim that it directs to the pedagogically failed didactic education (Daniel, 2012). They argue that the learner is focused on lecture based learning where platform does not facilitate or encourage the skills required for 21st century such as critical thinking, collaborative learning. Many MOOCs found to be having only 15% completion rate leaving many learners unsuccessful to complete courses (Bali, 2014).

Many researchers attempt to address the MOOC completion rates issue by increasing interactivity or improving assessment with interventions. However, those will be a short patch for a broader problem. The broader problem is “How can we improve the effectiveness of learning experience in MOOCs?” This broader question can address by few objective questions: What factors affects the effectiveness of MOOCs? How can we measure the improvement of effectiveness? In what way MOOCs platforms can be improved or what solutions can be implemented and integrated into improve MOOCs platforms using the dimensions found above questions?

In this research we try to answer the questions and find solutions incorporating Grounded Theory (GT), Human Computer Interaction (HCI) methodologies and Design Based Research (DBR) methodology. It is mainly because of the fact that the problems of MOOCs mainly need attention in the social behaviors and human interactions. We understand, the basic question of “How can a large group of humans at any age learn better in online situations?” should be identified. Hence, this research continuing to understand the bigger problem and in this paper we first explain the background literature, the objective of the research and the methodology which will follow to conduct this research.

2. Literature Review

2.1 Background to the problems in MOOCs

MOOCs attract wide spread attention and rapidly changed the attitude towards online learning. Although constructivist or cMOOC existed since 2008 the xMOOC became the “buzz” word since 2012 due to the emergent of Coursera, Udacity, and edX. Since then many number of MOOC courses and MOOC platforms are emerging at a high rate. MOOCs are special due to the massive number of participants and open to any user who is interests to learn. Although many MOOCs offer free of charge, some MOOCs are issuing credentials or verify the authenticity at a considerable lower cost. MOOCs by nature have some common characteristics; short videos, quizzes, peer base or/and self-assignments and online forums (Glance, Forsey, & Riley, 2013) yet there are pedagogical differences in courses even in the same MOOC providing platform (Bali, 2014). Offering or participating a MOOC has benefits to each party, however concerns are arising on the real value behind MOOCs and the consequences of it. It is mainly because there are higher dropouts in MOOC, which means only 7-13% of pass rate or sometimes less than that complete the courses (Jordan, 2014). Although, researchers found MOOCs has higher gain than the students taking a class on-campus (Colvin, Champaign, Zhou, Fredericks, & Pritchard, 2014), some researchers doubt whether there is active learning taking place in MOOC (Daniel, 2012) (Downes, 2013). The situation rising from this background leads to a requirement of quality or effective MOOCs where it meets all the learning goals of a participant.

2.2 Quality of MOOCs

Effectiveness or quality factors for online learning are widely available with empirical evidence (Ehlers, Ossiannilsson, & Creelman, 2014; Downes, 2013; Conole, 2013). However, those factors will not be suitable for MOOC due to the unique features of MOOC. Hence empirical tests should consider MOOC participants or courses (Yousef, Chatti, Schroeder, & Wosnitza, 2014). We explored the previous studies which have been focusing on identifying the factors leading to an effective xMOOC which recognize quality factors. Recent researches found the theories behind the effective learning and teaching (Andrew & Soloman, 2013). It is important to identify the affections it brings to the E-Learning as well and it is the beginning of an exciting effort to understand how people learn and how to educate effectively at scale (Ho, et al., 2014).

3. Motivation and research questions

Main objective of this research is to improve the effectiveness of E-Learning experience in MOOC. We claim that the existing MOOC model does not support to meet the challenges face in 21st century. The existing model mostly follow the didactic lecture base learning, leaving less room for the students to critically think and work collaboratively. We claim that MOOCs are not effective thus MOOCs are

young itself, there are many opportunities and methods in attempting to find an effective balance. In doing so, we set our objectives in the research as:

1. identify what is needed by students to learn best in MOOCs, what factors does affect the effectiveness.
2. how can we improve the effectiveness of MOOCs using the discovered factors in 1,
3. introduce an appropriate pedagogical model/ theoretical framework to enhance the Learning experience, and
4. design a working porotype model on the enhanced pedagogical model and empirically test the improvements in effectiveness.

4. Research Methodology and work completed

The research consists of identifying, modeling, building and testing educational pedagogy for MOOCs where it will enhance the effectiveness. Therefore, different methodologies will be practiced in different phases based on the suitability.

- Phase 1 - Identifying what factors affect in the effectiveness - *Completed*
- Phase 2 - Developing a pedagogical model to enhance the effectiveness - *Work in progress*
- Phase 3 - Modeling a prototype and testing the improvements - *In future*
- Phase 4 – Implement in the prototype and integrate as a learning intervention - *In future*

In the first phase we mainly practiced Grounded Theory (GT) approach. The aim of using GT in this research was to understand the E-Learning culture and identifying users' behaviors and desires. Our main claim is that, after the introduction of MOOCs, previous E-Learning behaviors and expectations may have affected. The main focus was on individuals live experience of events in continuing E-Learning. It is important to understand the depth of social reality, contextual importance in the new Web 2.0 era. As we used this qualitative method (GT) in order to identify these affections, we assured that the researcher is involved in every step listening to human needs. We were responsive and adaptive to explore what actually the users in MOOCs find as effective. By the end of the time period, we discovered 10 dimensions affect to effectiveness of MOOCs (Gamage, Perera, & Fernando, 2014). This discovery directed us to introduce Network grouping model/ algorithm, where we can group the students in MOOCs so that they can work effectively than following a typical MOOC by isolating the participants. End of the phase 1, we presented a 10-dimensional framework for effectiveness of MOOCs (Gamage, Perera, & Fernando, 2015). In phase 2, we propose a MOOC learning model based on the theoretical framework and introduce learning interventions. Proposed model treats the students in small groups. The clustering into groups will be based on an algorithm depending on students' interactions. Introduce an effective peer reviewing model where we hypnotize an Identified Peer Reviewing (IPR) model. In that, students can see the peers they grade which is opposite to the blind peer review. Students in these small groups perform course activities individually and as a group by peer reviewing each other and collaborating in forums. Unlike the current blind peer reviewing model, we propose peers to know the graders and build upon a relationship in providing feedback and networking. The last 2 phases will follow the research methodology "Design Based Research (DBR)". This method can compose a coherent methodology that bridges theoretical research and educational practice. DBR is a blend of empirical educational research with the theory-driven design of learning environments, hence it is an important methodology for understanding how, when, and why educational innovations work in practice.

In future, we plan to test the grouping algorithm/ networking in a prototype of online course in local university and based on the initial results, we intend create a national MOOC integrating the prototype system designs to an existing LMS. It will represent the learning intervention and we hope to integrate Human Computer Interaction (HCI) methodologies where the artifact interaction will provide optimal results. The domain of the MOOC will be selected based on the demand and the trend we see in the country, where we can attract many learners to take part in the course.

5. Conclusion

The world is moving to many online learning technologies and MOOCs found to be one of the intervention. Although it started as a hype, still it faces many challenges, such as very low completion rates and students complaining the isolation, lack of interest, lack of motivation to continue the courses and poor quality courses are some of the reasons. In this research, our main objective is to improve the effectiveness of E-Learning in MOOCs. Effectiveness is meeting the learners' goals. Since MOOC is a very new phenomenon, the real behavioral expectations and patterns of online learners are new to the field. Rather than proposing solutions to a surface problem, we use Grounded Theory to identify the theory behind the effective online learning in MOOCs and plan to design solutions using Design Based Research Methods (DBR) and incorporate Human Computer Interaction Methods (HCI) in implementing new models. The research aims to introduce a learning intervention which will assist students to learn effectively and more collaboratively than the existing pedagogical models followed by the MOOCs. We believe that the new learning model design will aid students to meet the challenges in the 21st century.

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Investigation of Reliability of Kit-Build Concept Map and Collaborative Approach to Build Sharable Knowledge

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Abstract: This paper describes an investigation of a reliability of automatic evaluation of concept map in the framework of Kit-Build concept map and procedure for using it in a collaborative approach to building sharable knowledge. Kit-build concept map is used as the learning task of the concept map for enhancing and assessing learners' comprehension of a topic, which they already learned. This framework is practically used in several kinds of school, but the reliability of assessment has not been investigated. So we try to examine the reliability of assessment of Kit-Build concept map by comparing with the handmade concept map evaluation method that is claimed as the reliability evaluation method for scoring concept map. Because the handmade method is used by a human who can understand the meaning of proposition in the concept map, even the used words do not contain in learning material. After the reliability of our framework is confirmed, we try to propose the collaborative approach that applies Kit-Build concept map for building shareable knowledge between learners. For making the different understanding to the same direction, the collaborative knowledge construction approach is implemented to Kit-Build framework. Learners have to make their concept maps and use the reciprocal Kit-Building that contains summarizing, questioning, clarifying and predicting for sharing their understanding on the different viewpoints, and they must try to harmonize the agreement and disagreement part of the topic.

Keywords: Kit-Build Concept Map, Concept Map Evaluation, Reliability, Sharing Knowledge, Collaborative Knowledge Construction

1. Introduction

A concept map is used for representing and organizing knowledge. However, it is also utilized for assessing learners' understanding widely. Kit-Build concept map is an automatic concept map framework that adopts concept map for enhancing and assessing learners' comprehension in the form of learning task of exercise. After learners learned a topic, they will be evaluated their understanding and instructor tries to analyze the difference between their understanding and instructor's objective. Kit-Build concept map is used in several kinds of school practically such as science learning in elementary school, geography in junior high school, and learning English as the second language. Nevertheless, it does not have investigated the reliability of the assessment method, the propositional level exact matching. So we try to confirm the reliability of this evaluation by comparing with the handmade concept map evaluation method, which is acceptable widely. If the correlation between Kit-Build concept map and the reliable handmade concept map evaluation is a positive relationship, we can conclude our framework is suitable for evaluating concept map.

The abilities of Kit-Build concept map and collaborative knowledge construction technique are focused on producing the procedure for making sharable knowledge between learners. The reciprocal teaching activity is chosen to integrate with our framework as the reciprocal Kit-Building procedure. The four principal strategies of reciprocal teaching that contain summarizing, questioning, clarifying and predicting are utilized as the main core of sharing knowledge process. And supporting of Kit-Build concept map can represent the different viewpoint of each learner that will give opportunities for learners to make agreement part and disagreement part on the topic easily. This procedure will push forward learners to give and take the knowledge between each other during learning situation well.

2. Literature Review

In this study, we investigated a lot of research about the concept map evaluation method and the collaborative learning. For the concept map evaluation method, we try to find the handmade concept map evaluation method that is a typical one for comparing with our automatic concept map framework reasonably. And the theory of collaborative learning process is necessary to guide the designing of knowledge sharing procedure that we try to apply Kit-Build concept map on it.

2.1 *The concept map evaluation method*

From our literature review, we separated the concept map evaluation methods into two groups. That is the handmade concept map evaluation method and the automatic concept map evaluation method.

2.1.1 *The handmade concept map evaluation method*

The concept map evaluation methods in the handmade group are used by the human who can understand the meaning of the proposition. In this study, we focus on the methods that pay attention to the structure of concept map and the meaning of proposition of concept map. The Novak and Gowin structural scoring (Novak & Gowin, 1984) is the typical handmade concept map evaluation method that investigates the structure of concept map such as the level of the hierarchy, characteristic of a branch, crosslink and so on intentionally. This method gives high scores for each correct level of the hierarchy and each valid crosslink. Because ordering the concepts into the hierarchy and connecting the crosslinks can facilitate constructor to have creative thinking. But it tends to the structure more than the meaning of the proposition, so it gives only one score for each valid relationship of proposition and example. After that, the methods for investigating the meaning of proposition are purposed. These methods consider on the meaning and do not concern about the structure of concept map as the proposition precedence. Scoring by meaning criteria is accepted widely. These meaningful methods always have a printed set of criteria as the rubric for assessing knowledge and for giving feedbacks differently. However, we focus on the relational scoring method from McClure and Bell. It is one typical assessment for scoring concept map. The evaluators must score concept maps individually by evaluating each proposition separately (McClure & Bell, 1990). The procedure investigates the suitability of meaning of each proposition. If the linking word is appropriate with concepts clearly, that proposition will get three scores as a perfect score. The score will be depreciated depending on the meaning of linking word. For the reliability of this method, they claimed this method has the most reliability when the using with the master map by comparing with the holistic method and the Novak and Gowin structural method. They confirmed it by using g-coefficient value (McClure et al., 1999).

2.1.2 *The automatic concept map evaluation method*

Most of the automatic concept map evaluation methods use the criteria map as the target of learning. They compare the learner map with criteria map to evaluate learners' understanding that we call an automatic comparison concept map evaluation method. This comparison inherits the property from the human method that is the structure of concept map and meaning of the proposition. If learner maps are the same as the criteria map, it shows that learners can understand in instructor's objective well, which includes the understanding of structure and meaning of the proposition. The reason why the automatic comparison concept map evaluation method is desirably used in automatic assessment is the ease of using a matching function to compare learner map with the criteria map reasonably. There are two types of concept maps that we must choose for construct as the criteria map. The formal concept map is the first one that is built by using valid meaning in universe context. It also has more concise relations between concepts. That makes it is appropriate for the automatic evaluation but is hard for constructing the formal concept map by the instructor. The informal concept map can be created freely by any words. It is easy to construct but hard for evaluating by the automatic method because the system cannot guess the used words thoroughly. For the level of analysis, some method focus on the topographical analysis methods to describe the overall geometric structure of concept map, we call the level structure analysis. But some method chooses to investigate on the attribute of each proposition instead of the overall

structure; we call the propositional level analysis. This level tries to find the valid proposition following its procedure and counts the number of the valid proposition as the evaluating score. One more attractive property is the type of matching method when the criteria map is compared with the learner map. The straightforward matching method that we call the exact matching is used widely. It will accept only the propositions that equal with the proposition of the criteria map. The others will be judged as incorrect proposition merely. While some researchers thought that the exact matching is so strict, so the synonym matching can support more flexible comparison.

Our framework, Kit-Build concept map (Hirashima et al., 2015) is an automatic concept map assessment that uses the exact matching in propositional level for evaluating concept map. It has been already used in classrooms practically and confirmed that the framework and results of the diagnosis were useful to support teachers in science learning in elementary school. Hence it is suitable for using in teaching situation that instructor gives the direction following instructor's interpretation. However, we have not examined the quality of the evaluation. So we produce the experiment to investigate the reliability of Kit-Build concept map by comparing well-known handmade evaluation methods. For using Kit-Build concept map, the instructor has to prepare the criteria map, which is called the goal map in our framework. It is constructed as the informal concept map because it should follow the instructor's objective that requires learners to understand that is not the universe context. After that, the goal map is extracted to the kit that contains a list of concepts and relationships. This kit that is provided to learners can help learners to reduce their cognitive load more than the traditional concept map, which they must create all components by themselves. After that, learners are requested to reconstruct concept map by using the kit; it is called the learner map. The framework will check learner maps by exact matching on each learner's proposition with goal map's proposition and generates a similarity score. The instructor can investigate learners' misunderstanding individually and can find the overview of all learners by overlaying concept map as the group map and the group-goal difference map immediately. After result analyzing, the instructor can adjust the goal map or teach learners about leaky content again.

2.2 The Sharing Knowledge and Collaborative Knowledge Construction

Collaborative learning supports learners to share their knowledge and makes the classes more active. Learning as a social process incorporates multiple distinguishable phases. They constitute a cycle of personal and social knowledge-building (Stahl, 2000). However, we try to investigate the collaborative techniques that can help learners to share their understanding and make an agreement on each other understanding apparently. Following this objective, we focus on the reciprocal teaching that is an instructional activity in which learners become the instructor (Barkley et al., 2014). Learners will act as in four strategies: summarizing, questioning, clarifying and predicting. Summarizing is a way to help learners reconsider their understanding. Questioning requires learners to think about the topic and forces them to identify areas that are confusing, need for clarification. It allows learners to think critically and get their classmates to do the same. Clarifying is the answering the posed questions. It also points out confusing areas and clarifies them. When learners predict, they send out the idea what can happen next in the comprehension they just learn. It requires learners to examine what has already taken place and utilize their imagination to think ahead.

3. Research Methodology

To confirm the reliability, we produce the preliminary experiment to compare the correlation between the handmade concept map evaluation method and Kit-Build concept map. For the handmade evaluation method, we chose the Novak and Bell structural concept map evaluation and the McClure relational propositional method that they are a typical traditional method.

In this preliminary experiment, ten university students were requested to read the article that described "Introduction of concept map." After that, they had to construct concept maps following their reading interpretation by using 21 provided concepts on CmapTools application. It means they must create linking word by themselves. We used the two handmade evaluation methods to evaluate these concept maps, and the raw scores of each method are normalized by using their perfect score. Then, they had to use Kit-Build concept map to reconstruct concept map by using kit. The kit contained the

same 21 concepts and additional 22 relationships. These concept maps were evaluated by our automatic evaluation methods. The score is represented as the similarity score when learner map was compared with the goal map. After reading situation, the participants were taught about the same article following instructor's interpretation, and they were requested to construct the concept map as same as step in reading situation. They had to create linking words by themselves and Kit-Build concept map.

In the part of sharing knowledge, the objective of sharing knowledge is to make an agreement on specific knowledge each other. We try to use the ability of Kit-Build concept map and the collaborative learning technique to support in this situation. The reciprocal Kit-Building, which is an integration of reciprocal teaching and Kit-Build concept map, is proposed. After learning situation, learners are paired, and they have to summarize their understanding as a concept map. After that, their concept maps are extracted to be a kit, and it is provided to their partner. Then, learners are requested to construct Kit-Build map by using the kit, which is decomposed from their partner's concept map. Afterward, the difference map of each Kit-Build map is generated, and learners have to discuss how their concept map different with their partner by questioning and clarifying. The difference map of our framework can represent the different viewpoint of each learner when learner map is overlaid. After the discussion, learners should build the shared knowledge between them in the form of agreement and disagreement part. And they should predict ideas of what can happen next in the comprehension they just learned. However, learners can represent their common knowledge in several formats such as the concept map, report and so on. It depends on the characteristic of the common knowledge that they got and the learning strategy that the instructor used.

4. Current Work

From the preliminary experiment result, we compute the correlation between the score of Kit-Build concept map and the handmade methods. The p-values show we cannot discuss the correlation between both structural and relational method with Kit-Build concept map in reading situations. Because, when the learners read the material, they interpret the information by themselves, and it is possible to be various ways. While the result from teaching situation has a marginal medium correlation between both handmade evaluation method and Kit-Build concept map, it shows the lecture from instructors can make an agreement on that material by teaching and guide the learners' understanding to the same direction with the instructor. From the assumption that the handmade concept map evaluation is reliable, the results suggest Kit-Build concept map is reliable for evaluating concept map in teaching situation by comparing with the handmade evaluation methods. However, we desire to make more definite confirmation of Kit-Build reliability by using g-coefficient value in a full experiment. And the stability of handmade evaluation method is analyzed because it may affect the quality of evaluation.

Acknowledgements

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Reference Information Model of Concept Map for Improving Learning Achievements

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Abstract: In this paper, we aim to confirm that Kit-Build concept map (KB map) is suitable to improve learning achievements in classroom situation. The main purpose is utilizing KB map on formative assessment to develop ongoing formative assessment. Because our framework contains a concept map construction, assessment and diagnosis tools, which can support to gather and assess learner's evidence well. For using KB map, instructor has to create the criteria as goal map and it will be extracted as a kit. The kit will be provided to learners when instructor wants to gather learner's evidence. After learners reconstruct a kit as learner map, their maps are evaluated by comparing each proposition of learner map and goal map by exact meaning matching, which is assessing learner's evidence as assessment result in form of similarity score. From this comparison, KB map can generate individual diagnosis result by overlaying learner map and goal map that can represent misunderstanding of each learner by displaying the difference between two maps. In addition, our framework can provide group diagnosis result that shows most common misunderstanding of learners as an overview of class. Both individual and group diagnosis is a great influence to contribute instructor's feedback designing to create intra-class and inter-class feedback. Based on practice results, two strengths of KB map, which are the kit and the group diagnosis, are significant ability and effective to influence on developing ongoing formative assessment in classroom situation. However, these abilities support only instructor role. To encourage learners to practice their knowledge and skills, self-reflection learning is focused. It can support learners to improve their achievements by themselves. So we would implement the reference information model of KB map for supporting learner's self-reflection. This model will provide the useful information for learner to reconsider their understanding. The provided information contains criteria-referenced as their own map that represent only correct propositions, norm-referenced as overlaying all learners map that shows an overview of class and self-referenced feedback that is their own map in previous step. After this information is provided, the action of learner will respond to self-reflection for improving their learning achievements.

Keywords: Kit-Build concept map, Ongoing Formative Assessment, Reference Information Model, Concept Maps, Proposition Level Exact Matching, Self-Reflection.

1. Introduction

Kit-Build concept map (KB map) is a digital tool for supporting concept map strategy, which includes construction tools, an automatic concept map assessment, and the diagnosis result. It is used to develop framework of Kit-Build concept map (Hirashima et. al, 2015) for using in the classroom situation. The framework of KB map places a stronger emphasis on confirming the understanding between instructor and learners in classroom situations. Based on the ability of KB map and characteristic of the framework, these are suitable to utilize in formative assessment.

The formative assessment is the procedure to assess learner's evidence for learning that includes goal setting, monitoring, and providing ongoing feedback. This procedure requires formative strategy, which uses to represent and assess learner's evidence. The strategy of formative assessment should represent and can assess learner's knowledge, which provides formative information to an instructor. And the instructor design feedback based on formative information is the key to improving learning achievements. We attempt to confirm the framework of KB map is appropriate to utilize in the formative assessment as more as possible for developing the ongoing formative assessment. And the primary purpose is the implementing in order to improve the ability of KB map, which can play a

significant role in encouraging reflective thought and action. The diagnosis results are formative information to contribute instructor’s feedback designing that encourages self-reflection of instructor. And reference information model is used for developing a new task to promote reflection of learners.

2. Kit-Build Concept Map in Formative Assessment

2.1 Kit-Build Concept Map Ability

The general practice flow of KB map framework can support through of learning process in classroom situations (Hirashima et. al, 2011). Sharing knowledge from instructor to learners is the lecturing in class, and instructor anticipates learners to understand lecture content in the same intention. An instructor constructs a *goal map* to represent the intention on lecture content that he/she want learners to understand as same as his/her expectation. And the instructor requests learners to construct *learners map* to express what they understand on lecture content. KB map provides a “Kit” that is decomposed from the component of goal map, which includes concepts and relations with linking words. Learners construct the learner’s map by integrating the kit, and upload it to the KB map server. An automatic concept map assessment method of KB map is the proposition level exact matching that can generate the useful assessment result and diagnosis result. The assessment results show the similarity score between learners map and goal map that mentions about the progress of instructor’s expectation. The diagnosis results report information in the form of three error links that consist of lacking links, leaving links and excessive links. They are used to explain what difference of learner maps from goal map.

2.2 Ongoing Formative Assessment

Formative assessment is the monitoring to provide ongoing feedback. It is used to improve learning achievements. It means the assessing learner’s understanding in the classroom situation can support to improve learner’s understanding. Figure 1 shows a scenario of intra-class feedback and inter-class feedback in classroom situation when utilizing KB map in formative assessment. An instructor constructs a goal map as a *final state* before being the class and giving a lecture. After that, learners are requested to construct learners map for checking their understanding following check point, which is the way for identifying *learner’s state*. The automatic diagnosis of KB map provides the assessment result and reports the diagnosis result, which is used to contribute instructor’s feedback designing (Sugihara et. al, 2012). The instructor’s feedback is the key to improving learner’s understanding. And it is also the way to closing the gap between learner’s state and final state. The kit, the proposition level exact matching, and the diagnosis result are main reasons that make an advantage of KB map when using in the classroom situation.

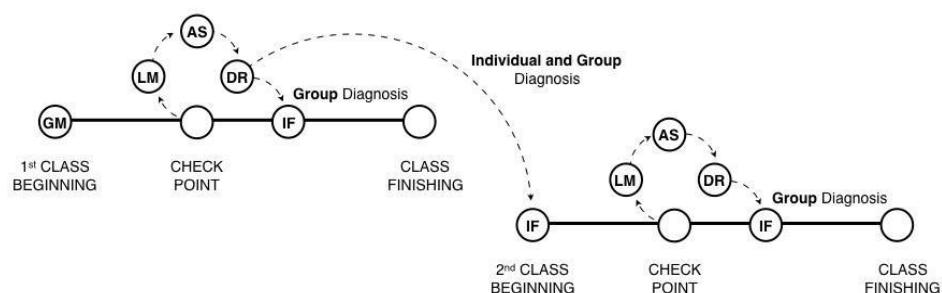


Figure 1. Intra-class feedback and inter-class feedback in classroom situation.

The kit is a list of concepts and relations with linking words. It is decomposed from the goal map and is provided to learners when they construct learners map (LM). It can confirm understanding between instructor and learners on lecture content by using the same components, and it is possible to use the kit to assess learner maps by using the proposition level exact matching. Several researchers proposed various approaches for concept map assessment such as using synonym words and graph theory, but it requires the instructor to confirm the result before identifying learner’s state. The assessment result of the proposition level exact matching can identify learner’s state clearly without instructor’s

confirmation that is the ready-to-use result. Moreover, the same component can be used to generate the group map of learners. The group map can represent the most common understanding of learners, which is additional learner's evidence in term of formative assessment. The propositional level exact matching and the group map are advantages of KB map for investigating the progress of learners.

The diagnosis result (DR) is one more advantage of KB map that provides effective information to contribute instructor's feedback designing. The diagnosis result in the form of three error types can represent what is the difference of learners map from goal map, which is called the individual-goal difference map. The error links can address to critical areas that are important incorrect propositions, and instructor should focus at the time. Especially, the additional information of KB map is the group-goal difference map, which can represent the most misunderstanding of learners. The instructor can recognize most common misunderstanding of learners in a one-time analysis. In this point, the group-goal difference map creates a chance to develop the ongoing formative assessment. Considering the number of learners in the classroom may be impossible to recognize all of the learners in a class period. To give feedback in next class (inter-class feedback) for improving learner's understanding may be too late. Nevertheless, the group support diagnosis of KB map can provide the additional information to an instructor that is possible for designing and providing instructor's feedback in a class period (intra-class feedback). The effectiveness of KB map in ongoing formative assessment is confirmed by the practically use in elementary school. The result shows KB map can utilize in various practice flow and can contribute instructor's feedback designing positively. And we emphasize on the providing information process, which is important to support instructor's feedback. As more as possible to address critical area always increases opportunities for instructors improving learner's understanding.

3. Reference Information Model

Proposition level exact matching of KB map can be represented as the comparison method that is used to generate feedback. The instructor can use this feedback to improve understanding of his/her learners. In the previous section, the main contributions are the ability of KB map for developing the ongoing formative assessment that supports only instructor role. For supporting learner role, we continue the developing of a new feature from the comparison method for encouraging learner's reflection that is a reflector of KB map. We would implement the reflector by using three types of feedback from the reference information model which contains criteria-referenced feedback, norm-reference feedback, and self-referenced feedback.

The reflector of KB map is an additional task of learners when they completed a map. KB map can provides the reference information model for supporting learner self-reflection well. This task requires learners to think about unconfident propositions, which are mentioned by reference information model, again. From the definition of the reference information model, the self-referenced feedback means a lot of movement based on learner's behavior of the previous map. The criteria-referenced feedback is the difference of propositions between the learner map and the goal map. Last, the norm-referenced map is the relative movements' frequency of learners in the same class. In the reflection of KB map, it will highlight unconfident propositions to active learner's reflection and confirm their understanding again.

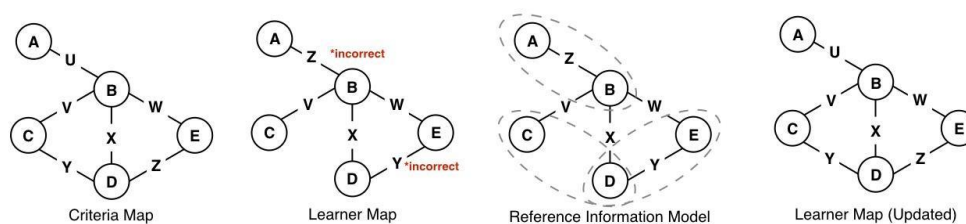


Figure 2. An example of learner's map transitions with reference information model.

The reference information model can identify confident and unconfident propositions based on learner's behavior. The confident proposition may be considered by movement from learners. If they understand in the proposition well, they can connect concepts and links in a short time and a few changes. In contrast, the unconfident propositions are constructed from their confusion. We can notice

their indecision by investigating the movement of the component in KB map. If they move the link with linking word adrift, it can mention to the area that learners cannot understand and need to reconsider. We assume learners construct their first map following their understanding of lecture content. After KB map analyzes data, the system generates the reflector and provides to learners as the critical areas depending on each learner. The actions of learners after received the reference information model is the response of self-reflection. In this step, learners have to construct concept map with self-reflection because they have to reconsider about their misunderstanding by themselves. From these assumptions, the reference information model will provide an opportunity for learners to self-reflection, which is the way to improve learner's understanding by themselves. Figure 2 shows an example of learner's map transition when the reference information model activated.

4. Experimental design and Evaluation plan

The practices flow when using KB map in the classroom situation of elementary school is situation that an instructor request learners to construct a learner's map three times in each class (Yoshida et. al, 2013). And the investigation covers two classes with different learners group on the same lecture content. The practice results show the number of lacking links (incorrect links) is continuously decreased that can confirm the effect of intra-class feedback. Another result shows an effectiveness of inter-class feedback when intra-class feedback is ineffective. And investigating the practice results by the correlation coefficient between assessment results and standard assessment test score was positive correlation. Accordingly, the practice flows and these results confirm KB map can develop the ongoing formative assessment in classroom situations.

The reference information model is a purpose for developing reflector that is a new feature of KB map for encouraging self-reflection of learners. It is possible to use the same experimental design that request learners to construct learners map three times in class. And the reflector is available to insert in the end of several checkpoints for investigating the effectiveness of reflector. Based on learner's activity on practice flow, the behavior of learners when they construct the learner's map can be used for analyzing and discovering some information, which may be adapted for improving learning achievements.

5. Discussion

Kit-Build concept map is a digital tool that supports concept map strategy. The ability of Kit-Build concept map is suitable to develop ongoing formative assessment in the classroom situation. Especially, the proposition level exact matching and the diagnosis results can contribute instructor's feedback designing that is a key of formative assessment to improving learning achievements. It is the contribution of Kit-Build concept map on instructor role. For learner role, we propose the reference information model and reflector of KB map for encouraging self-reflection of learners. Based on learner's behavior and the ability of Kit-Build concept map, it can identify the propositions which are necessary to require learners to reconsider for improving their understanding.

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A Comparison of the Experience of Confusion Among Filipino and American Learners while Using an Educational Game for Physics

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Abstract. In this paper, we propose to investigate the affective experience among Filipino learners and compare it to their American counterparts while using Physics Playground. In particular, we focus on the confusion affective state and compare the experience between learners based on facial expressions, confusion trajectories, behaviour and interactions inside the learning environment. We present our methodology, analysis and preliminary results and possible contributions.

Keywords: Confusion, Affect detection, facial expression, Physics Playground

1. Introduction

Affect detection in learning environments has gained interest among researchers. The most commonly observed affective states in Intelligent Tutoring systems are engaged concentration, frustration, boredom, and confusion (D’Mello, 2013). Recent findings suggests that confusion may be beneficial for learning (D’Mello, et.al, 2014) but prolonged state of confusion may lead to frustration and may eventually lead to disengagement and boredom which eventually may result to the learner giving up (Craig, et.al., 2004; D’Mello et.al., 2011; Liu, et.al, 2013). D’Mello and Graesser studied the chronometry of confusion and proposed a model that predicts specific confusion trajectories based on the severity of discrepant events that triggers confusion (D’Mello & Graesser, 2011). They posit that there is a zone of optimal confusion, a certain point of time where confusion may be beneficial for learning. D’Mello and Graesser also proposed a model on the affect transitions of learners in educational learning environments (see Figure 1) (D’Mello & Graesser, 2012).

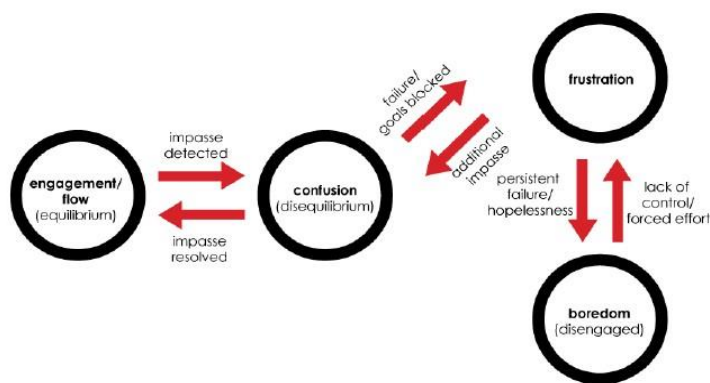


Figure 1. D’Mello & Graesser Affect Transitions Model

At the heart of this model is the theory of cognitive disequilibrium. According to this theory, a learner who encounters a new event or stimuli that does not match his expectations or contradicts his prior knowledge or understanding is in a state of disequilibrium and is experiencing confusion. When the learner acts on the stimuli with a deliberate effort to resolve the discrepancy and restore cognitive equilibrium, the learner is expected to have attained learning gains as a result of the effort. However when the efforts to resolve the impasse results to failure, the learner may transition to a state of frustration. When further impasses are experienced, the learner may oscillate back to confusion. The learners tend to disengage when they consistently fail to resolve the impasse, at which point they will experience boredom. When forced to keep on doing the task even when they have already mentally disengaged can lead back to frustration (D'Mello & Graesser (2012). This model was tested and developed with American learners using AutoTutor (Graesser, et.al., 2014).

We wish to investigate whether the model holds among Filipino learners while using Physics Playground, an educational game in Physics. In particular, we will narrow our investigation on the experience of confusion and compare these experiences among American learners of similar age using the same software.

2. Proposed Research Work

The furrowed brow particularly AU4 (brow lowerer) sometimes accompanied by AU 7 (tightened lids) was found to be associated with confused expressions (McDaniel, et.al. (2007); Bosch, Chen & D'Mello, (2014)). We would like to find if the Filipino learners shows the same facial expressions when they are confused. We would also like to investigate the temporal dynamics of affective states of our subjects to see if they align with the Affect transitions model proposed by D'Mello and Graesser. We particularly want to check on the rise and decay of confusion along with what are the factors causing the rise and decay of confusion including the facial expressions during these events. We would also like to build a model of confusion among Filipino learners and test this model against the American learners. If the model is able to predict confusion among the American learners well, it could mean that Filipino and American learners have the same confusion characteristics. However, if the model performs poorly, this probably means that Filipino confusion is different from the American learners' experience of confusion. It is our goal to determine what are the differences and similarities of these experiences.

Ekman's basic emotions (anger, disgust, fear, happiness, sadness and surprise) are found to be accurately recognized across cultures hence they are labelled as universal emotions (Ekman, 1992) However, he also acknowledged that there are subtle differences in the way emotions are facially expressed within cultures which could be accounted for due to gestures being culture specific; through cultural norms that regulates when to display or hide facial expressions; and through cultural influence on the causes of emotion (Elfenbein & Ambady, 2002).

Though the study that we are proposing focuses on confusion, we would like to posit that if in case we find differences in terms of the way confusion is experienced between the Filipino and American learners, we take it as due to the cultural differences between these learners. Though we will only be looking at two different nationalities in this study, given the geographic location of the subjects that we are proposing to study (East and West part of the globe), clearly, the two groups of subjects are culturally different.

3. Research Methodology

3.1 Data Collection

Participants of this study used Physics Playground, a two-dimensional computer game that is designed for high school students better understand physics concepts related to Newton's three laws of motion: balance, mass, conservation and transfer of momentum, gravity, and potential and kinetic energy (Shute et al., 2013). Inexpensive webcams were mounted at the top of each computer monitor. At the start of each session the webcam and its software was configured so that the students can adjust themselves in a position where their face is at the center of the camera's view. Students played the game for an hour inside computer laboratories. Student affect and

behavior was collected using the Baker-Rodrigo-Ocupaugh Monitoring Protocol (BROMP), a method for recording quantitative field observations, described in detail in (Ocupaugh, Baker, and Rodrigo, 2015). The affective states observed within Physics Playground in this study were engaged concentration, confusion, frustration, boredom, happiness, and delight. The affective categories were drawn from (Ocupaugh, Baker, and Rodrigo, 2015). The observers recorded their observations using the Human Affect Recording Tool, or HART. HART is an Android application developed specifically to guide researchers in conducting quantitative field observations according to BROMP, and facilitate synchronization of BROMP data with educational software log data. FACET a facial expression analysis software was used to extract facial features from the video recordings.

3.2 Preliminary Analysis and Findings

We have made initial analysis on the Filipino learners data. The prevalent affective state is Concentrating at 76%, followed by Frustrated at 7%, Confused at 6%, Happy at 5%, Delight at 2% and the other five affect combined at 4%. We have applied Logistic Regression to determine which facial features are associated with the affective states. Our findings so far is shown in Table 1.

Table 1. Initial Results

Affective State	Our Findings	Previous Findings
Concentrating	AU6 (cheek raiser), AU1 (inner brow raiser) , AU5 (upper lid raiser)	AU1, AU2, AU4, AU14 Grafsgaard,et.al. (2013)
Confusion	None so far	AU4, AU7 AU1, AU1 & AU4, AU45 McDaniel, et.al. (2007) Bosch, Chen & D’Mello, (2014)
Delight	AU12 (lip corner puller)	AU7, AU12, AU25, AU26 McDaniel, et.al. (2007)
Frustrated	AU20 (lip stretcher)	AU12, AU45, yaw, AU4 McDaniel, et.al. (2007) Bosch, Chen & D’Mello, (2014) Grafsgaard,et.al. (2013)
Happy	AU6 (cheek Raiser)	AU6, AU7, AU2 Kohler, et.al (2004)

4. Contribution Of The Proposed Research

There is a need to establish that confusion is part of the learning process and beneficial for the learners. Though there are studies showing that this is so, further results confirming it will strengthen the acceptability and universality of this claim. Technology has allowed us to develop Intelligent Tutoring Systems that can be further instrumented to detect the learners’ affective states and respond appropriately. Seeing the potential of learning gains on the experience of confusion among learners, providing the right amount of challenges that maximizes learning gains is advantageous to the learners. Hence, being able to detect it while students are using intelligent tutoring systems is essential for us to build systems that are able to provide the right intervention for learners to be gainfully learning.

The literature on cultural differences suggests that culture impacts learning and emotion (Joy & Kolb, 2009; Elfenbein & Ambady, 2002). Our investigation may shed light on how different learners from the eastern and western cultures are in terms of their experience of confusion while using a game-based learning environment.

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Design of TEL environment to improve Hypothetico-Deductive Reasoning skill

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Abstract: Undergraduate level science and engineering learners are required to apply Hypothetico-Deductive Reasoning (HDR) within various topics of their curriculum. HDR include steps like formation of hypotheses, checking of individual hypothesis by experimentation, designing of experiment, predicting the outcome based on experiment, collecting the observed outcome and comparing predicted and observed outcome. In order to provide causal explanation behind any phenomena, designing of experiment and for accepting or rejecting hypothesis this skill is important. Fewer efforts have been made at college level especially in the context of biology to develop this reasoning in learners. Geneticus Investigatio (GI) aims to improve learner's HDR skill in the context of genetics and was developed to address this gap. Technology affordances like agent-based modelling is used which includes functionalities like variable manipulation, providing immediate feedback and self-paced learning.

Keywords: Technology Enhanced Learning Environment, Hypothetico-Deductive Reasoning, Model based reasoning, Agent based modeling, Geneticus Investigatio, Genetics

1. Context and Motivation

Hypothetico-Deductive Reasoning (HDR) is applied in a variety of topics especially in science and engineering curricula. Learners are supposed to perform sub-skills of HDR which are formation of hypothesis, checking of individual hypothesis by experimentation, designing of experiment, predicting the outcome based on experiment, collecting the observed outcome and comparing predicted and observed outcome (Lawson 2000). In order to identify correct explanation from many competitive underlying plausible explanations learners are required to apply this reasoning. However, HDR is not taught explicitly in undergraduate curricula leading to lack of application of HDR skill when required (Jong & Van Joolingen 1998). A number of pedagogical strategies and Technology Enhanced Learning (TEL) environments like Model-It (Jackson et al., 1996), Geniverse (Concord Consortium), WISE (Slotta, J. 2002) are used to develop skills similar to HDR up to different extents. However, most of them are focused on either modeling of phenomena or reasoning at individual steps of inquiry especially within K12 level. Fewer efforts have been made at college level especially in the context of biology. Biology learners have to apply this reasoning in different contexts like identifying particular pattern of inheritance.

We developed Geneticus Investigatio (GI) aiming to improve learner's HDR skill in the context of genetics. Currently GI is designed for college level biology undergraduates with focus on concepts of pattern of inheritance. Learners can access genetics domain content within this environment which is required to answer focus question. Learning activity requires learners to read the context and focus question which s/he will have to solve. Within this agent based modeling and simulation environment, learners identify properties and behaviors of agents and define rules governing the interaction between agents. They then execute their model and compare their output with that of expert model. Then they are required to accept or revise their hypothesis. Learners are required to perform different steps of HDR while doing these learning activities. In order to perform these learning activities affordances of TEL environment like variable manipulation, providing immediate feedback and self-paced learning are used to help learners develop this reasoning.

2. Statement of Thesis/Problem

The broad problem that I am considering is “How to develop Hypothetico-Deductive Reasoning skill in Bio-Science undergraduates?” More specific research problems are:

- What are the sub-skills of Hypothetico-Deductive Reasoning skill?
 - How to develop each of these sub-skills through TEL environment?
- How to evaluate/measure Hypothetico-Deductive Reasoning skill in learners?

3. Research goals and methods

3.1 Design Based Research (DBR)

I am following Design Based Research (DBR) (Reeves 2006) methodology in which problem identification was done from literature and development of solution was done by identifying design features, interactions, affordances and scaffolds needed. In the next step, GI prototype was designed which was based on different theoretical basis (model based reasoning and agent based modeling) and pedagogical approach (formative assessment and self-paced learning) which were identified in previous step and a preliminary study was conducted. Currently I am in 3rd step of first research cycle (design and redesign of GI).

3.2 Technology Enhanced Learning of Thinking Skill (TELoTS) framework

The conceptual framework of my solution is the TELoTS framework (Murthy et al. 2016) which is a "pedagogical framework that helps researchers to design effective technology enhanced learning environments targeting thinking skills using a DBR methodology." I have mapped different steps of TELoTS framework for developing my solution (Table 1).

Table 1: Steps of TELoTS framework adapted for GI.

TELoTS Framework	Geneticus Investigatio (GI)
●0. Choose the thinking skill, topic and problem-solving context	HDR, Genetics, Patterns of Inheritance
● 1. Characterize the thinking skill	
1 a. Identify the competencies of the chosen thinking skill	Mapped to Lawson's flowchart of HDR (Lawson, 2000)
1 b. Create learning outcomes	LO's created
1 c. Consider assessment measures	For now, using ISLE rubric (Etkina et al, 2006)
● 2. Design the learning activities	
2 a. Analyse expert actions and learner needs	Need identified for learners from literature
2 b. Decide instructional strategies and supports	Adapted from CTSiM (Basu et al, 2013)
2 c. Identify technology features to realize the instructional strategies	Adapted from CTSiM (Basu et al, 2013)
2 d. Create a sequenced set of learning activities	Learning activities created
● 3. Architect the components and interfaces of the SLE	Prototype version created in HTML

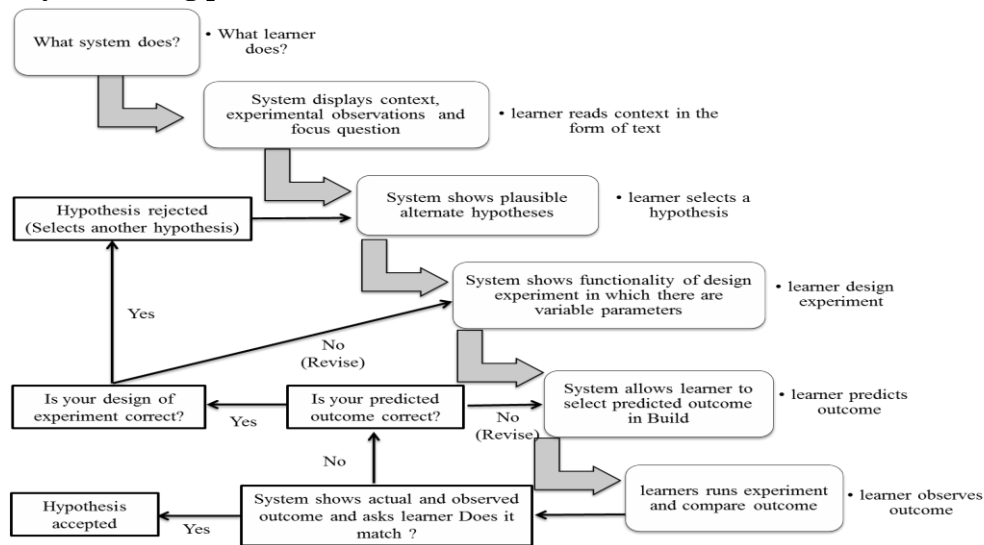
3.3 Geneticus Investigatio (GI) learning environment:

The GI learning environment focuses on development of HDR reasoning in the context of genetics. GI has functionalities like experiment designing, modeling agents and their properties, running and comparing of models. Brief descriptions of different functionalities are:

- Experiment Design: Learners selects the hypothesis and state their reason for selection.

- Model: Learners identify agents and specify their properties along with their values. They also specify values of environmental variables like no of generations, no of plants, type of cross.
- Build: Learners define rules which govern interaction between agents.
- Run and compare: Learners runs the model and compare their output with the experimental output. Within this learners sees a summary of values chosen in different functionalities and they are prompted whether they want to revise their values.
- HDR: Summarizes about what is HDR with an example from real-life context and definition of terms like hypothesis, prediction and observation.
- Domain: Learners are provided with domain content related to problem context which is for reference purpose.
- Focus question: Displays the context with expert result and focus question which is to be answered.

Summary of learning path in GI:



3.4 Evaluation Plan

I am planning to evaluate GI environment from three different perspectives (engagement, learning and interaction). Evaluation from these three perspectives will help in assessment of learning (HDR and domain), design and re-design of TEL and motivation to interact with TEL. Table 2 describes broad goal, sub-goal, research questions (RQ) for sub-goals and data collection method and analysis. I am planning to focus on engagement in the beginning because before learning from any TEL environment learners should find the environment engaging. In the beginning i will focus on these RQ's:

- What are learner's perceptions of GI?
- How much HDR skill do learners learn?
- How does learner's interaction pattern (learning path, time, scaffolds used) with GI relate to HDR learning?

For this, research studies will have to be both qualitative and quantitative in nature.

4. Pilot Study

I did a pilot study with the prototype of GI with 22 learners (convenience sampling) from 3rd year Bachelor of Science (Zoology) undergraduate course to answer RQ's:

RQ1: What are learner's perceptions of usability of GI?

RQ2: What are learner's perceptions of learning from GI?

Learner's responses to the survey and open-ended questions helped me to validate some design features. Based on observations during study and learner's difficulty, we decided to incorporate some

user interface changes in GI.

Table 2 Evaluation Plan

Broad Goal	Sub-Goal	Research Question	Data collection and analysis
(Engagement perspective) Determine how engaging the learning environment is.		What are learner's perceptions of GI?	Perception survey questionnaire on Likert scale/observational study
(Learning perspective) Determine how much learning has happened in learners who interact with GI	Learning of HDR skill	How much HDR skill do learners learn?	Pre-Post test measuring HDR skill based on ISLE rubrics
	Learning of domain	How much content knowledge do learners learn?	Pre-Post test measuring HDR skill within genetics content
(Interaction with TEL perspective) Design and re-design of TEL environment	Validating pedagogical design and identify aspects which needs to be re-designed.	How does learner's interaction pattern with GI relate to HDR learning?	Screen recording and analysis of time spent on each functionality, scaffolds used etc.
	Validate user interface and identify aspects that needs to be re-designed.	What is the usability of GI?	Interview questions focusing on ease of use of different functionalities of GI, SUS survey

5. Expected Contributions

Since this research is focused on developing learner's HDR skill through a TEL environment, as an outcome of this research project a tool (GI) will be developed which will focus on developing this skill. It will help a bio-science researcher to do research independently e.g. designing experiments instead of following regular protocols. For a learner this tool will help them both in developing this skill and practice different problem solving context. For a teacher this tool will help them to develop this skill among their learners since this skill is not taught explicitly in existing curriculum. Other anticipated future contribution includes validation of scaffold design framework (Quintana et al. 2004) for designing pedagogical scaffolds. It also includes assessment of effectiveness of the tool in development of this skill. Also within the first step of DBR which is problem identification phase, difficulties faced by learners in its various sub-steps will be identified and validated.

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How to teach troubleshooting skill to Computer Science undergraduates?

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Abstract: Troubleshooting is an important ability to required by Computer Science undergraduates. The current research work tries to teach troubleshooting as a skill using a technologically enabled smart learning environment. This proposal gives an overview of the literature related to teaching troubleshooting, the instructional strategy of the learning environment and a plan to evaluate the learning environment.

Keywords: Troubleshooting skill, Computer Networks, Smart Learning Environments, Design Based Research

1. Introduction

Troubleshooting is an important ability required by professionals working in IT industry. A LinkedIn* search for the keyword 'jobs requiring troubleshooting skill' in India showed 23 thousand result. Troubleshooting is a process which ranges from the identification of problem symptoms to determining and implementing the action required to fix that problem (Schaafstal, Schraagen, & Berlo, 2000). Troubleshooting is an ill-structured problem requiring human troubleshooters to involve in high level cognitive activities like analyzing the behavior of a system, generating multiple hypotheses which are plausible causes for the problem, keeping track of the troubleshooting process etc. (Jonassen, 2010). This proposal talks about the problem of teaching troubleshooting skills to Computer Science undergraduates in the domain of Computer Networks. Then an overview of the solution approach using educational design research methodology is given. The solution approach includes the sub-skills of troubleshooting skill and instructional strategy. A rudimentary idea of how to evaluate the solution and the contributions of the thesis is explained in the end.

1.1 Motivation

Troubleshooting is a part of daily activities of an IT professional. Be it a code developer or network administrator, he/she might have to troubleshoot some system ranging from embedded chips to data centers hosting exabytes of data. And for the novice professionals these are most probably complex systems already setup by others. This aspect of complex technology adds to the ill-structured nature of troubleshooting. My assumption is allowing undergraduate students to work with appropriate complex problems & essential scaffolding will alleviate some of the problems they face in professional lives.

1.2 Scoping the problem

The approach I am taking is to train students with troubleshooting skill, i.e., making them aware of cognitive processes involved in troubleshooting and allowing them to practice these processes in authentic troubleshooting environments. This requires that the students be familiar with concepts & techniques in the domain.

I have chosen 3rd year Computer Science Engineering undergraduate students and the domain of Computer Networks to setup the authentic troubleshooting scenarios. The complex nature of troubleshooting task and authentic problems in Computer Networks would require a technological environment for the students to work with. Also, scaffolds and affordances required by students can be easily provided in a technologically enabled learning environment. This leads to the research goal of teaching troubleshooting skill in the domain of Computer Networks with a smart learning environment.

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The specific research questions are explained in next section.

2. Statement of Thesis/Problem

The broad research question that is being considered is “How to teach troubleshooting skill to computer science undergraduates in computer networks as the domain using a TEL environment?” This leads to more specific research questions like:

- i. What does troubleshooting skill consist of? (its sub-skills/competencies)
 - a. How to teach each of those sub-skills?
 - b. How to evaluate these sub-skills of troubleshooting skill?
- ii. What technological features are required to teach troubleshooting in a TEL environment?
- iii. How does learning happen when the students interact with the TEL environment?

3. Related Work

Studies on teaching-learning of troubleshooting are reported in the domains of chemical, electrical and mechanical systems (Johnson, 1995; Ross & Orr, 2009; Woods, 2006). These studies report the abstract sub-skills of troubleshooting skill. Another thread of research has been the design and development of expert systems for troubleshooting where knowledge organization and representation models like “structure-behavior-function” and causal maps were developed (Chandrasekaran & Mittal, 1983). Some researchers are interested in the cognitive and meta-cognitive processes of experts and novices with respect to troubleshooting (Johnson, 1987; Reed, 1993; Yen, Wu, & Lin, 2012). The expert studies provide a starting point for designing assessments and learning outcomes. The novice studies help in understanding the learner needs and designing scaffolds.

The tools (gdb, wireshark etc.) which intend to help in program debugging or network troubleshooting are tied very much to the domain. They don't aim to teach the process of troubleshooting explicitly. They will be of more use when the learners understand when & where to use them.

There are very few systems which intend to teach the process of troubleshooting to students. Jonassen (Jonassen, 2010) talk about the architecture of one such system. However, there have been research studies to investigate the technological features that will help students in learning such ill-structured problem solving (Basu, Dickes, Kinnebrew, Sengupta, & Biswas, 2013; Jonassen, 2010). There are studies (Quintana et al., 2009; Xun & Land, 2004) that talk about providing different types of scaffolds for different tasks while teaching to solve an ill-structured problem like scientific inquiry or troubleshooting. Some of these scaffolds are representation that would enhance ‘meaning-making’, prompts and reflection for metacognitive processes etc.

4. Research Methodology

The research methodology I am using is educational design research (EDR) (McKenney & Reeves, 2014) along with the conceptual framework of TELoTS (Murthy, Iyer, & Mavinkurve). EDR is an iterative method consisting of phases – analysis and exploration of the problem, design and construction of solution, evaluating the solution to verify problem solving. An output of EDR apart from the solution is to produce theories related to solution development. EDR includes the participation of all stakeholders like the researcher, instructor, students etc. in the solution development.

TELoTS stands for technology enhanced learning of thinking skills. The TELoTS framework provides step by step guidelines for developing TEL environments for thinking skills like troubleshooting, considering EDR as a research methodology. The following diagram summarises the steps of TELoTS framework as mapped to EDR.

5. Solution approach

I have synthesized the following sub-skills of troubleshooting. The students are made to practice these sub-skills in different troubleshooting contexts.

5.1 Sub-skills of troubleshooting

The sub-skills of troubleshooting as synthesized from literature are as follows:

- a. **Problem Space Representation:** where students have to represent the problem space in various levels like the structural composition of the system, the function of each component in the system and the connections between each of those components etc.
- b. **Hypothesis Generation:** The students need to generate a number of plausible, testable reasons for the error before they actually go and test the reasons. These reasons are called hypotheses.
- c. **Hypothesis Prioritization:** Once there are multiple hypotheses, the students need to prioritize those hypotheses according to some criterion (like easiest one to test, most probable hypothesis etc.). Then they select the most prioritized hypothesis to test.
- d. **Design and run test:** The students will have to identify the testing means/instruments for the hypothesis that they have chosen. Then they have to predict the result of that test and compare it with the obtained result after the test is done. This comparison is intended to interpret the result and take further decisions. The iteration of generation, prioritization & testing continues till the reason for error is found.

5.2 Instructional Strategy

The system will have students trying to solve simple to complex problems. At the beginning, students will be given an overview of the troubleshooting process consisting of 4 sub-skills. Then students will have to complete tasks corresponding sub-skills of troubleshooting. The tasks have scaffolds related to i) domain concepts (Computer Networks), ii) the process of troubleshooting and iii) reflective prompts intended to aid in metacognitive processes.

The following diagram represents the part of work completed (the blocks with dark blue background) and the part of work (the blocks with light blue & white background):

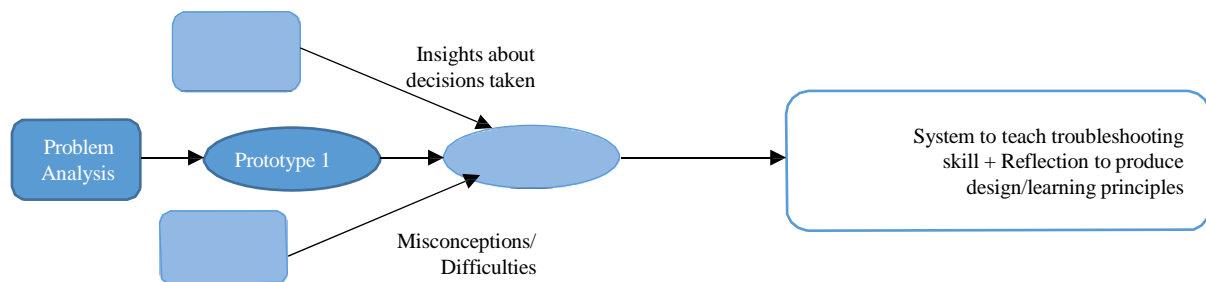


Figure 2. Overview of dissertation status

6. Evaluation Plan

The troubleshooting skill teaching system will be evaluated along the following dimensions:

- i. Learning – What do the students learn & How do they learn using the system – using post-test, interview & analyzing student interactions in the system
- ii. Evaluating the usability of the system – using perception survey reports from students & interview
- iii. Evaluating the perception of learning – using survey reports from students & interview

7. Expected Contributions

I intend that my thesis would result in the following contributions:

- i. Sub-skills as applicable for troubleshooting in computer networks and assessment rubrics for

- the same
- ii. A system to develop troubleshooting skill to computer science undergraduates in the domain of computer networks
- iii. A theory which explains how learning happens when students interact with the system.

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