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Nov. 28th - Dec. 2nd, 2016

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PREFACE

Welcome to the Workshop Proceedings of the 24th International Conference on Computers in Education, held from November 28th through December 2nd, 2016 in Mumbai, India.

Established in 1989, ICCE is now an annual international conference organized by the Asia-Pacific Society for Computers in Education (APSCE), and it has become a major event for scholars and researchers in the Asia-Pacific region to share ideas and to discuss their works in the use of technologies in education.

This year, we accepted seven workshop proposals with the goal of exploring focused issues across various themes. Each proposal in these proceedings was peer-reviewed by international reviewers in their respective areas to ensure the highest quality work. We believe that the workshops provide a valuable venue for researchers to share their work and have the opportunity to collaborate with likeminded individuals. The workshop papers spanning various topics will certainly stimulate more interesting research in respective areas in Asia-Pacific countries. We hope that readers will find the ideas and lessons presented in the proceedings relevant to their research.

Finally, we would like to thank the Executive Committee of the Asia-Pacific Society for Computers in Education and the ICCE 2016 Program Co-Chairs for entrusting us with the important task of chairing the workshop program, and giving us an opportunity to work with many outstanding researchers. We would also like to thank the Local Organizing Committee for helping with the logistic of the workshop program.

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Build our Town - Using an Augmented Reality Game to Enhance Young Children's Spatial Cognition

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Abstract: Having good spatial cognition strongly predicts children's later achievement in Science, Technology, Engineering, Arts and Math (STEAM) skills. How to improve children's spatial cognition properly and what type of games might enhance spatial ability were discussed in previous studies. Video games were proved significantly more effective than other games in improving spatial performance. Additionally, previous studies indicate that augmented reality (AR) technology present unique features to stimulate children's optimal spatial learning. This paper presents preliminary work illustrating the utilization of an AR game: "Build our Town" that combines a virtual world with a real board game for the purpose of enhancing young children's spatial cognition.

Keywords: Augmented reality, spatial cognition, young children, video game

1. Introduction:

Numerous studies demonstrate the reciprocal relationship between children's play and their learning (Yilmaz, 2016). Play is one of the most important part of a child's life. Children begin their learning as they explore their world through playing. Research on young children's use of play through video games have mixed results. Some research demonstrates that video games result in negative effects on young children's physical and mental development (e.g. Vandewater, Shim, and Caplovitz, 2004). In contrast, there is some evidence that video games may help children develop imagery, memory, language, logic reasoning, attention skills, problem-solving skills, and creativity if we use video games in an appropriate way (e.g. Dye, Green, and Bavelier, 2009; Staiano and Calvert, 2011).

"Spatial cognition is an important building block to general cognition, as it is the process that a child perceives, stores, recalls, creates, edits, and communicates about spatial images." (Osberg, 1997, p.1). During children's early years, their spatial cognition is developed through their interaction with environments such as, through play or parent's tutoring. The child with weak spatial ability is likely to have difficulty in his/her academic performance and may have challenges with daily adaptive skills (e.g., Jirout and Newcombe, 2015). Children can enhance their spatial ability by playing with constructional toys, or mazes and puzzle games, or even just by drawing a picture. In addition to the fundamental spatial skills, sensory processes, attentional processes, vision-motor coordination, speed, and memory are also considered as the indispensable cognitive processes that support spatial cognition. These cognitive processes are closely interrelated when players engage in a video game because the characteristics of video game such as the player's enthusiasm, focus, engagement, and persistence in their game tasks; quick interactive feedback to the player; appropriate difficulty in each level; risk-free setting makes the enhancement of these cognitive processes more feasible (Spence and Feng, 2010). With the technological evolution, augmented reality (AR) games such as "Pokémon go" swept over the whole world this year. The potential of AR technology for entertainment and presenting unique affordances for learning has attracted great interest (Bhadra, Brown, Ke, Liu, Shin, Wang, and Kobsa, 2016). According to Azuma (1997), AR technology can be defined as providing three features together: combining the real world with virtual worlds, providing interaction, and presenting three-dimensional objects. The combination of physical experience, virtual content, storytelling and the imagination of the child is the ideal learning experience for children (Stapleton, Hughes, and Moshell, 2002). However, there is a dearth of literature that focuses on young children and age appropriate toys developed with AR technology. From the current body of limited studies, some researchers have tested the effects of AR technology on spatial cognition skills, and children's attitudes towards AR (e.g., Bhadra, et al., 2016; Richard, et al., 2007). It is believed that AR technology could be widely used in enhancing children's spatial cognition development due to the fact that AR can provide tangible 3D objects along with 2D content, help children to practice mental rotation, 2D to 3D translation, mental slicing, and penetrative thinking. Children learn to recognize a map in a situated context. Additionally, AR can stimulate children's collaborative play and increase the frequent interaction between children with the game (Wu, Kai, Lee, Chang, and Liang, 2013). The advantages of AR technology make the development of an AR game for young children promising for improving children's spatial cognition.

2. Game Design

2.1 Explanation of the game

"Build our Town" is an AR technology based video game for young children to play. It explores a new technique application in the educational and entertaining environment, integrates the AR technology on a traditional board game in addition to offering an innovative interactive and situated experience. This game motivates children to use their imagination and spatial abilities to build a town by using the cardboards from a picture pool. Children practice their spatial problem solving abilities by learning to translate 2D pictures into 3D objects, and developing their overall arrangement ability while playing the game. Children move the cardboard and match different cardboard pieces together in reality upon an AR tile, and the AR space (mirror image of children and their cardboards upon the tile) showed in the mobile device will transfer a 2D object from cardboard to a 3D object supported by AR technology. In AR space, the river can flow, the car can move, and the people living in the town have their own "life".

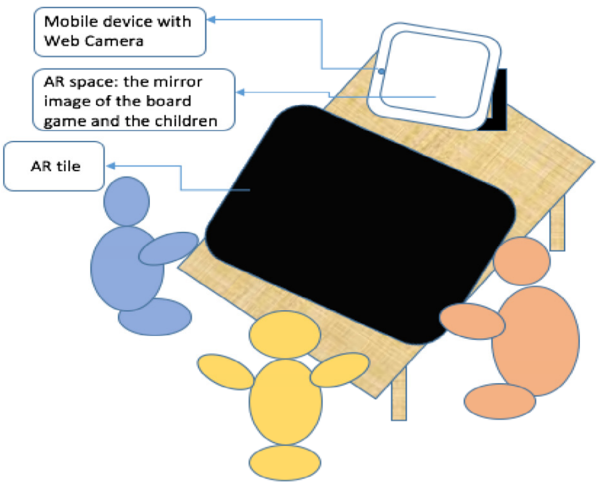
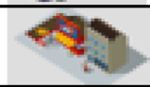


Figure1. Children Playing the Game While Seeing the 3D Mirror AR Image in the Mobile Device

There are 5 kinds of cardboards in the picture pool: 1) location cardboard (home, hospital, school, etc.); Every location has four views: front view, back view, side view and top view; 2) road cardboard (one-way street, crossing, etc.); 3) avatar cardboard (mother, father, etc.); 4) nature cardboard (trees and flowers, etc.); and 5) special cardboard (river, bridge, car, fountain etc.). When children pick up one cardboard and put it on the AR tile, the mobile device of AR space will show its corresponding 3D style image. Children pick up one location cardboard at a time and use road cardboards to connect each location, different road cardboards may have different road types, such as a crossing road, T-junction, etc.

Table 1: Examples of the comparison of cardboards (2D) and corresponding AR images (3D)

Number	2D cardboard (front, side, back, top view)	3D in AR space	Detail
1			Church
2			Cafe
3			Shopping mall
4			School
5			Truck
6			Gas Station
7			Crossing road
8			Fountain

2.2 Two or more ways to play and explore

An initial way to play the game is called the matching module. Augmented reality space in the mobile device presents a finished 3D town. Children follow the layout of 3D town to have the town "reappear" using 2D cardboard on AR tile. The children match every different kind of road cardboard with each other while they also attend to their locations. Not every location card can match with every road card. In the 3D town, the building might have a different orientation. Children are required to distinguish various building's location and orientation, and put their 2D cardboard in the matching orientation. Only when every location cardboard and road cardboard matches the right place, children will win. The purpose of this module is for children to practice their ability at recognizing 3D objects with its associated 2D counterpart. Children can choose different levels of difficulty for the game to make it more or less challenging.

Children also can design their own town while engaged in pretend play (such as role play as a mother, or a doctor). They pick an avatar from the cardboard. The cardboard avatar also has its corresponding 3D figure in the virtual town. The children can also choose their preferred and imaginary lifestyle. For example, if they want to go to the park, they need to figure out where the park is located. If they did not "build" a park yet, they will need to choose the park cardboard and then find a matched road to connect the park to their home. Children can also add river cardboards in their game, and they can build a bridge over the river. Children can build a town on their own or collaborate with partners. Children can discuss with a partner to decide their total layout and make sure that every road can go through the town. Collaborative work is encouraged because this can help children increase interaction with each other thus enhancing children's social ability while also promoting children's cognitive skills. After the children finish their design, they can put one "car" cardboard in the street, and the car will "drive" in the AR space. A "timeline" can be added into this game to make the life in the game more interesting. If children click the button in the mobile device "add a clock", the clock will show in the interface, and if children add a "bell tower" into their virtual world, the bell tower will strike every hour. All transports in the road can make noises, and children can follow the instruction to add the traffic lights and the traffic signs. Children can use their finger to move the screen of the mobile device. The virtual town in AR space can be viewed as a panorama.

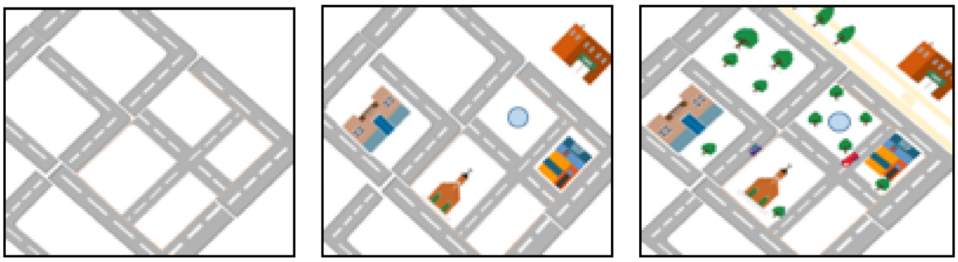


Figure 3. The Process of Building the Town with Cardboards (2D objects)

Figure 4. The Process of Building the Virtual Town in AR Space (3D objects)

2.3. Related game and this game's contribution

The conception of this game was inspired by a cardboard game called "community" produced by eeBoo. "Community" makes children connect home and location tiles as efficiency as possible using a set of road tiles. With the rise of AR technology, there is still a limited number of appropriate AR games for children to play. In "Build Our Town", children can obtain and improve the following skills: imaginary, 2D to 3D transitions, spatial orientation, collaboration, mental rotation, attention, memory, organization, planning and problem solving, multi-sensory processing (visual, auditory and motor), social and collaborative interactions when played with partners, self-control and self-confidence. The purpose of this game is to stimulate children using their creativity to build a virtual town. Children will enjoy this game, and pretend they are living in this town, which might help children to learn the 2D-3D transitions through play. The game will attract children's interests during their interaction with AR space, and children will learn abundant spatial knowledge with fun. This game is a new educational game using AR technology, and will fill the gap in the educational game based learning field.

3. Future work

This paper describes a conception of an AR based educational game to enhance the spatial cognition of young children. The next steps of the current study would be the implementation of the game and the techniques needed to make the game become applicable. Children's knowledge construction process, cognitive attainments while playing the game should be investigated in a further study (e.g., Yilmaz, 2016). Augmented reality technology will provide children plentiful interactional opportunities between the game and with each other when playing the game with a peer. How to keep children interested in the game, what kind of behavioral actions children exhibit during their playing, and how to implement the useful and proper instructional strategy by teachers and parents are also important elements to study in the future. The issues of children's selection preference; the game's accompanying sound audio; and the game's data mining also will be explored in the future.

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Trading Card Game

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Abstract: In this paper, we describe an in-house trading card game which can be adopted by teachers and played freely by students. Teachers can give students cards that can be used by students while playing with others as rewards of their performances on different designated learning activities. Also, since the game can be accessed by anyone in the world and supports multiple languages, students might get more motivated since they can play the game with others who may come from different classes, grades, schools, and even different countries and continents. For students who don't want to compete with others, the game allows them to watch others' matches as audience. Moreover, just like coin, stamp and baseball card collection students may want to collect all cards that the game has and no need to play the game and see others playing at all.

Keywords: Trading Card Game, in-game item, reward, discipline independent, open access

1. Introduction

Winefield and colleagues (1984) argued that rewards positively affect students' learning performance. Past research shows that symbolic educational rewards are meaningless to students; however, at the meantime, students would not appreciate if the real educational rewards are not so useful to them (Marinak, 2007). Although McNinch (1996) considered that cash are attractive for students and could be used as reward to encourage students learning, "money as rewards" shouldn't be considered (Kohn, 1999). According to the above studies, we know that only when students think the rewards they received are valuable or meaningful, the reward mechanism can be effective in terms of engaging students in learning.

Commercial games have become the most popular entertainment in these few years. Online games allow players to create and manipulate their own avatars and to interact with each other via chatting, in-game Emotes (ElderScrollsOnline.info, n.d.), raiding and dueling (Bartle, 2003). Card games are sort of multiplayer games and very common and welcome by students in different ages and even for undergraduate, graduate students, and adults. Despite of paper-based or digitalized form card games are, most of card games are either commercial ones or difficult to take as educational reward systems due to its in-game elements are not free accessed by teachers. Even the game itself is free, teachers may still need to spend a lot of efforts (e.g., time and energy) to stock a variety of in-game items for awarding their students.

Chen and colleagues (2009) designed a trading card game based on three famous ones - Magic: The gathering, Yu-Gi-Oh!, and Aquarian Age. In this paper the research team is demonstrating the developed game and talks how teachers can use the cards in this game as educational rewards. The trading card game is intended for teachers to give students different cards according to their performances in different teacher-designated learning activities (e.g., classroom participation, discussions, assignments, quiz, exams, etc.). Teachers can give students higher-level or rare cards if students did exercises well, actively answer teachers' questions or participate and contribute discussions heavily. Once students receive higher-level or rare cards, they might have higher opportunity to win the match in the game. On the other hand, when students are not doing learning activities well, they probably will not receive cards as rewards or only receive lower-level cards for what they have done.

Since the game is developed by the research team, new and different cards like higher level and much rare ones can be continuously designed and added into the game and available for teachers to provide their students as educational rewards without restriction and limitation. In such case, the game can keep attracting students to play from class to class, course to course, grade to grade and students may always find themselves having card missing in their collection and get motivated in terms of doing better homework, actively join the in-class and out-of-class activities, having better performance on quizzes and exams, etc. It is also worth to mention, the game supports multiple languages and students who study in different countries and use different languages can still play and compete with others.

2. The Game

2.1 The Concept

The game is a discipline independent game, which means, the in-game items can be delivered by any teacher as rewards in any course, grade, and school level. The in-game rewards are cards that students need to use while playing with others. Well-designed peer competitions have been proved as a good way to get students motivated and it is the basic idea of the game. In order to make students have correct perception and positive attitude towards the competitions, a student's ranking among all students is based on her or his credits rather than how many matches she or he has won or lost before. The student can get credits for the efforts she or he has tried to make in the match, so she or he still receives credits even she or he loses the match; sometimes, a student who loses a match could even receive more credits than the winner of that match.

A student might be able to have more options and strategies in the match if she or he has more cards and even might be able to defeat his or her opponents easier. The only way he or she can get new cards including higher-level or rare cards is to have good enough performance on the learning activities the teachers designated.

For those students who don't want to compete with others, the in-game rewards (i.e., the cards) have collectable feature just like coins, stamps, hockey and baseball cards; students may want to see higher level cards as well as rare cards in their collection. The effect of the game-based educational reward mechanism will be kept in student's mind and the learning motivation engaged by the mechanism can be carried to the followed courses, grades, or school levels. The students may want to get better in-game rewards in the followed courses by learning harder and putting more efforts in the assignments, participation, discussions, and etc.

2.2 The Design

The game is turn-based. Each player acts after the previous player finished her or his actions. When all the players take their turns, the circle will restart again from the first player. The game will stop when one of the players achieved the game goal – her or his opponent's life point drops to zero. In the game, there are three kinds of cards: Avatar Card, Magic Card and Trap Card. Table 1 explains their definitions, effects, and attributes.

Table 1: Cards in the proposed trading card game.

Card Categories	Card Type	Definition	Related Attributes
Avatar	Avatar Card	Fight with other Avatar Card.	Attacking Power, Hit Point, Size, Race, Rank etc.
Tool	Magic Card	Active: players can use it actively. Magic Card can alter Avatar cards' attribute values.	Description/Effect, Duration, Rank, Scope etc.
	Trap Card	Passive: players can't use it directly; it will be triggered when opponent attacks.	

Figure 1 below shows a five-star card – Silver Dragon. It has 30 Health Points and has very high Attacking Power (i.e., 15) and its Defending is also high enough (i.e., 7) when it is placed as defending position – a card cannot attack while at defending position and cannot defend itself while at attacking position. Silver Dragon is an extra-large (XL) Avatar card which means its dead will make its player lose a lot of life points. As a dragon can fly, doesn't like most of Avatar cards, its attacking range is 2.

Figure 1. Silver Dragon, one of the most powerful 5-star card currently in the game.

Figure 2 shows the game field, which has two sides for two players (and the game allows two additional players to join a match as audience). Each side has four areas: Hand (H), Deck (D), Graveyard (G), and Field where two kinds of cards, Avatar Card (A) and Tool Card (T), can be placed. Each player can place her or his Avatar Card into one of six places which are presented in three rows. Each row makes a sense of "distance" to the others. Therefore, if an Avatar Card's "attack range" is shorter than the distance between it and its target, the player must first "move" it, from one row to another, and make it closer to its target; of course, she or he can never move or put her or his Avatar Card into the opponent's game field.

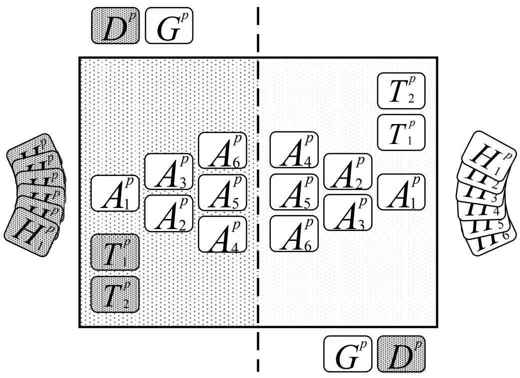

Figure 2. The game field and areas.

2.3 The Mechanics

At the beginning of the game, each player has certain life points (depends on the match settings), 30 cards in the Deck and can draw 6 cards from the Deck for the preparation. The goal is to reduce opponent's life points to zero. On the other hand, if the opponent runs out of her or his cards in the Deck area, the player also win the match. After both players get ready to start, one of the two players begins her or his first turn. Each player has 3 Action Points (APs) to spend for taking any actions. When a player completed her or his turn (i.e., cannot do anything further or find herself or himself has nothing to do even she or he still has action points left), she or he should click the End Turn button. In Figure 3 we can see the two players are maiga and eric. It is the 3rd turn of their combat. They both have 5 life points. It is eric's turn, so he has 3 Action Points and he is now checking the cards he has in hands. Archaierai is a large card and has enough Health Points and its attacking power is also good.

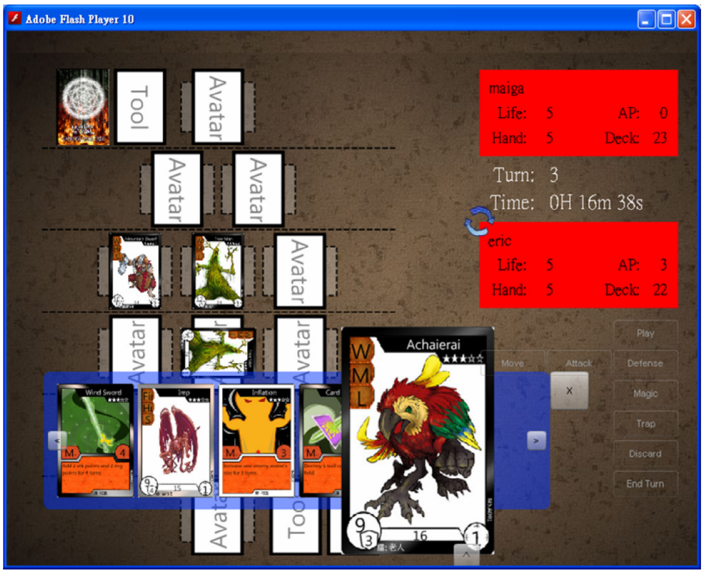

Figure 3. Third turn of a match between players “maiga” and “eric”.

3. Experience

We had done a pilot study in a computer software summer camp. During the week of the summer camp, students were taught Microsoft Office suite every day via the day activities and had an afternoon entertainment session in the end of a day. They were allowed to choose and register for playing either Wii games or the proposed trading card game. When they were learning in the day activities, they would receive trading cards as rewards from the lecturers if they performed well. They could then use the cards they got when they played the trading card game with their classmates. At the end of the summer camp, we hosted a championship for students who are interested to register and compete with each other.

In the summer camp, we first found out that all students chose to play the trading card game in the afternoon entertainment session every day and no one chose to play Wii games. This result encouraged us and showed that the proposed trading card game was considered as a real game for students, although we didn’t interview students and couldn’t rule out the possibility that all students have Wii console and games in their home so Wii games are not attractive for them at all.

The second finding was from the results of the championship. We found that students who had received more, better, and rare cards as rewards of their learning activities did get better ranks in the end of the championship. The results confirmed both of our expectation and hypothesis since students who have better and rare cards do have advantages in the matches with their peers. Although the result was in line with our expectation, one special case needs to mention – the 1st place student (i.e., the gold medal holder) defeat all his opponents by using the beginner’s set of cards without using any of the cards he received from the lectures, even he was the one in the summer camp who received most rewards.

When we asked him the reason of not using the rewards in the matches, he told us that he was just wanting to prove that anyone can play the proposed game very well as long as she or he can use strategies efficiently. His words actually revealed one truth and reflect our design concept – the proposed game is fair enough and we do want to make students have correct perception and positive attitude towards the competitions via the game play.

4. Recommended Process of Adopting the Trading Card Game

Before a course starts, teacher can first create accounts for her or his students. All students will then receive a beginner's card set automatically and they can start to play the game by organizing the cards into different decks based on their preferred game-play strategies. Teachers can start to think of when is good timing to give students rewards (e.g., quizzes and inquiries in the class, assignments, and exams) and what cards would be better to reflect the students' performance and could be rewards (e.g., different card types and rarity).

When the course starts, students are going to do many different learning activities in the class, out of school as well as at home; for instances, discussions and question and answering in the class, doing group projects and worksheets in field trip, and writing assignments at home. Teacher can give students different types of cards according to the types of learning activities such as giving student magic cards for assignments, trap cards for discussions, and avatar cards for exams and quizzes. Moreover, better performance the students reach more rare and higher level cards the teachers can give to the students as rewards.

During the course, students can play the game with their peers any time as long as they have a computer which has Internet available and are allowed by their parents, teachers, and schools. When the playing the game, they can freely use all the awarded cards and the more rare and higher level cards they have might make them defeat their opponents easier. Also, since the game allows two players to fight with each other and also two players watch the match as audience, the game's multiplayer feature can attract students to play, watch and watch-only the game. Students may also want to observe their future opponents' strategy beforehand or learn from high ranking players. For students who neither like to play the game nor watch the game, they might want to collect more and more cards to make their card collection book complete.

In either player or non-player case, the students would be engaged to perform better in the learning activities, because players who lose their matches may want to get better, rare, higher level cards to win the game more often; players who win their matches may want to have more powerful cards to keep winning and keep their positions in the ranking list; and non-players who may want to make their card collection book complete by collecting different cards from different learning activities. It would be very important for teachers to plan ahead before the course starts and ensure that students can get different cards as rewards from different learning activities so they can be continuously motivated. If multiple courses in a school are adopting the trading card game, then the effect of the game-based educational reward mechanism will be kept in student's mind and the learning motivation engaged by the mechanism can be carried to the followed course.

5. Conclusion

The game is free access[1] and there are two guest accounts for teachers and students to try the game-play. Also, everyone can self-register an account to start her or his own character and collect high level cards online. The research team can create teacher account which allows teachers (1) to create and manage their classes; (2) to create batch student accounts or individual student account; (3) to add existing student accounts, if students self-registered accounts earlier, to their classes/courses; (4) to create accounts for people co-teaching/collaborating with them; (5) to give individual students cards; (6) and to play the game with their students or to watch their game-plays. We can also create a school administrative account so administrator can (1) create account for individual teacher; (2) grant privilege to existing account if teachers already have a self-registered account, so the particular accounts can use teacher function; and, (3) to grant privilege to existing student account so she or he can use the game for her or his club, school activities, etc.

[1] http://tcg.is-very-good.org

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Virtual Slate: Microsoft Kinect Based Text Input Tool to Improve Handwriting of People

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Abstract: Text input is a mundane activity that is very closely associated with Human Computer Interaction. In this paper, using the object tracking facility of the Microsoft Kinect sensor and Tesseract for Optical Character Recognition (OCR), we made it possible to write the text by moving our finger in the air as though we were writing on a virtual slate. One of the main purposes of this proposed work is to help the children so that they can improve their handwriting without somebody to check and monitor their writing activity continuously.

Keywords: Microsoft Kinect, OCR, Teserract, Virtual Slate, Hand-writing.

1. Introduction

We have been writing on pen and paper for a very long time but now with the huge improvement in tools for Human Computer Interaction, we are constantly trying to improve the means by which we can perform these mundane actions of writing. Several methods have been proposed for text input to a computer including variations of existing tools, like various types of keyboards. In our proposed work, we tried to create a *Virtual Slate* by means of which we would be writing in the air, and the device would convert these gestures into the text that the computer can process (Schick et al., 2012). This has been made possible with the help of the Microsoft Kinect Sensor.

As children everyone learns to write on an actual slate using chalk to write. But in the digital age we are looking for a means to replace this old technique. This problem is important because Human Computer Interaction is a constantly evolving field. We propose a new technique by which children can repeat this same procedure but without chalk or any physical surface. The *Virtual Slate* makes it possible for them writes all their text simply by waving their finger in front of a Kinect sensor.

Another aspect of this technique is that it varies the tolerance for conversion of gesture to text as a simulation of *difficulty level*. By varying this the child in question can get continuous feedback as to whether his/her handwriting is improving or not. This would be a completely unbiased opinion as it is purely based on how close to the actual character shape the drawn character is.

The rest of the paper deals with the various stages of the aforementioned procedure. Section 2 discusses the literature survey. Section 3 describes the proposed methodology. Section 4 explains the implementation details followed by results and analysis discussed in Section 5. Finally, Section 6 concludes the paper with the future work.

2. Literature Survey

As mentioned earlier, not much research work has been done in the area of human computer interaction to recognize the input data from the hand gesture in mid air. Alexander Schick et al. (2012) proposed a hand gesture character recognition system in mid air using Hidden Markov Model (HMM) but it was criticized for its low input speed and physical strain.

Oikonomidis et al. (2011) proposed a robust Particle Swarm Optimization based 3D gesture recognition system which recognizes the hand gesture using Kinect sensor and OCR, but they haven't extended their work for the design of any application. Further, for real time scenario they used GPUs for faster hand gesture recognition.

Jin et al. (2013) proposed Kinect based fingertip recognition tool for deletion of the geometric model and their future work on extending their character set to include English and Chinese Characters. Ayshee et al. (2014) proposed fuzzy rule based hand gesture recognition system but it is used to recognize only Bengali characters. Further, this is a static hand gesture character recognition system. Burgbacher U et al. (2016) proposed stroke based virtual keyboard for mobile devices, as the name suggests giving input requires the physical contact of finger with the device.

There are several works from Feng et al. (2013), Chattopadhyay et al. (2008), Chen et al. (2015), MChen (2016) etc., discusses either static or real-time character recognition from hand gesture using sensors but none of these applications uses character recognition as a game based learning tool for improving the users' handwriting. Table 1 summarizes the merits and limitations of existing works. Hence, in this paper, we propose a real-time Kinect based text input tool for improving the users' handwriting.

Table 1. Summary of Existing Works

Authors	Method	Merits	Limitations
Schick et al. (2012)	HMM based Character recognition system.	High character recognition accuracy.	Low input speed and physical strain.
Xiao-Jie et al. (2013)	Kinect based fingertip recognition system.	Used for geometric models.	English characters are not considered.
Tanzila Ferdous Ayshee et al. (2014)	Fuzzy rule based hand gesture recognition.	Accurate character recognition for Bengali characters.	Character recognition is limited only for Bengali characters.
Mingyu Chen (2016)	Air-Writing Recognition.	Modelling and recognition of both characters and words for mid-air character recognition.	This application was not designed for Game Based Learning or improvise their learning style.

3. Proposed Methodology

The proposed methodology consists of hand tracking using Microsoft Kinect sensor (Figure 1), storing the tracked coordinates into bitmap image, then recognizing the character and finally giving the feedback to the user for the improvement of his(her) hand writing (Figure 2).

3.1 Hand Tracking

Object tracking is the main feature of the Microsoft Kinect sensor as shown in Figure 1 and it is able to do this with very high accuracy. When a person is present in front of the Microsoft Kinect, the Skeleton Frame is captured for each person. But in our application we rely on tracking on a single person's hand joints. The minimum distance between the Microsoft Kinect and person to be tracked is 6 feet. The Person who is near to the Microsoft Kinect is taken as the person to be tracked depending on the z- axis value. It is taken as Primary Skeleton and up to twenty joints of the body of the person are tracked. From the Primary Skeleton, we obtained the wrist and hand joint points of the skeleton hand. For our application we retrieve the coordinates of the left and right hand joints (Mori et al., 1992). Using this data, we decide whether the writing is yet to start or ongoing. When the user's left hand is raised then the application assumes that the drawing has begun. Based on the relative z-coordinate of the right hand with respect to the person's head the application begins tracking the x- and y- coordinates of the right hand when it is thrust forward. It is in this stage that the drawing is recorded. When the user's left hand is put back down then the application stores the tracked coordinates in the form a bitmap image.

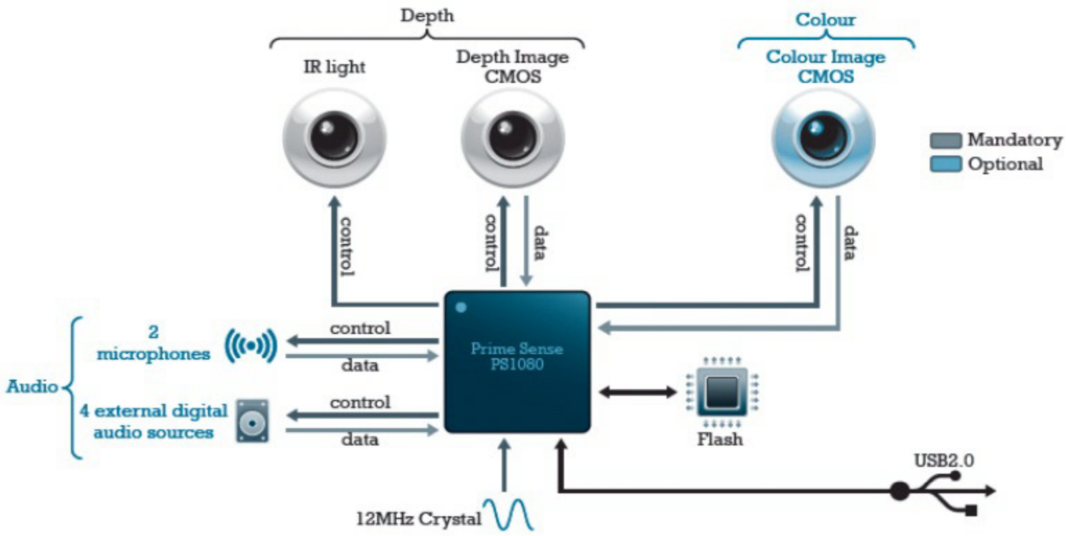

Figure 1. The Kinect Architecture

3.2 Optical Character Recognition (OCR)

Optical Character Recognition (Oikonomidis et al., 2011) is the next step after storing the tracked coordinates. The bitmap image that was generated after the previous stage is passed to the portion of the application that handles OCR. To aid with OCR, we used the open source library Tesseract sponsored by Google. Tesseract is mainly written in C and C++ and hence the APIs to use it in C++ are fairly intuitive. It has proved itself to be the best open source OCR engine at the moment and the accuracy achieved during our application is reasonably high. This is mainly because of its excellent character recognition kernel. The application in its current stage only uses the OCR one character at a time but it can be extended to apply OCR to words or even sentences as a whole at a time. Tesseract is capable of both these features and hence should scale with the application if we add these features.

3.3 Tesseract

Tesseract assumes that its input is a binary image with optional polygonal text regions defined. Processing follows a traditional step-by-step pipeline. The first step is a connected component analysis in which outlines of the components are stored. This was a computationally expensive design decision at the time, but had a significant advantage: by inspection of the nesting of outlines, and the number of child and grandchild outlines, it is simple to detect inverse text and recognize it as easily as black-on-white text. Tesseract was probably the first OCR engine able to handle white-on-black text so trivially. At this stage, outlines are gathered together, purely by nesting, into Blobs. Blobs are organized into text lines, and the lines and regions are analyzed for fixed pitch or proportional text. Text lines are broken into words differently according to the kind of character spacing. Fixed pitch text is chopped immediately by character cells. Proportional text is broken into words using definite spaces and fuzzy spaces. Recognition then proceeds as a two-pass process. In the first pass, an attempt is made to recognize each word in turn. Each word that is satisfactory is passed to an adaptive classifier as training data. The adaptive classifier then gets a chance to more accurately recognize text lower down the page. Since the adaptive classifier may have learned something useful too late to make a contribution near the top of the page, a second pass is run over the page, in which words that were not recognized well enough are recognized again. A final phase resolves fuzzy spaces, and checks alternative hypotheses for the x-height to locate small-cap text (Smith, 2007).

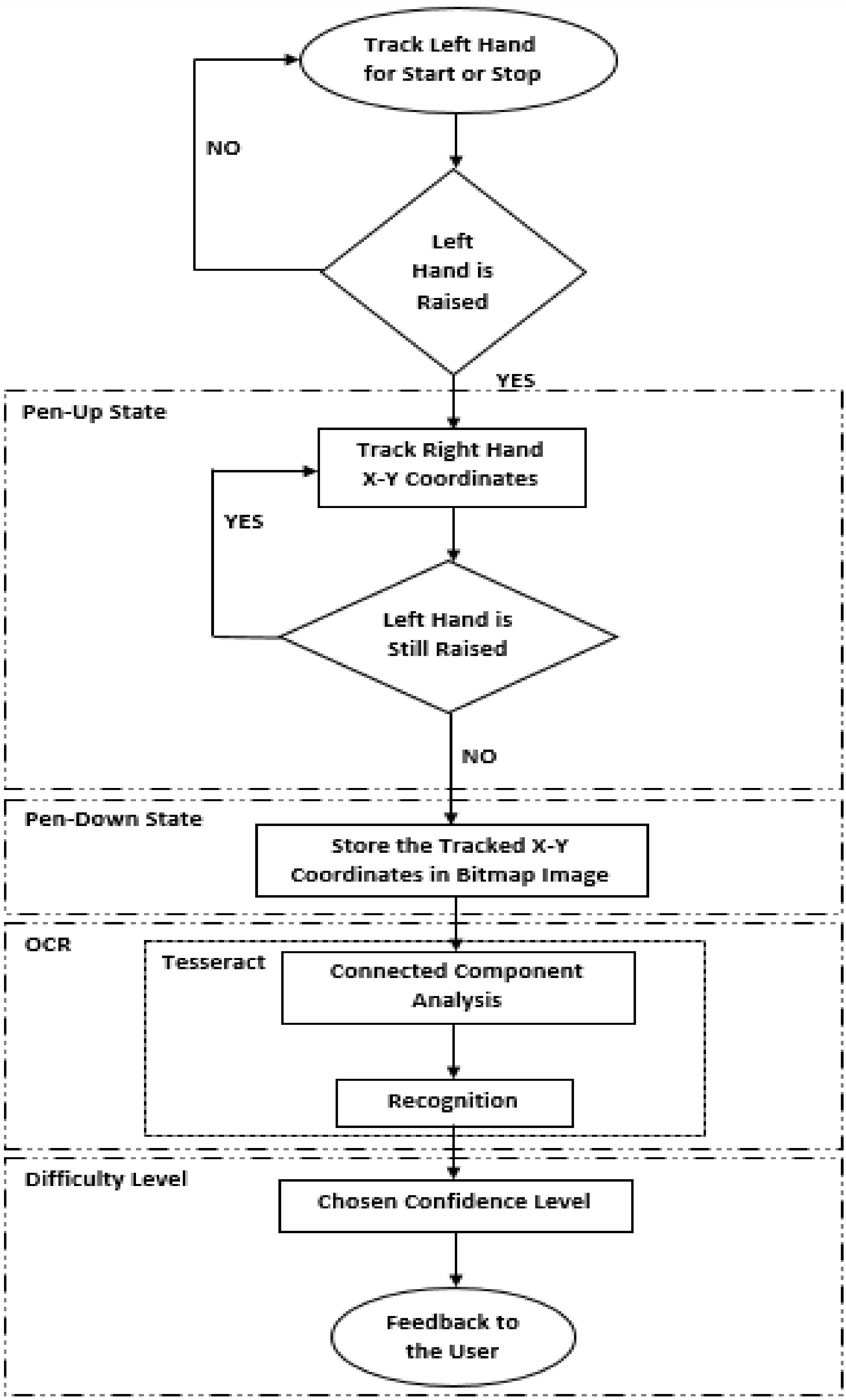

Figure 2. The Proposed *Virtual Slate* Architecture

4. Implementation Details

To implement the *Virtual Slate,* we programmed the Kinect sensor using C++. The platform for the implementation is Microsoft Visual Studio as it offers several features that simplify the process of programming the Kinect sensor. The various stages of the implementation are as follows:

4.1 Object Tracking

Microsoft Kinect does this object tracking with very high accuracy and with very less effort. The APIs to track joints allow us to choose the Left and Right hand joints directly (Frati et al., 2011). Once we have the coordinates of these joints, we simply monitor them continuously for changes that will reflect the User's intentions.

The left hand indicates whether the user wishes to start drawing or not. When the left hand is down in the normal position, we consider this as the start state or the stop state depending on whether the user has been drawing till now or not. Once the left hand is raised, we begin tracking the right hand. The right hand is the equivalent of the user's pen. The left hand being thrust forward indicates that the user wishes to start drawing i.e, *pen-down* state. When he brings his hand back it represents the *pen-up* state. When the left hand is raised, we begin recording the varying coordinates of the left hand and storing them in a bitmap file. When the left hand is put down again the bitmap file is saved (Figure 2).

4.2 Converting the Image to Text

Once the bitmap file is saved we must convert this image to text and for this we must rely on OCR. At this stage, we call the Teserract API and pass the bitmap image to it. Before this stage we need to do some basic image processing in order to make sure that the image is of sufficiently high quality so that Teserract can convert it into text with good accuracy. The API returns the probable character or text that the image represents with the confidence level which it associates with the conversion.

4.3 Difficulty Level

Now we have the probable text form as well as the confidence level of the conversion. We now need to alter the results based on the difficulty level. This portion of the application is purely for the purpose of giving feedback to the user on whether their handwriting is improving or not (Figure 2). Based on the chosen difficulty level, we then alter the results based on varying confidence level. We permit the conversion of the image to text only if it is greater or equal to the minimum required confidence level at that difficulty level. Hence, if the drawing does not get converted to the text then the user receives immediate feedback that their drawing is not close enough to the accepted shape of that character.

5. Result and Analysis

5.1 Experimental Setup

The experiment was set up and tested with more than 60 students with the age group of 4 to 7 years. The system configuration for the proposed experiment is shown in the Table 2.

Table 2: System Configuration Details

System Configuration		
Sl. No.	Hardware	Software
1	Microsoft Kinect	Visual Studio
2	NVIDIA GeForce 630 Graphic Card	Kinect SDK
3	Intel i7 Processor	OCR-Tesseract
4	8 GB Ram	
5	64 bit Operating System	

5.2 Usability analysis

Initially a video of two minutes is shown to the children from which they will learn how to use *virtual slate*. Then they were made to stand in front of the Kinect Sensor which is next to the monitor. This Monitor contains the GUI which shows the recognized character and the difficulty level they have chosen and also it shows the difficulty level they have completed. Further, each set of play contains recognition of 5 particular alphabets with their own chosen Difficulty Level (i.e, Confidence Level (CL) from 1 - 10). There is also a provision of starting the game directly without choosing the difficulty level. Depending on the gesture recognized by the *Virtual Slate*, the difficulty level is automatically selected and displayed. If the highest difficulty level is not attained, then the user can continue and complete the highest difficulty level. Monitor is preferred to the voice acknowledgement since the system proposed by Schick et al. (2012) is criticized for continuous voice feedback for every character recognized, which is annoying.

The Confidence Level (CL) was set for a scale of 1-10 and 10 denotes exact 100% match for that particular alphabet. Table 3 contains the data of those 30 students who successfully completed the confidence level 10 for five particular chosen alphabets. The initial CL number in the Table 3 denotes the CL Value from which they have started and the Table 3 also contains how many attempts they took to reach the highest confidence level.

Table 3: Confidence Level Analysis

User No.	Initial CL No.	No of Attempts to Reach Max CL	User No.	Initial CL No.	No of Attempts to Reach Max CL	User No.	Initial CL No.	No of Attempts to Reach Max CL
1	3	17	11	5	5	21	5	9
2	4	15	12	5	8	22	6	10
3	3	13	13	3	11	23	7	5
4	4	11	14	5	15	24	8	5
5	5	9	15	5	6	25	8	6
6	4	11	16	6	5	26	8	6
7	4	10	17	7	6	27	8	8
8	3	12	18	6	7	28	8	7
9	4	8	19	7	7	29	5	9
10	5	9	20	7	9	30	4	5

According to Alan et al. (2004), in order to make an application successful it should be used (Make people want to use it). In order to check this, we kept our *Virtual Slate* in a classroom for the entire day for 1 week. Whenever students had leisure time they were allowed to come and play. It is observed that most of the students who had played earlier and hadn't completed all the levels for all the English Alphabets, repeatedly played to complete the level. Further, surprisingly those who had completed also played and tested for their consistency for maximum confidence level i.e., 10.

We also collected the feedback from the students either orally or through the written feedback form for Virtual Slate for more than 30 students and the summary is shown in Table 4.

Table 4. Summary of Feedback obtained from more than 30 Students
(5-Point Likert Scale)

Q No.	Items	Value
1	The Virtual Slate functions were easy to use.	4.22
2	The Virtual Slate user interface is friendly.	4.00
3	Whether Virtual Slate keeps students from wandering	4.76
4	Virtual Slate Increases the interaction with the students	4.81
5	Virtual Slate Improves the Handwriting	4.85
6	Overall, I enjoy the Virtual Slate.	4.11
7	Overall, Virtual Slate helps me to learn better.	4.21
8	I would suggest this to my friends to improvise their learning	4.53

We also tested on more than 30 teenagers/adults with an age group of 15 to 55 years, they found it as very interesting tools to check/improve their writing skills. Further, we also collected the feedback from them which is shown in the Table 5.

Table 5. Summary of Feedback Obtained from 30 Teenagers/Adults
(5-Point Likert Scale)

Q No.	Items	Value
1	The Virtual Slate functions were easy to use.	4.79
2	The Virtual Slate user interface is friendly.	4.83
3	Whether Virtual Slate Improves the Handwriting	4.85
4	Overall, I enjoy the Virtual Slate and feel satisfied.	4.22
5	Overall, I think Virtual Slate helps me to learn better.	4.17
6	I would suggest this tools for the adults to improve their handwriting	3.21
7	I would suggest this to the children to improvise their learning	4.71

5.3 Users' Feedback

Even though the Kinect sensor's gesture recognition is accurate, it requires sufficient amount of light in the place where it is kept. Further, since we are using Kinect sensor, we need a computer with an operating system. Hence it fails an application portability. Our work is for character by character recognition, those who completed all the levels successfully for all the cases requested for a sentence or word in cursive writing. Players complaint of physical strain due to continuous use of both the hands.

6. Conclusion and Future Work

Children will be able to practice their handwriting and improve it by getting continuous feedback from the *Virtual Slate* system. Also, by introducing a level of Gamification we introduced a motive for them to keep trying to improve. The *Virtual Slate* can possibly revolutionize the way we give the text input to the computer. For the time being, the accuracy and speed of input make this impractical and lacking when compared to a traditional keyboard. But with some improvements we may be able to reach a stage where the keyboard is made redundant.

Future work includes the usage of handwriting recognition rather than OCR as it offers a larger dataset to process. Also we could replace the drawing of characters with gestures that represent commonly used words or sentences and we could type these with a single gesture. Further, the gesture based text input could be beneficial to differently-abled users such as those suffering from blindness.

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Multidisciplinary Collaboration on Mobile Game Development for Engineering Education

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Abstract: Traditional engineering education focuses heavily on scientific knowledge and technological training. Previous studies realized modern engineering education need to include multidisciplinary collaboration and experiences of product development cycle in this fast changing world. This paper reports an empirical study of how to run an engineering course in which students collaborated with students from the design departments of another college and anther university. Students evaluated the course favorably and the results revealed some benefits and problems.

Keywords: Engineering education, multidisciplinary collaboration, mobile games, product development, communication

1. Introduction

Traditional engineering education stresses on the technical knowledge of engineering and produces highly technically trained engineers (Jørgensen et al., 2011). But it becomes increasingly clear that consideration of social and environmental concerns, in addition to technological issues, would bring more innovation in consumer products. A product development team should involve all concerned parties of a product starting from the planning stage. Hence, Jorgensen et al. suggested a multidisciplinary approach to design and innovate education by building three basic knowledge and skills components: reflective technological engineering competences, creative synthesis oriented competences, and innovative socio-technical competences. Researchers in other countries share similar concerns, e.g., Sweden (Bergström, et al., 2007), U.K. (Baxter and Somerville, 2011), and the U.S.A. (Shah, et al., 2004).

According to a National Science Foundation report (2007) of the U.S. on engineering education, *"The context of engineering education is changing. Markets have become more international. Other countries have a competitive advantage in low cost manufacturing and services. In some countries, excellent engineers are available at one-fifth of the cost of a U.S.-educated engineer. Supply chains are increasingly integrated across companies and nations, requiring a different set of communication and cultural skills. Other countries ... have greatly increased their production of engineers. Conventional engineering work from conceptual design through manufacturing is increasingly outsourced to lower cost countries. The speed of change means that any set of technical skills may quickly become obsolete. To prosper, U.S. engineers need to provide high value and excel at high-level design, systems integration, innovation, and leadership."*

Addressing the issues raised above, the authors submitted a proposal to transform an engineering course on mobile application development by adding elements of inter-university, multidisciplinary collaboration on mobile game development. This proposal was well received and funded by the Ministry of Science and Technology, Taiwan. In spring 2013, a traditional engineering course on app programming on mobile devices, taught by one of the authors, focused on programming skills. In order to increase the motivations of students to learn more actively, most of whom like playing mobile games, the course content shifted to focus on the design of games on mobile devices. However, a successful game on mobile devices should include attractive graphics, sound effects, game story, game levels, marketing strategies, etc. Lacking these elements, the final projects of engineering students in such a course often produce boring games. On the other hand, design students can produce stunning graphic designs but might not be very skillful on programming. Hence, it is natural to put engineering students and design students to work together in a team to produce an attractive game on mobile devices.

This study involved three instructors at three different departments of two universities, namely, the Department of Electronic Engineering and the Department of Digital Media Design at National Yunlin University of Science and Technology, and the Department of Digital Design at Mingdao University. Another researcher was responsible for evaluating the issues of student collaboration. Each instructor was teaching a course at his department in spring 2015 and in spring 2016. In addition, a number of weekend workshops were scheduled for the students of these three courses throughout the semester. The students formed multidisciplinary teams to produce games for mobile devices with Unity, a popular and free game engine, as their semester projects.

This study aims to study how the engineering students felt about the multidisciplinary approach in the game design course, what benefits and problems might arise from the collaboration among students from different disciplines, and what implications the findings would have for engineering education.

2. Literature Review

2.1 Concerns of Funding Agencies

Traditional engineering training of universities pays attention almost entirely to the technical skills and knowledge of engineering. In 2004, "**Engineering Design in 2030: A Strategic Planning Workshop"** was held in Arizona and its results recommended to National Science Foundation showed that engineering training should be transformed fundamentally. Quoting from the report of the workshop (Shah et al., 2004), "Scientific needs and social importance not only drive the needs to elucidate and apply the process of design to new *products* throughout the economy, and new *processes and services* that increasingly drive the economy, but also the *organizations* that create and are the economy." Social-technical aspects should also be stressed in addition to engineering innovation and design informatics. These aspects refer to the "basic knowledge regarding how humans and social dynamics influence design that involves multiple stakeholders with wide societal roles."

In a later workshop reported by National Science Board (2007) with theme "Engineering Workshop Issues and Engineering Education: What are the Linkages", some innovative approaches to engineering education were discussed. Examples included "providing first year students with hands-on engineering and integrative experiences that involve design, imagination, and communication", "emphasizing social relevance, collaboration, and problem solving in the curriculum", "putting students on multidisciplinary and even multinational project teams". Our proposed course followed the above recommendations closely.

2.2 Similar Courses in Other Universities

Pirker, Economou & Gutl (2016) reported a pilot study that involved 24 students studying different subjects, such as computer science, law, or biology, in United Kingdom and Austria, who collaborated in a game project. Game development provides learners opportunities in going through an entire development cycle, to learn how to do team work, and to learn new skills to produce games. Preliminary results show that such programs are highly engaging for students, can improve their employability, have a good learning outcome, and increase their motivations in doing international collaborations. Our study was similar but did not involve international collaborations so the collaborating students in our study had more face-to-face meetings than the subjects in the international collaboration between UK and Austria. Our study was done at a lower cost, which was an important consideration.

Bourdreaux at al. (2011) reported a game development class offered by the Computer Science department at the University of Louisiana at Lafayette (ULL). Multidisciplinary students in the course teamed up to develop 3D video games for personal computers as term projects. Depending on their background and interest, they served as programmers, artists, and musicians in the teams. A rendering machine called Ogre was used as the game engine. The characters used in the games were created with modeling software such as Maya, Blender, and Milkshape. Each team chose a leader, who assigned tasks to members and dealt with conflicts, and monitored tasks to meet the deadlines. Another member of each team was appointed as an artist liaison, who was responsible for spelling out the requirements of art or music assets needed by the programmers. Students' evaluation of the course was very positive.

There are several differences between our study and that at ULL. Our students worked with Unity for mobile devices while the ULL projects were done with Ogre for personal computers. In addition, our students were taking one of the three collaborating courses so there were a sufficient number of programmers (two to three) and graphic designers (two to three) in each team and there were about a dozen teams providing an atmosphere of in-class competition. Moreover, our students came from two universities about 30 km apart and they generally chose to chat online with social media such as Facebook instead of traveling to meet face to face. The group dynamics were different from those of face-to-face communication in the ULL course. Nevertheless, there were several weekend workshops providing face-to-face meetings for all students throughout the semester. In order to encourage good collaboration among students, the instructors had to work closely with each other.

3. Empirical Study

An empirical study of the three courses were done in spring 2015 and spring 2016. It involved three courses taught at three departments of two difference universities for this spring semester. The first course was "programming for mobile apps" offered by the department of electronic engineering with 17 students in spring 2015 and 32 students in spring 2016 at NYUST. There were three instructors for the course. In the first four weeks, game designs on PC and mobile devices were discussed and students learned some basic concepts and terminology of video games. In the next nine weeks, they learned the user interfaces and assets of Unity and writing animation and interaction scripts with JavaScript. In the last five weeks, they learned about android programming in spring 2015 and WebGL programming, which provided more training with JavaScript programming in spring 2016.

The second course was "game planning" offered by the department of digital media design, College of Design, NYUST with 23 students both in spring 2015 and 23 students in spring 2016. These students were generally well trained in graphics design, e.g., 3D models in Maya, but they had little knowledge of Unity. The third course was "game plan and marketing" offered by the department of digital design with 25 students in spring 2015 and 20 students in spring 2016 at MingDao University, which was about 30 km away from NYUST. They were well trained in graphics design and game planning with some experiences of Unity from previous courses. The students taking these three courses were asked to form teams of four to six members from at least two of the three courses. Each team was asked to design and implement a game using Unity for mobile devices such as smartphones or tablets by the end of the course.

In addition, four monthly workshops were held for all students in both semesters from March to June. In the first workshop in spring 2015, students became acquainted with each other by playing group games and chose their team members for the term project. In the second workshop, students did one page design by changing the rules of a board games. In the third workshop, each team reported the progress of the term project. In the final workshop, they presented their projects.

In the first workshop in spring 2016, students formed teams just for the workshop to design a board game with paper. Then the students were asked to form teams for the term project within two weeks and each team started to design a mobile game. In the second workshop, each team presented their game proposals and the course instructors commented on their proposals so that they could improve their design and implementation. In the third workshop, all teams reported their progress while in the last workshop, students presented their projects. At the end of each workshop, students filled in questionnaires about their team dynamics, e.g., trust, responsibility and communication.

In order to let students form teams earlier, a winter workshop was offered in 2016 before the semester began. Candidate students of the three courses were asked to take part in a 3-day winter workshop in January 2016 that involved training on game design and collaboration to design and implement a game prototype using Construct 2. The rules for team formation in the workshop was similar to the rules used for the semester project. About two thirds of the students of the courses participated in the winter workshop.

4. Results

The course was offered in three semesters in 2013 spring, 2015 spring and 2016 spring. In the last two semesters, multidisciplinary collaboration was adopted and the instructors were experts from engineering and game design. The statistics of the official course evaluation for the three courses were shown in Table 1. Each item of the evaluation provided five choices depending on how a student agree with the item. The choices correspond to the scores of 5 (strongly agree), 4 (somewhat agree), 3 (it is ok), 2 (somewhat disagree), and 1 (strongly disagree). Each item showed a rating averaged over all students who filled in the evaluation. The results showed that the re-designed course offered with multidisciplinary collaboration and multidisciplinary instructors, where the average scores of 4.47 (2015S) and 4.56 (2016S) compared to 4.01 (2013S), was much better received by the students.

Table 1: Summary of course evaluation of the app course in three semesters.

Semester	***2013S***	***2015S***	***2016S***
No. of students	19	17	32
Multidisciplinary collaboration	No	Yes	Yes
Multidisciplinary instructors	No	Yes	Yes
Questionnaire items (Max score = 5)	***Score***	***Score***	***Score***
Good quality of instruction materials	3.89	4.50	4.56
Good clarity of instruction	3.89	4.56	4.5
Smart pedagogy	3.74	4.56	4.53
Good progress monitoring	3.79	4.44	4.47
Good fitness of assignments	3.89	4.50	4.44
Good fitness of grading	4.16	4.50	4.53
Good attitude of instruction	4.21	4.50	4.56
Good quality of instructor-student interaction	4.26	4.50	4.59
Good promotion of learners' motivation	4.05	4.38	4.56
Instruction tailors to the background of students	3.79	4.38	4.53
Respecting students responses	4.05	4.50	4.53
Enthusiastic in answering student questions	4.21	4.56	4.63
Good after-class assistance to students	4.21	4.38	4.56
Course benefits students	4.05	4.44	4.56
Good overall quality of this course	4.00	4.31	4.56
Average	4.01	4.47	4.54

5. Discussion and Conclusion

With years of experiences of teaching an engineering course on mobile application development, we learn some important lessons for how engineering education can be done and should be done. From the results of the course evaluations, the course was much better received by students when offered with multidisciplinary collaboration and multidisciplinary instructors in 2015S and 2016S. Items as "smart pedagogy" and "fitness of assignments" were about 4.5 compared to about 3.8 in 2013S when no multidisciplinary approach was used in the course.

Comparing the two semesters 2015S and 2016S, the course scored slightly higher in 2016S than in 2015S. There were two possible factors. The first was that the instructors of the course became more experienced so that the course was better organized in 2016S. The second factor was possibly the extra pre-course winter workshop before the course began in 2016S. The winter workshop helped the students from different colleges and different universities got acquainted with each other before they chose the partners of their project teams. This helped some teams to form earlier and got a head start in their projects. The projects produced by these teams were generally more interesting than those produced by the teams which were formed later and less active in working on their projects.

There were other more qualitative results from this study. From students' responses, their collaboration in a team improved their self-efficacy, which should help innovation. This worked even for average engineering students who thought their programming skills ordinary before doing the team project, since they felt their programming skills made a difference in team work. In collaboration, they felt some pressure, but not too much of it, and they trusted their partners, which could lead to better performance.

Since it might not be convenient to meet face to face due to distance or schedule conflict, students generally relied on online tools such as Facebook to discuss their projects. However, they still preferred to meet face to face if possible. Students confessed there were misunderstandings and arguments during discussion, but most of these problems were finally resolved. When asked to weigh two factors in their success in completing their team project, they thought collaboration was more important than their expertise.

Inspired by the findings of this study, several directions are suggested to enhance engineering education. First, in their collaboration, students need to solve problems not only from a programmer's perspective but also to consider the graphics designer's perspective. Such multidisciplinary thinking, lacking in traditional engineering education, is needed badly. Second, creativity and innovation are also called for in order to solve complex problems by considering multiple viewpoints. Game design trains engineering students to design, build, test a game repeatedly until a set of criteria are met. This is in accord with the current maker movement that is believed to cultivate creativity and innovation (e.g., Hagel et al., 2014; Martin, 2015). Third, engineers must learn to explain difficult concepts to audiences from different disciplines who might have biases and misconceptions. By collaborating with designers, engineering students learn to communicate and collaborate with people outside the engineering circle. To summarize, engineering education should include more training on multidisciplinary collaboration, creativity and innovation, and communication by providing students more opportunities in doing projects such as the ones exemplified in this study. For example, collaboration projects can also be done on machine designs that involve mechanical engineering and industrial designs, or on maker projects that involve electronic engineering and physical therapists to help patients with physical disabilities.

Several directions are suggested for future studies. First, the progress of the term projects can be monitored more closely by the instructors so that problems can be identified and resolved in time. Second, experienced professionals can involve in the term projects from the beginning and provide more feedback to students. This would make the projects more realistic and similar to authentic product development in industry. Finally, international collaboration can be considered.

Acknowledgements

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Toward a Teaching Strategy Design for Game-Based Learning

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Abstract: In this paper, we apply interactive teaching strategy and game-based theories to improve the lecture of Programming Fundamentals such that students have more willing to concentrate on their learning in this lecture. We increase more portion of game-based programming in this new proposed lecture in contrast to the previous lecture only teaching the traditional content. In addition, the game-based theory combines with social presence theory which can give more interactive between the teacher and students. Therefore, it can improve learners' interest and efficiency in learning. Moreover, we design an experimental and a control classes from the Programming Fundamentals course, each class having 40 students. This forms a comparison on the implementation of curriculum design Games-Based Learning theory for experimental group and general education theory in classroom for control group. The pre-test score suggested no significant differences between these two groups of students, while the post-test score clearly indicated a big advantage of the experimental group class over the control group class.

Keywords: Collaboration Learning, Cooperative Learning, Game-Based Learning, Social Presence

1. Introduction

1.1 Overview

This research tries to use a variety of possible techniques and a game-based theory to achieve the goal of optimal teaching and learning. It allows teachers and students to achieve their presentation and interaction easily to create an atmosphere environment in classroom. We apply above theory as the base of teaching architecture design to construct game-based programs and interesting teaching materials from the teacher, so that learners can easily accept in social presence environment of classroom. In other words, the game-based theory will be a modest increase participation of social presence in the classroom between teachers and students, and improve learners' interest and efficiency during the learning period.

1.2 Motivation

Multimedia teaching materials in the traditional teaching and learning are quite diversified, like the streaming video proposed by MIT OCW (open courseware) which has been widely accepted and used in teaching and online learning. Later in the 1960s, due to advances in computer technology, computer-based instructional materials have been widely used in education and most of the universities as their supplementary learning contents.

In view of the above, how to digitization for teacher to use the programs or teaching architecture design to construct game-based programs and interesting teaching materials in lectures to increase the readers' learning effectiveness is the very important trend and issue.

Due to the attention to rise of classroom developed rapidly, it becomes more and more attractive for a lot of researchers. As we know, we can find a lot of poor teaching materials which need to be improved. Therefore, in the teaching theory there still needs much more good smart ingenuity and learning environments supporting to prompt the learner, which can more easily absorb and the teachers can breakthrough cognitive loading limit to effectively improve of students learning.

2. Literature Review

2.1 Collaboration Learning

Students are collaborating with each other through a media to learn more about specific subjects, to test out ideas and theories, to learn facts, and to gauge each other's opinions (Otero, Milrad, Rogers, Santos, Verissimo, & Torres, 2011; Jones, & Issroff, 2005; Smith, & MacGregor, 1992). In most cases, the collaboration process boosts everyone's interactive frequency.

According to Jones and Issroff (2005) research on collaborative learning and educational technologies, some key concepts are needed to take into account the interaction between cognitive, social and affective/emotional factors (Otero et. al., 2011; Jones, & Issroff, 2005). Some highlights are summarized as follows:

- Social affinity between partners: some studies suggest that friend relationships facilitate the communication processes and interaction regulation that in turn increase motivation and collaboration.
- Actual and perceived cognitive abilities of the partners: this factor draws the attention to possible difficulties managing asymmetries in collaboration.
- Distribution of control: the way about the different members of a learning group are able to control their learning pace and how available tools enable this process during collaboration.
- Nature of the task: the nature of the task also influences the way a group 'decides' to collaborate. The difficulties of being able to collaborate synchronously might lead to losses in the activities, which increase the chance of demotivation towards group work.
- Time: socio-affective relationships evolve in time. Thus, it is important to conduct longitudinal studies in order to reveal how the different elements of a group are able to appropriate the technologies at their disposal.

2.2 Cooperative Learning

Many studies have been proven that cooperative learning benefits to students with improving their achievement and learning experience. Also, based on mutual cooperation among students, it can enhance students' learning motivation. The five elements of cooperative learning are summarized as follows: (Johnson, 1991; Felder, Richard, & Rebecca Brent., 1994).

- Positive Interdependence: Interdependence is the first element of cooperative learning. Team members can promote positive interdependence via goal setting, resources sharing, and role assignment.
- Individual Accountability: Individual accountability is the second element of cooperative learning. In cooperative learning, the group's success is on behalf of each member's success. In the cooperative learning, each member needs to take the responsibility of his/her success to fit the group success. Definitely, this element can reveal the group spirit in contrast to hero-style performance.
- Face-to-Face Promotive Interactions: A face-to-face promotive interaction is the third element of cooperative learning. Through the guidance of teachers and the arrangements such as experimental groups, group discussions, and group reporting, team members can help each other to exchange information, encourage feedback and progress interaction. Finally, a whole team can be successful in learning and promote to achieve personal goals and group goals.
- Social Skill: Social Skill is the fourth element of cooperative learning. During the cooperative activity, each member in a learning group can develop some social skills including effective communication skills, mutual respect and trust.

- Group Processing: Group Processing is the fifth element of cooperative learning. During the group processing, students can understand and learn some processing manners with their peer.

Therefore, the cooperative learning can enhance the team's solidarity and cohesion. Also, it can increase interaction and enhance each other's feelings to share psychological experience.

2.3 Game-based Learning

Games can provide a learning difference from traditional learning environment and interface. In 2003 Professor James Paul Gee (University of Wisconsin-Madison) made impact on the cognitive development of the game-based learning. They are related research and development in continued. In fact, the popularity of a variety digital tools games is more diverse progress. James Gee believe that the basic value of the game including the provision of the player one kind of sense of control (Ownership), to stimulate lateral thinking, problem solving and teamwork (Gee, 2003; 2014). The player will attempt to overcome the frustration, and adhere to the target. His research indicates that: the game can interact with the participation of the ways to help people learn.

The "Quest to learn" is a middle school with the curriculum based on video games, the designer Katie Salen who specializing in Game-based Learning and spent a lot of time thinking about making learning more relevant to students.

Katie Salen said: Now we have a lot of learning games. However, not all games have good design, the educators often find the learning content and the integration of the game quite challenging. However, what is a good way to learn the game? That can cause learners motivation to play, but also to effectively achieve the purpose of study. The survey found that online gamers spend an average of ten to fifteen hours a week on the Internet to do research on how to crack the game, educational game if you can achieve the same result, it would be great (Salen, 2008).

Also, games include many characteristics of problem solving, i.e. an unknown outcome, multiple paths to a goal, construction of a problem context, collaboration in the case of multiple players etc., and they add the elements of competition and chance. However, online games provide the additional possibility of building teams of players who are geographically scattered. The benefits of learning through games are numerous (Mann et al., 2002), and games are often closer to simulating real life experiences than more traditional educational media. This allows the students to immerse themselves in a realistic simulated setting without the fear of real life consequences, which – although not the necessity it is in Medicine – is also very useful in Civil Engineering (Ebner, & Holzinger, 2007).

The concept of gaming goes beyond games, in the same way in the learning goes beyond the configuration of a classroom management. Gaming constitutes of activities, literacies, knowledge, and practices are instant achievements of teaching management of a game-based learning. Thus, the teachers can set special of behavior and activities in classroom management, which focused on determining, within specific behavior settings, environmental conditions that influenced behavior (Emmer,1987; Emmer & Stough, 2001). Therefore, the main purpose of classroom management is to make students enjoys in social learning environment and to participate in teaching activities in the classroom.

Gaming plays across media, time, social spaces, and networks of meaning. It includes engagement with digital FAQs, paper game guides, parents and siblings, the history of games, as well as the games themselves (Salen, 2008). Therefore, the requires players to be fluent in a series of connected literacies that are multimodal, performative, productive, and participatory in nature social presence. In other words, they are same as the social interaction between students and teacher in classroom. The main purpose is to enhance learners' learning attitude, interest and efficiency in the learning process.

2.4 A Game-Based Learning Design Be Leveraged to Enhance Cognitive Adaptability

McFarlane (2002) argues that the gaming generation is bottom-line oriented. He states that students often want metrics and want their performance measured if the form of measurement is meaningful to them. As the players improve, the gamers expect the challenges to become more demanding. Translating this into classroom pedagogy is critical for reaching students who learn well in this type of environment.

Galarneau & Zibit, (2011) mentioned that the 20th century visionaries foresaw that mastery of the dynamic processes underpinning the acquisition and manipulation of knowledge would be critical in the 21st century. Formal educational systems have not yet changed to facilitate the development of these necessary capabilities, and so people of all ages are developing them through a variety of digitally mediated mechanisms. Online games offer one area in which to examine patterns of spontaneously occurring phenomena that represent the natural development of such capabilities.

3. Method

To test the assumed effects of the navigational feedback concerning a true experiment (Ross & Morrison, 1996) was carried out in which participants were assigned to an experimental group and control group. In other words, we offered to use game-based learning to the experimental group and in a control group we proceeded through an otherwise identical learning without any policy to strengthen the teaching and learning strategy game-based learning on the classroom.

3.1 Participants

Participating students are in the MingDao University of Taiwan. There are regular college students who take an elective Programming Fundamentals course in February 2016, which is a basic programming language. The total number of students is 80. We randomized grouped into the experimental and control groups. Our subjects were 40 students to do three weeks of use Games-Based Learning theory for experiment. The other 40 students to do a three-week general education in classroom. But in the Quiz, the two of group each have one student absent in week 4.

The announcement highlighted that the course was designed with the purpose of understanding data structure of programs, that it would take approximately 9 hours to study the course (3 hours each week). The course would be available to begin the first phase of a 3-weekscourse in February 2016. In the course, a student must complete the test pass to receive a final grade of 25% score. A prerequisite knowledge was defined as: “having some experience with Internet (surfing the web and using email) and a passive understanding of English”. At the start of the course, participants were asked to fill in a small questionnaire aimed to gather some basic background information about the learners: age, sex, educational level and computer skills.

In this study, we did literature review, and made questionnaire pre-test for the experiment to collect and analyze the student data before the experiment. Two classes whose level are almost the same were looked as experiment class and control class separately by an exam. After a pre-questionnaire statistical results of the experimental group, the male and female students were 18 and 22. A control group of male and female students were 16 and 24, as in this experiment. The pre-test score suggested no significant differences between the two groups of students.

3.2 Mode Design

The experimental group and the control components of two classes, each 40 students in classroom. The Fig. 1 is the comparison on the implementation of curriculum design Games-Based Learning theory and General education in classroom.

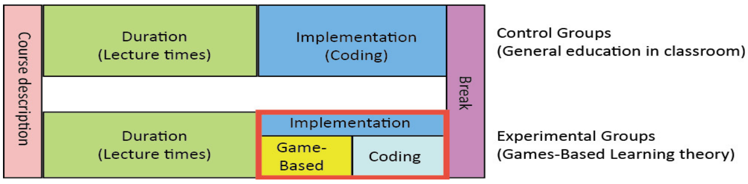

Fig. 1. Comparison on the implementation of curriculum design Questionnaire design

This study uses questionnaires measured the five-point Likert scale mining scale. Likert scale (Rensis Likert) is a psychological reaction scale, often is used in the questionnaire, and is the most widely used scale. Such questionnaire answered by the project is total 12 items.

3.3 Analyses

The first hypothesis states that the games result in more effective in experimental group for game-based learning environment of classroom. We tested for two different variables: The first consideration is related to the course contents of the game. The second consideration is the content of the game not related to the course topic. The premise is that student must complete a three-week course on this case and is not absent from class.

The second hypothesis states that the student is interested in the course in experimental group how just love the game or like teaching curriculum into the game-based learning environment of classroom. The first job is to design a program called "告白 (serious relationship)" game to let students more encouraging retype the "I love you" from the program C to replace “hollo”, and then disclosed to the projector. The second job is to design the data structure “if... else...” game from the program C. A team of students should use “if ..., else ...” to clarify some relationship and cooperative thanking. They make a program in collaboration to show their idea in the C program. For example, someone designs a program “I love you, do you love me too?”. The program has been designed to wait for answer in choosing, the follow-up program will analyze formula “if…, else…” function in C program. The Fig. 2. is the students observed a C programs coding for cooperative learning.

Fig. 2. The students observe a C programs coding for cooperative learning.

4. Results

4.1 Effectiveness

The results for effectiveness has been described separately for the two variables amount of progress made towards achieving the goal (the number of student questionnaire responses and feedback) and goal attainment (the number of learners completing three-weeks class). Moreover, the teachers’ course design description has been arranged before the class in the experimental and control group classroom.

According to the five-point Likert scale questionnaire, we ask students the following question: “If the teacher uses Game-Based mode teaching in class, it may increase my interesting on classroom?”. The result obtained to select 4 or more accounted for 61.6%. The Fig. 2. showing the students are interesting to the Game-Based learning in classroom. The Fig. 3. shows the students' acceptance rate in Game-Based learning method.

Furthermore, the above activities have no significant differences between the two groups of students on the pre-test score in t-test. After three weeks of teach in classroom, we make a quiz in the classroom. The post-test is clearly indicated a big advantage of the experimental class over the control class (Fig. 4, Fig. 5).

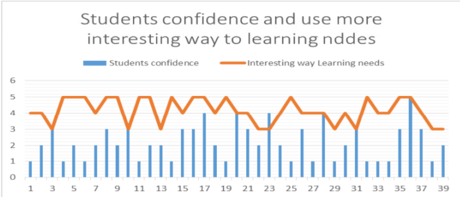

Fig. 2. Before the class, the students consent using interesting way to learning and confidence rate.

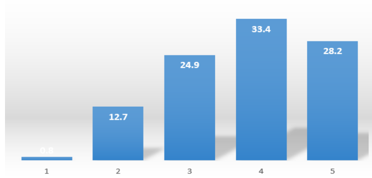

Fig. 3. The students had acceptance rate of Game-Based learning method.

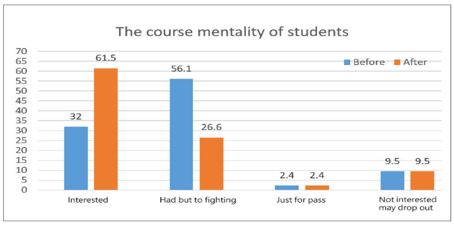

Fig. 4. The course mentality of students in before and after.

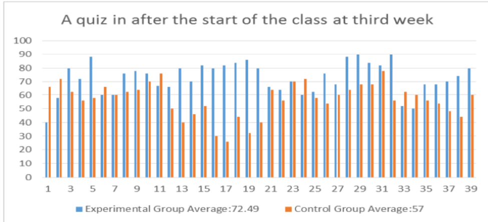

Fig. 5. A quiz in after the start of the class at the third week.

5. Conclusions

The results of the experiment lead us to conclude that Games-Based Learning theory which can support our design, which including integration into the cooperative and collaborative learning theory to enhance the learners' learning effectiveness. Thus, it showed a significantly higher amount of progress and higher learning rates in the experimental group. The Games-Based Learning theory proposed in this study did have a significantly positive effect on efficiency.

There are, however, a number of limitations with the experiment. First, although we get some evidence to suggest that the proposed method is effective, there is no evidence that can be applied to all courses. Second limitation lies in our use of elapsed time rather than actual study time. In addition to student learning and discipline in the classroom, also some extracurricular possibilities made unpredictable efforts which we do not have this measurement. Third, we do not have classroom design for dedicated gaming App to improve the social presence in the classroom between teachers and students.

A further clarification of the results could be extending to include a greater proportion of a learner first class test, midterm and final test of corroboration might lead to stronger effects. Further research is needed to address the above Games-Based teaching method to this research topic to have a greater impact on effectiveness and efficiency in class learners.

Despite the limitations of the present study, we believe it shows that the use of Games-Based teaching and learning method principles is efficient and effective in class learning.

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The Effects of Communication Problems of Interdisciplinary Team on Teamwork Quality of Mobile Game Development

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Abstract: Any interdisciplinary team should use good division of labor and effective communication to achieve the team's goals. Since the team members come from different disciplines, it often leads to communication problems and poor results. An empirical study was done with 72 college students from three courses related to mobile game design within a period of 18 weeks. The study focused on what communication problems affected the quality of the resulted games. The results show that the effectiveness of communication and teamwork quality were highly correlated. The factors affecting the quality of the resulted games included developing time, personal skills and work planning. This study found out that the interdisciplinary members of a team lacked a common language, leading to communication problems. It is recommended that such teams need to establish clear goals and learn to solve the problems.

Keywords: game production team, communication effect, interdisciplinary team, teamwork quality

1. Introduction

1.1 Research background and motivation

Any interdisciplinary team should use good division of labor and effective communication to achieve the team's goals. A good team needs to consider more diverse ideas before they can converge to a good idea. Interdisciplinary team can solve these problems better than a team with members of the same background, especially in a game development context (Brainard, 2002). To develop a successful video/mobile game, the team need to use knowledge of various disciplines, such as programming, art, planning, audio, and marketing. It is difficult to found a developer who have the knowledge of all needed disciplines, so mobile games are often done by teamwork (Jesse, 2014).

During cooperation, the team members often need to work with people with different backgrounds. However, the terminologies of different disciplines will lead to misunderstandings of communication and poor cooperation. So an interdisciplinary team need to establish a common communication language to avoid misunderstandings (Yang & Lin, 2015). In a mature game team, the game designer usually responsible for the tasks of mediation and communication. The members of the team will work together for a clear team goal (Jesse, 2014). In an interdisciplinary team of students, they may not have sufficient understanding or relevant experience to understand members from other disciplines. A student team might have more communication problems. In an interdisciplinary team, how to effectively cooperate is a problem that need to be solved. As Knight (1999) mentioned, interdisciplinary members would have more misunderstanding problems. Moreover, students also lack professional experiences and the conflicts of communication may led to poor results of the team work.

Research purpose and problem

In this study, students from the department of digital media and that of engineering formed teams to design and develop mobile games. The following are the research questions.

1. To explore the influence of communication effectiveness on teamwork quality among student team members.
2. To explore the influence of communication effectiveness and teamwork quality on the final projects' score.
3. To find out the problems of communication in interdisciplinary teams.

2. Literature Review

2.1 Interdisciplinary team

A group consists of two or more members and each one may influence the others (Paulus, 1989； Forsythe, 1999). A team is a group of member working together to achieve a common goal (Cohen & Bailey, 1997；Hackman, 1987). An interdisciplinary team consists of a number of members with complementary skills, cooperating on a common task, goal, and plan (Jason, 2000).

Interdisciplinary teams should be more effective in solving the problems than a team with members from the same discipline (Brainard, 2002). In an interdisciplinary team, the members have different professional skills, and can provide different perspectives in discussion. Parker (1996) believes that interdisciplinary team will have the opportunity to enhance the ability to solve complex problems by combining different skills. This type of cooperation between the team will effectively enhance the effectiveness of innovative research and development.

2.2 Communication effect

In a group design process, people often communicate to exchange views and build mutual understanding. When communicating, people convey their feelings, attitudes and knowledge to help others understand their ideas, persuading others to accept their own ideas, and further expressing their understanding of the ideas of others. In this way, the team communicate to solve problems or stimulate creativity in the process of project development (Albrecht & Ropp, 1984; Nemiro, 2005).

Shannon and Weaver (1949) proposed that communication emphasizes the process of a series of social behavior, with persistent, interactive and dynamic efforts. The speaker is not only to convey the information to the other members but also hope the receiver understand the message, and then provide feedbacks. This cycle is repeatedly carried out. The quality of team communication is mainly determined by the willingness and ability to exchange information between members.

Knight (1999) suggested that the interdisciplinary team members often misunderstood each other. People with different professional backgrounds will have different reactions when encountering a problem. When they failed to convey their messages to others, conflict will arise. Communication is very important in team work. One needs to get their messages across to others and also understand the messages from others. This task is more difficult to achieve in an interdisciplinary team. In different areas of expertise, the different technical jargons are used. How to make interdisciplinary members understand each other? An interdisciplinary team needs to give priority to solve the problem.

2.3 Teamwork quality

Hoegl and gemuenden (2001) suggested six constructs to evaluate teamwork quality, including communication, coordination, balances of member contributions, mutual support, efforts, and cohesion. The six constructs were used to develop a scale on teamwork quality.

Good teamwork quality depends on the effectiveness of team communication. However, communication inevitably produces conflicts. Knight (1999) defined team conflict in two aspects, emotional conflict and task conflict. Emotional conflict affects interpersonal relationship. Common emotional behavior includes anger and frustration. Emotional conflict is easier to produce in face to face communication. Task conflict means team members are unable to reach a consensus in a task. Emotional conflicts have negative effects on teamwork quality (Sarason, 1984).

From the above literature review, it is clear that the effectiveness of communication affects the teamwork quality. A game production team includes members of game designer, artist, and programmer. Good communication and cooperation are needed. This study is to investigate communication problems in students' teams and their effects on teamwork quality.

3. Methodology

Research Method

This study adopts Questionnaire Survey. In this study, the subjects were college students study game who formed teams to develop mobile games for their term projects. A questionnaire was filled out by the subjects for data collection and statistical analysis. There were three research variables in this study, including team communication effectiveness, teamwork quality, and the score of the final project. This study proposes the following two hypotheses:

H_1: Team communication effectiveness is positively correlated with the quality of teamwork.

H_2: Team communication effectiveness and teamwork quality is positively correlated with the score of the final project score.

Research subjects

The research subjects consisted of 72 students, including 23 students from the department of digital media in a university of science and technology; 32 students from department of electronic engineering; 17 students from department of digital design in another university. The study began in February 2016. Twenty three students were taking a "game planning" course of the department of digital media. The course lasted for 18 weeks with 54 hours of classes. The course content was about game planning, and the students were trained by designing game plans. Thirty two students were taking a "mobile application design" course of the department of electronic engineering. In the course, the students learned how to develop games for mobile devices with the game engine Unity. Seventeen students were taking a "digital media integration" course by department of digital design. The course lasted for 18 weeks with 72 hours of classes. In the course, the students learned about game production, game planning, and developing game prototypes.

Traditionally, the three courses were taught in their own department with no collaboration with students from outside the department. For 18 weeks, the students formed 13 groups to develop mobile games as their term projects. Each team needed students from at least two departments. The team needed to have roles of programmer, artist, and game designer. A workshop was held once a month including a final project presentation (Table 1).

Table 1: Workshops and Final project presentation

First workshop	Second workshop	Third workshop	Final project presentation
Game prototype production and team formation	A game plan was presented by each group. Discussion and game production	Progress report was presented by each group Discussion and game production	Game was presented by each group Grading by experts and peer assessment

The final projects were graded by six experts and peer assessment was also done. Students filled out a questionnaire which were about communication effectiveness and teamwork quality. Finally, individual interviews were conducted for a member of each group.

The game platform were all Android smartphones and tablets. The game engine was Unity, and game art software included Maya, 3D MAX, Photoshop, and so on. Among the 13 games, 6 were puzzle games, 4 teams were action games, and the rest were a shooting game, a music game, and an adventure game.

Research instruments

The research instruments included questionnaires, expert score and interviews. The "communication effect and teamwork quality questionnaire" was designed by the authors (appendix).
A 6-point Likert scale was used ranging from 1 to 6, 1 means strongly disagree; 2 means disagree; 3 means disagree somewhat; 4 means agree somewhat; 5 means agree; 6 means strongly agree. The questions were categorized in two dimensions:

(1) "Communication effectiveness": to find out whether students can understand the problems of different professional fields, and whether the team members can achieve consensus. There were 9 items for this dimension.
(2) "Teamwork quality": to find out whether the members trust each other, whether team interaction was good. There were 8 items for this dimension.

There were six experts to grade the final projects on five major items, including game fun, innovation, art design, creativity, and market potential. The weighting of each item was 20%.

Interviews were also done for 11 students. Questions included which tools (e.g. Line) were used for communication; how was the atmosphere of the communication; whether misunderstanding occurred due to background differences. There were 8 questions and each interview lasted about 5~8 minutes.

4. Research results and Discussion

This study used SPSS 18.0 to analyze the data. Pearson correlation coefficient and regression were used. Among the 72 questionnaires sent out, only 66 were valid ones. The results of the analysis was reported next.

Results of questionnaire

Results of team communication effectiveness

There were 9 items about team communication effectiveness. The average of the item "I can listen to the opinions of members from different backgrounds" is the highest (average 5.14). About 85% students responded with levels 6 and 5 (strongly agree and agree). The average of the item "I can understand the professional language used by members of different professional backgrounds" was the lowest in the study (average 4.47). 44% responded strongly agree and agree. 43.9% responded slightly agree. Second to lowest was the average for the item "During discussion with members from different professional backgrounds, I can give feedback in a timely manner" (average of 4.67). 56.1% students strongly agreed or agreed; 39.4% students only slightly agreed. The third lowest average was from the item "I can use effective communication tools (e.g. Line) to facilitate the communication between the members of different professional backgrounds" (average 4.7). 61.1% students strongly agreed or agreed. The results of communication effectiveness are summarized: (1). There were problems in understanding professional terminology among interdisciplinary students; (2). There were problems in providing feedbacks in interdisciplinary discussion; (3). There were problems in using effective tools to promote communication.

4.1.2 Results of student teamwork quality

There were 7 items about teamwork quality. The average of the item "I think that cooperation with students of different professional backgrounds will help to make the game better" is the highest (average 5.3). 51.5% of students strongly agree with this item. The average of the second highest item was "I think game results depends on a clear team goal" (average 5.15). 80.3% strongly agreed or agreed. The lowest average was that of the item "I think the team members are able to make the same contribution to each other" is the lowest in the study (average 4.94). 71.2% of students strongly agreed, agreed or slightly agreed. On the other hand, 28.8% responded negatively. This showed that the equal distribution of the load of teamwork was questionable.

The relationship between communication effectiveness and teamwork quality

Table 2 showed that the positive correlation between communication effectiveness and teamwork quality was significant ($p<0.05$). The coefficient of Pearson correlation was 0.686. Like the result suggested by Hoegl and gemuenden (2001), if communication problems occur, they will affect the teamwork quality.

Table 2: Pearson correlation analysis of communication effect and teamwork quality

		teamwork quality
Communication effect	Pearson Correlation	.686**
	P-value	.000

The relationship between communication effectiveness and teamwork quality on the score of the final project

Table 3 shows that communication effectiveness and teamwork quality were not correlated with the score of the final project ($p < 0.05$). The corresponding Pearson correlation coefficients were respectively 0.048 and 0.137

Table 3: Pearson correlation analysis of communication effect, teamwork quality and the score of final project

		Final projects' scores
Communication effect	Pearson Correlation	.048
	P-value	.701
Teamwork quality	Pearson Correlation	.137
	P-value	.268

The relationship between peer assessment and the score of final game

Table 4 shows that the positive correlation between peer assessment and the score of the final project graded by experts was significant ($p < 0.05$). The Pearson correlation coefficient was 0.461.

Table 4: Pearson correlation analysis of peer assessment and final projects' scores

		Final projects' scores
Peer assessment	Pearson Correlation	.461**
	P value	.000

Interview content analysis

In this study, 11 students were interviewed. S1 represents the first student, S2 represents the second student, and so on. The purpose of the interview was to survey the details of team communication. First the researchers tried to understand "whether there are communication problems among the members of each group". The following were sample responses:

S1: Well, there's a solution to some problem at the face-to-face meeting.
S3: I feel quite good. The atmosphere is very harmonious. Some problem also can get a solution.
S4: Not particularly warm, but can still get the solution.
S8: Everyone were friendly at first. However when deadline was approaching, the atmosphere in the team obviously became bad and conflicts occurred.

According to the above responses, the discussion atmosphere of each group was different. It seemed problems were solved in general.

The researchers also tried to understand "what communication problems might occur among members from different disciplines." The following are sample responses:

S2: I am the game designer in this team. I have similar cooperation experiences. So, I understand some knowledge about programming and art. Therefore we got fewer misunderstandings.
S5: Sometime programmer got problems. The game designer asked the programmer to implement a desired function. However the programmer made a mistake, so the production was delayed sometimes.
S6: Our communication have some misunderstanding, but finally we overcame these problems. More communication may confirm the needs of the game's function.
S8: There were misunderstandings. We presented an example provided by artists, and then communicated with the programmer. The programmer completed some of the functions and discussed with the other team members and confirmed whether the function is correct.
S10: We have less misunderstanding. We would confirm whether this function can be made. Moreover game designer didn't learn much about programming, so we got less misunderstandings in communication.

There were problems of misunderstandings in almost all groups, but most of the problems were solved. Team members may use other ways to explain, such as providing examples or a sketch of the game design. If the person has a basic knowledge of other professional fields, there would be less misunderstanding.

Then, we got interviews after each group finished their projects. The following is the content of the interview:

S1: I think our mobile game is a bit simple. Because this is the first time for the programmer in our team to make games. We did not understand game planning well, so we made a simple game finally. If our skills were good enough, maybe like the other group we would have done a more complex game.
S4: Overall our game is good, but some function still can be improved. Because we did not play a lot of games, so we don't know whether the game is fun or not.
S9: We did not make good progress, so we did not do very well in the final result. However we are still learning something.
S10: Time is not enough. We finished 70~80% of the whole game.
S11: I think our game got only 60% in my standard. We finally did not finish. But I think that we have done our best.

As the above interviews show, many teams did not complete the development of their game due to lack of time, not-so-good planning, and insufficient personal skills.

Discussion

Research results showed that communication effectiveness and teamwork quality were positively correlated. Communication effectiveness, teamwork quality were lowly correlated with the final project scores. This was supported by the data that showed some teams had high communication effectiveness and teamwork quality but got low scores for their final projects. According to the interview we know, the factor of affect the final project include: (1) the lack of time; (2) not-so-good game design; (3) the lack of professional skills. If a team had the good communication effectiveness, but lack the other two factors, the final project might get a low score. In addition, since the student peer assessment and final projects' score were moderately correlated, the students were very aware of the quality of the final projects.

Results also showed that communication problems occurred in interdisciplinary teams: (1) students did not understand the professional terminology of another discipline; (2) students did not provide feedback to interdisciplinary members; (3) students did not use effective communication tools.

5. Conclusion

This study focused on investigating the relationship between communication effectiveness and teamwork quality. Results confirmed the communication effectiveness among team members will affect the teamwork quality. Some communication problems were found among the students in team cooperation. The biggest problem was that students did not understand professional terminology of another discipline.

According to these results, we suggest that instructors can first teach students the concepts and language of the needed disciplines before starting their projects. Moreover, instructors can train students to solve the difficulties they might encounter during team cooperation on the project. For example, students should be trained to establish clear team goals and learn about the difficult problems in mobile game development.

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Appendix

Communication effect and teamwork quality questionnaire

	SD	D	DS	AS	A	SA
Communication Effect						
1. I can listen to the opinions of members from different backgrounds.						
2. I can understand the professional language used by members of different professional backgrounds.						
3. When discussing with students of different professional backgrounds, I can understand the focus of the discussion.						
4. During discussion with members from different professional backgrounds, I can give feedback in a timely manner.						
5. I can use effective communication tools (e.g. Line) to facilitate the communication between the members of different professional backgrounds						
6. In the process of cooperation in the development of the game, I think there is a good communication between the team members.						
7. In the process of cooperation in the development of the game, I think the team can reach a consensus, establish a team goal.						
8. In the process of cooperation in the development of the game, I think the team members to maintain a positive view of each other's professional background.						
9. In the process of cooperation in the development of the game, I think the team members can actively put forward ideas.						
Teamwork Quality						
1. I am very pleased with the outcome of the game that our team members have finally produced.						
2. I think the outcome of the game depends on good communication between the team members.						
3. I think game results depends on a clear team goal.						
4. I think that cooperation with students of different professional backgrounds will help to make the game better.						
5. I think the team members are able to make the same contribution to each other.						
6. I am very pleased with the idea proposed by the team members.						
7. I am very satisfied with the mode of communication between the team members.						
8. I am very satisfied with the decision-making process between the team members.						
Note: SD- Strongly Disagree; D- Disagree; DS- Disagree Somewhat; AS- Agree Somewhat; A- Agree; SA- Strongly Agree						

ICT Trends in the Era of Contemporary Education in Emerging Developing Countries within the Asia-Pacific Region

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Instructional pedagogies and learning has changed tremendously over the recent years, especially in the era of contemporary education. The integration of emerging technologies has transformed classrooms into dynamic entities where information and knowledge are shared seamlessly among instructors and learners. ICT plays a vital role in elevating the education system that an ICT Development Index (IDI) was published to, among others, measure the level and evolution of ICT over time within countries that can enhance growth and development (Dotong, De Castro, Dolot, & Prenda, 2016).

In emerging developing countries within the Asia-Pacific Region, educational transformation are sprucing. The rapid developments of ICT has brought improvements to the education system. It not only offers access to knowledge and information, but also opportunities for instructors and learners alike to address issues and problems in education (UNESCO Bangkok, 2015). Instructors and students are furnished with pedagogical innovations and new technologies. They are groomed with knowledge and skills that could elevate the educational system and prepare teachers and students for 21st Century education demands and needs.

In response to the growing research diversity among emerging developing nations within the Asia-Pacific region, the Fifth International Workshop on ICT Trends in Emerging Economies (WICTTEE 2016) is held in conjunction with the 24th International Conference on Computers in Education, Mumbai, India. WICTTEE 2016 is organized by the SIG on Development of Information and Communication Technology in the Asia Pacific Neighbourhood—DICTAP. The visions of DICTAP are to:

1. Share ideas and best implementation practices related to government policies and incentives aimed at promoting human resource development, technology transfer, effective e-learning strategies and implementation, software and content development suitable for each member of the Asia-Pacific neighborhood;
2. Coordinate and promote community-based e-learning activities, global sharing and management of information and knowledge. Examples of such communities are the Asia-Pacific Society on Computers in Education (APSCE) and the Association of South East Asian Nations (ASEAN); and
3. Coordinate and promote student and staff exchange among Asia-Pacific neighborhood member nations to promote more effective sharing of knowledge and practices.

The missions of DICTAP are to:

1. Connect researchers from emerging developing countries within the Asia-Pacific region to share scholarly findings and professional insights in ICT development in the field of education;
2. Establish networking opportunities among researchers, reduce the research gap between the researchers from more developed and less developed countries; and
3. Foster, enhance and sustain collaborations among these researchers.

WICTTEE 2016 is the fifth workshop that we are organizing in the hope to realize the aforementioned visions and missions. The workshop is a continuation of our relentless effort to provide a dynamic platform for practitioners and researchers alike to come together to share their country experiences.

We are extremely pleased that practitioners and scholars with university affiliations from Thailand, Malaysia, Indonesia, India, and Nigeria will be congregating in Mumbai, India to present their research findings and share their views at WICTTEE 2016. A total of nine papers will be presented in a full day workshop.

We would like to take this opportunity to thank all the authors who submitted their papers to WICTTEE 2016. We would like to record our sincerest appreciation to our Program Committee Members who dedicated their time and expertise to the most challenging and demanding task of reviewing the paper submissions. Last but not least, we would like to thank DICTAP's Advisory Committee Members for their wisdom and guidance in making WICTTEE 2016 a reality.

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Modeling the Effects of Job Relevance, Facilitating Conditions, Perceived Usefulness and Perceived Ease of Use on Teachers' Intention of Using Technology in Tertiary Schools of LDCs

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Abstract: This study proposes a model that investigates the effects of job relevance, facilitating conditions, perceived usefulness and perceived ease of use on teachers' intention of using technology in schools of least developed countries (LDCs). Borrowing from the perspectives of Technology Acceptance Model (TAM), the study was a survey design conducted among 212 teachers in selected tertiary colleges of Nigeria – Africa. The instrument of data collection was a structured questionnaire adopted from previously validated studies. The study data was analyzed using SPSS 22 for descriptive statistics and AMOS 22 for testing a model for the study. The study model has explained 30% of the variance in teachers' behavioural intention of using technology in the classroom with the R_2 of behavioural intention being .30 and the R_2 values of perceived usefulness and perceived ease of use being 15.1% and 0.2% respectively. Two of the hypothesis of the study were supported with statistically significant p-values. Job relevance was found to have direct significant effects on perceived usefulness. Perceived usefulness was also found to have direct significant effects on behavioural intention. However, contrary to the claim of TAM, the direct effects of facilitating conditions on perceived ease of use was not supported. This peculiar finding might not be unconnected with the weak structure of facilitating conditions among the target population studied, which is a less developed society. Based on this and considering the peculiar sample that participated in the study, the study has limited potential for generalizability. Additionally, it was based on self-report, characterized by high chances of bias responses. Future research can employ experimental or qualitative designs.

Keywords: Job Relevance, facilitating conditions, perceived usefulness, perceived ease of use, behavioural intention, technology, LDCs

1. Introduction

For several decades, researchers have been keenly interested in studying how people accept technology but the question of acceptance has still remained provocative. As observed by Hennington, Janz, Amis & Nichols (2009) and Samantha &, Gaurav (2016), up the contemporary times several organizations and institutions of learning have to use compulsory policies to implement technology; thereby making it even more complex to resolve the problem of acceptance. Basically, technology acceptance is explained by the end users behavioural intention to use technology (Davis, Bagozzi, & Warshaw, 1989) and previous studies have attempted to investigate the influence of subjective norm on job relevance and on intention to use technology, various findings showing significant effects between subjective norm and job relevance and between subjective norm and behavioural intention. However, in Teo, (2011); Isiyaku, Ayub & Kadir (2015a), findings users do not rely on their institutional mandates or expectations to decide to use technology it is not likely that subjective norm will significantly influence behavioural intention or job relevance. Unfortunately, this is one of the common characteristics of LDCs (Peter, Philip & Victor, 2005; Isiyaku, et al, 2015a). The variables investigated in this study are theoretically underpinned in TAM

3 and they are: Job Relevance (JR), Facilitating Conditions (FC), Perceived Usefulness (PU), Perceived Ease Of Use (PEOU) and Behavioural Intention. The purpose of the study was to predict the effects of these variables with regard to technology acceptance in educational institutions of the LDCs. Extant literature has shown that among other things, much of the educational difficulties faced in less developed countries are not unconnected with the ICT infrastructural deficiencies of these countries and the subsequent neglect of their education sectors (Asogwa & Eze, 2013; David, 2012; Ololube, 2014; Prasad, Lalitha, Srikar, (2015). Invariably, lack of ICT integration in educational institutions of a developing country such as Nigeria is a key factor in the existing gap between less developed countries and the developed ones (Isiyaku, Ayub & Kadir, 2015b)

Conducted in the northwestern region of Nigeria where teachers rarely implement ICTs in the classroom Isiyaku, et al. (2015a) and where majority of the people are educationally and technologically disoriented, Kolawole, Omobitan, & Yaqub, (2015) and Ukiwo (2007), this study has potentials for improving teachers perceptions of the job relevance, usefulness and ease of use of technology in the classroom. In effect, it is expected that this would raise their intentions of teaching with new technologies.

Until recently, in regions of less-developed-countries (LDCs) such as Africa, the diffusion of ICTs has remained extremely low, resulting in critical ICT development gaps (digital divide), between regions of Africa and the rest of the world (Anandarajan, Igbaria, & Anakwe, 2002; Odedra, Bennett, Goodman, & Lawrie, 1993). Unfortunately, despite the evidence in recent surveys showing annual growth rate of 90% in purchases of microcomputers/ICT tools in the business sectors of the LDC regions (The Fourteen Major Trends, 1997), the benefits of effective ICT usage have remained far from being actualized in countries like Nigeria, (Anandarajan et al., 2002; Asogwa & Eze, 2013; Delaviz, Andrade, Pouwelse, & Epema, 2012; Ololube, Egbezor, & Kpolovie, 2008; Olusola & Alimi, 2015). Hence, the UNESCO (2010), has observed that while teachers in places like Europe, America, Australia and most of Asia, have advanced in using ICTs for teaching and learning López-Nicolás, Molina-Castillo & Bouwman, (2008), teachers in places like Nigeria – Africa, are still using obsolete technology for traditional learning.

To support the above assertion Okolie (2014) has observed that most of the technical and vocational education departments in Nigerian institutions do not have up-to-date ICTs that are crucial for improving the quality of teaching and learning in schools. Congruently, unfavourable dispositions and perceptions of a large number of the Nigerian citizenry toward ICT adoption and usage has remained one of the foremost challenges facing the Nigerian education system (Okolie, Elom Elisha, Nwuzo Alphonsius, Inyiagu Emmanuel, & Ndem Joseph, 2014). Findings in Olusola Olayiwola and Alimi (2015) have also shown that ICT facilities in tertiary colleges in Nigeria are inadequate for any meaningful ICT program to take off.

2. Research Hypotheses and Model

2.1 Job Relevance

Extant literature indicates that teachers' perception of the relevance of ICTs to their teaching jobs is potentially important in determining how they accept and use such ICTs. Egbri (2012) has observed that the use ICTs for teaching and learning in tertiary institutions is vital for the impartation and acquisition of technology for both the lecturers and the students. Job relevance is defined as the degree to which an individual believes that the target system is applicable to his or her job (Venkatesh & Davis, 2000). In their attempt of developing and testing a theoretical extension of the TAM (Venkatesh & Davis, 2000) found that there are interactive effects between perception of job relevance of technology and the perception of its usefulness (Venkatesh & Davis, 2000)

In TAM2 & TAM3, job relevance was posited to significantly influence individual's perception of the usefulness of technology. Hitherto, Venkatesh et al., (2000) stated that "job relevance is a function of the importance within one's job of the set of tasks the system is capable of supporting". Accordingly, Venkatesh et al (2000) regarded job relevance to be a cognitive judgment that directly affects perceived usefulness, as distinguished from social influence processes. Unfortunately, some poor systems are used by individuals not because of their relevance to specific job functions but probably, just because of some social influence or other reasons and as a result, individuals do not often maximize the benefits of certain systems. Significant correlations were found between the perception of teachers with regard to the relevance of ICTs for teaching business education contents and the usefulness of such ICTs in a study conducted in Nigeria (Ezeani & Akpotohwo, 2014). Therefore, investigating the job relevance construct is fundamental to underpinning why teachers use technology. Hence, this study hypothesizes thus:

H_1: Job Relevance has a direct significant influence on Perceived Usefulness of technology

2.2 Facilitating Conditions

No matter how positive teachers' perceptions are likely to be, with regard to their capabilities at using ICTs, if they are not supported with adequate facilities, they would be constrained. Facilitating conditions can be referred to as the degree to which an individual believes that organizational and technical resources exist to support the use of the system (Venkatesh et al., 2003). In other words facilitating conditions can be defined as one's control belief concerning the availability of organizational resources and support structure for facilitating the use of technology (Venkatesh et al., 2008).

Venkatesh (2000) & Venkatesh et al., (2008) proposed facilitating conditions as one of the four anchors that drive peoples' initial judgments of their perceptions of the ease of use of technology. Teo, Lee, & Chai (2008) have also revealed that individuals' perceptions of facilitating conditions have significant influence on perceptions of the ease of use technology. In Ahmad, Kamariah & Rohayati (2014) teachers' attitudes towards using ICTs in the classroom were positively correlated with the teachers' access to ICT resources. Unfortunately, learning institutions in Nigeria are lacking ICT facilities and support for the integration of technology in teaching (Onwuagboke, Singh and Onwuagboke, 2014; Isiyaku, Ayub & Kadir, 2015a). From the foregoing, teachers' perception of facilitating conditions are fundamental to their acceptance or rejection of technology. Hence, this study hypothesizes thus:

H_2: Facilitating Conditions have a direct significant influence on Perceived Ease of Use of technology

2.3 Perceived Usefulness

As stated earlier, perceived usefulness and perceived ease of use were the core perceptual beliefs theorized in TAM, determining of individuals' intention to accept or reject technology. Perceived usefulness is defined as the degree to which a person believes that using a particular technology will enhance his or her job performance (Davis et al., 1989). People tend accept or reject technology on the basis of their perception of the usefulness of such technology to their jobs (Davis et al., 1989). In Luan, & Teo, (2009) perceived usefulness of computer technology was found to be a significant determinant of intention to use technology.

Congruently, Teo et al. (2008) has observed that when an ICT application tends to enhance people's job performances by decreasing the time they spend on doing the job or by enabling them to perform more effectively and accurately on the job; they tend to attach more value to it. Hitherto, in order to understand why teachers accept or reject ICTs in the classroom, their perceptions the value of ICTs to their jobs should be investigated. This was the theoretical foundation that supports the investigation of teachers' perceived usefulness of ICTs in this study. Hence, this study hypothesizes thus:

H_2: Perceived Usefulness has a direct significant influence on Behavioural Intention to use technology

2.4 Perceived Ease of Use

When individuals perceive that using technology is easy, it is more likely that they would want to use such technology. Venkatesh et al. (2003) defined perceived ease of use as the degree to which a person believes that using a system would be free of effort. Strong correlations were found between perceived ease of use and perceived usefulness in Igbaria et al. (1995), with perceived ease of use having direct positive effect on perceived usefulness.

In TAM, perceived ease of use and perceived usefulness were the core perceptual beliefs theorized as the determinants of individuals' intention to accept or reject technology. Hitherto, close linkages and associations were identified between perceived ease of use and computer self-efficacy several works (Davis et al., 1989; Venkatesh, 2000; Davis & Venkatesh, 2004 and Venkatesh 2000). This study hypothesizes that:

H_3: *Perceived Ease of use has a direct significant influence on Behavioural Intention to use technology*

2.5 Behavioural Intention

Being the fundamental measure for technology acceptance in TRA, TPB and TAM, Pynoo &van Braak (2014), behavioural intention was defined as the degree to which an individual is willing to perform a specific behaviour (Davis et al., 1989). It was also defined as the degree of a teacher's willingness to use technology (Teo, 2011).

Studying teachers' behavioural intention is fundamental to understanding their commitment to the use of technology in the classroom; and the extent to which teachers are willing to use ICTs in the classroom will determine whether or not they eventually use those technologies (Isiyaku et al, 2015a). The theoretical underpinning of the behavioural intention construct in this study was derived from the underlying assumption of TAM that people's computer use can be reasonably predicted from their intentions (Davis et al, 1989).

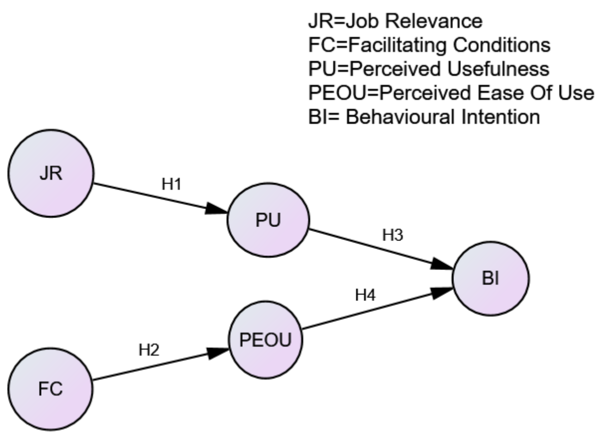

Figure 1. Research Model

3. Research Method

This research was conducted using a quantitative survey design based on the TAM 3 instrument for job relevance, facilitating conditions, perceived usefulness, perceived ease of use and behavioural intention.

A sample of 220 teachers were administered with questionnaires, out of which 212 (96%) were responses were valid 133 (63%) males and 79 (37%) females. The study data was screened for missing values and outliers and for descriptive statistics using SPSS v22. Structural Equation Modeling was employed to test the research model using AMOS v22.0.

4. Data Analysis

AMOS version 22.0 was used to run Confirmatory Factor Analysis (CFA) on all the constructs in the study and to test the fitness of the proposed research model based on technology acceptance theories and the data obtained from the participants of the study (Hair, Black, Babin & Anderson, 2010). We assessed reliability (including construct reliability) and validity (convergent and discriminant) and met all the conditions for Average Variance Extracted (AVE) (Hair, et al, 2010). We used the goodness-of fit values to assess the overall fit of the hypothesized model (Ho, 2006 & Hair et al. 2010). We found satisfactory indices for incremental fit, absolute fit and parsimonious fit as shown on Table 1 for both the measurement and the structural model.

Table 1: Indices for Models of the Study

Model Indices	Measurement Model	Structural Model
Chi Square/df	121.338/67 = 1.811	153.923/72 = 2.138
GFI	.927	.914
CFI	.977	.966
IFI	.977	.966
TLI	.969	.957
RMR	.026	.038
RMSEA	.062	.073

5. Results

Descriptive analyses has revealed that the average mean for facilitating conditions was the lowest among the variables investigated in the study; M=2.71 (SD=0.62). Surprisingly the average mean for teachers behavioural intention to use technology was up to M=4.51 (SD=0.57) being the highest mean score among all the constructs. The study model has explained 30% of the variance in teachers' behavioural intention of using technology in the classroom with the R2 of BI being .300 and the R2 values of PU and PEOU being 15.1% and 0.2% respectively. Two of the hypothesis of the study were supported with statistically significant p-values. We found JR to have direct significant effects on PU, supporting fundamental TAM relationships. PU was also found to have direct significant effects on BI as hypothesized in TAM and in several subsequent studies as summarized in our literature review. However, contrary to the claim of TAM, the direct effects of FC on PEOU was not supported. Possible explanations for this peculiar finding might be because the study has revealed lack of adequate facilitating conditions in the institutions that participated in the study. Hence, FC has predicated a decrease in teachers' perceptions of the ease of use of technology for classroom instructions implying that owing to inadequate facilitating conditions, the teachers do not perceive that using technology for teaching is easy. Similarly, the direct effect of PEOU on BI was not found to be significant. This has also contradicted extant literature. But the explanation for the peculiar scenario may not be unconnected with the negative effects that FC had on PEOU.

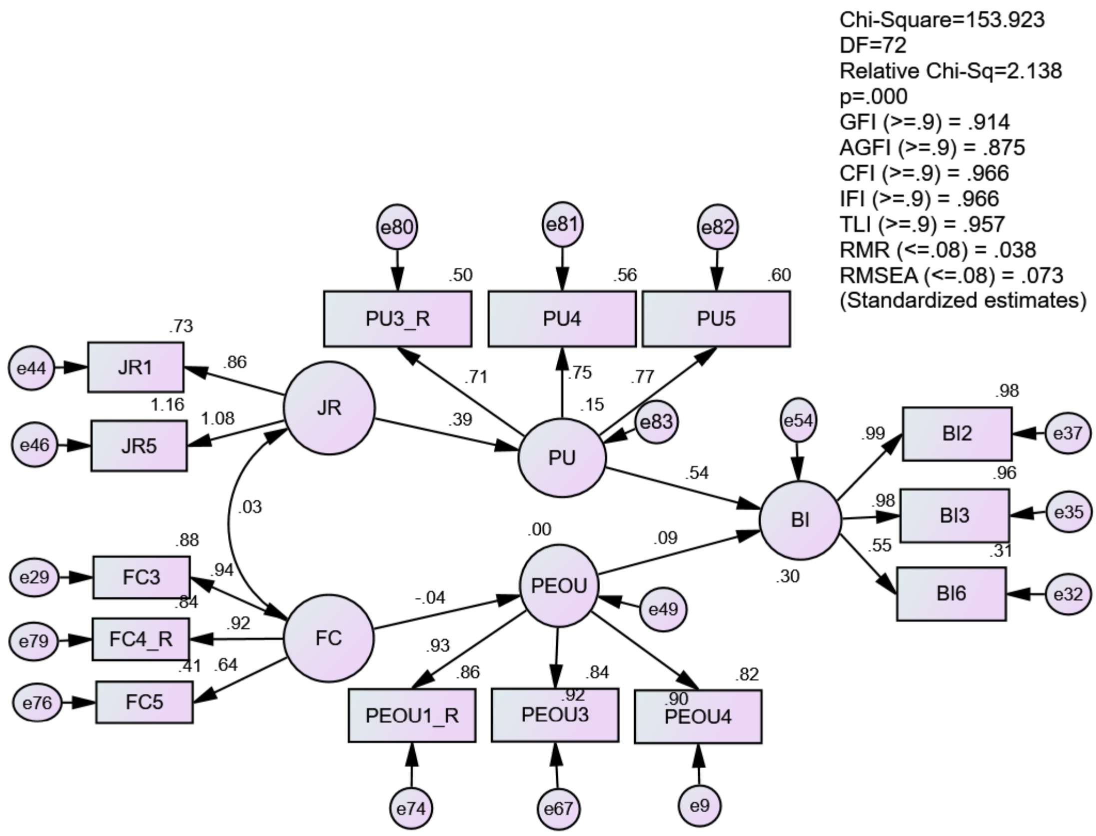

Figure 2. Effects of job relevance, facilitating conditions, perceived usefulness and perceived ease of use on teachers' intention of using technology in tertiary schools of LDCs

6. Discussions

Out of the four hypothesis of this study, two were supported, affirming the influence of JR on PU and PU on BI. One of the key findings in this research is that the effect of teachers' perception of facilitating conditions on their perception of the ease of use of ICTs for classroom purpose was not significant. Based on the standardized negative beta coefficient of the perception of teachers with regard to the adequacy of ICTs in their faculties a decrease was predicted in their perception of the ease of use of ICTs for classroom instructions. This relationship had not been established in previous research. In previous research FC always influence PEOU, but now we find that where FC is weak it is not likely to impact PEOU. Previous research has also shown than PEOU impact BI. But another key finding in our study is that where PEOU is weak, it is not likely to impact BI.

7. Limitations and Future Research

One of the limitations of this study is that it was located in a less developed country where ICT infrastructure is weak and the technology investigated is not contemporary with the technologies of more developed countries. Based on this and considering the peculiar sample that participated, the study has a limited potential for generalizability. Additionally, as the study was based on self-report, there are high chances that rebiased responses and possibly affect the reality of the situation investigated. Future research can employ experimental or qualitative designs

8. Conclusions

This study has attempted to survey the effects of the interactions of JR, FC, PU and PEOU on BI. The study has contributed to bridging the gap in ICT research between LDCs and the rest of the developed world, using the predictive modeling approach. The study has underscored the need for authorities in LDCs, to enhance ICT support for schools especially around the Northwestern region of Nigeria, because they are more educationally and technologically disoriented. Enhancing the facilitating conditions for ICTs can yield positive results for teachers' perceptions of the usefulness and ease of use of technology in the classroom. Whereas descriptive analyses has revealed a very low average mean for facilitating conditions indicating that these facilities are inadequate in the schools that participated in the study, it is worthwhile to appreciate that teachers' intention to use technology is very high. Consistently, since teachers intend to use technology in the classrooms frequently and would also want to use them to do different things besides teaching in future, school authorities should reinforce efforts to support teachers with adequate ICT infrastructure in order to achieve the desired reform in educational sectors across LDCs.

However, being that the variables investigated in this study have only explained 30% of the variance in teachers' behavioural intention to use technology, it is implicit that there are other important explanations associated with about 70% of the variance in teachers' intention of using technology. School leaders in LDCs should not expect teachers to stop at their intentions of using technology but to also use it. Hence, teachers' high intentions of using technology, should be rewarded with adequate ICTs and regular training programmes and incentives/policies to support their usage of technology in the classroom. Additionally, school authorities can combine the priority of the teachers' perceptions of the relevance and usefulness of technology to ensure that they make important technologies adequately available for use. Although these findings have important implications for ensuring appropriate uptake of technology in LDCs, further research may be needed to investigate how the perceptions, beliefs and attitudes of school leaders towards ICTs affect the appropriate integration and implementation of technology in schools across LDCs.

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The Benefits and Drawbacks of Interactive Whiteboard in Preschools: A Review of the Literature

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Abstract: The integration of interactive whiteboards in the education system has created a huge impact on classroom instruction, with preschool education also affected by the emergence of this technology. This paper provides a systematic literature review based on published evidences about the benefits and drawbacks of the interactive whiteboard in preschool settings. The findings of this study show that the interactive whiteboard is beneficial to children as it enhances their motivation to learn, assists in the development of their conceptual understanding, provides variety in the learning environment, and supports collaborative learning. Teachers also benefit from the use of this innovation. Besides improvement in the quality of pedagogy, administrative tasks are also made easier. Nevertheless, the integration of the interactive whiteboard comes with some drawbacks. The whiteboard is not child-friendly and children are often allowed only limited access to this costly equipment.

Keywords: Interactive whiteboard, technology integration, preschool education, education system, benefits, drawbacks

1. Introduction

The emergence of state of the art technology in recent decades has revolutionized classroom settings worldwide. One of the most popular technologies that is currently making its way into the education system is the interactive whiteboard, an electronic whiteboard that displays content projected by a computer, tablet, or another source. This technology combines touch (pen or finger) control of the screen with computerized input from a variety of devices operated by teachers or students (Md. Khambari, Hassett, Thomas, & Wong, 2014; Karsenti, 2016). It can also function as a multi-tasking equipment (Twiner, Coffin, Littleton, & Whitelock, 2010). This technology is considered very useful from a pedagogical perspective as its features allow interactivity, collaborative group working, accessibility, and recordability (Morgan, 2010). It is not surprising, therefore, that the interactive whiteboard has become a popular educational tool for more than a decade (Littleton, Twiner, & Gillen, 2010). The features of the interactive whiteboard are such that they enable ease of integration at all levels of instruction, from preschool to higher education settings.

Preschool is the first level of formal education for children. They need to be prepared mentally, emotionally, spiritually, and physically for the rest of their educational career (Barnett, 2008). In this challenging 21st century, children, as potential future world leaders, need to be trained from an early stage to be more confident and independent (Malaysian Education Ministry, 2013). This is because children are considered as future human resource to develop a nation in the coming time. For that, we have to make sure they are provided with sufficient exposure and infrastructure that can be used as learning tools in the 21st century education. At this educational level, they also need to be prepared for the next stage of their education, the elementary school. As preschool is one of the early experiences in child's school career, the setting should be stimulating and conducive to learning. Hence, the use of the interactive whiteboard as one of the instructional delivery tools is seen as a step in the right direction because of the various advantages offered by the technology (Harlow, Cowie, & Heazlewood, 2010; Wong, Goh, & Osman, 2013).

2. Background of the Study

The interactive whiteboard is recognized as a very useful tool that can help teachers enhance their effectiveness in the classroom (Gillen, Littleton, Twiner, Staarman, & Mercer, 2008; Coyle, Yañez, & Verdú, 2010; Blue & Tirotta, 2011; Md. Khambari et al., 2014), as well as improve students' achievement (Smith, Gentry & Blake, 2012; Bourbour & Björklund, 2014). Since its introduction, this innovation has been widely distributed and adopted at different levels of education (Twiner et al., 2010; Bahadur & Oogarah, 2013). Scholars are of the consensus that the interactive whiteboard has a number of positive effects on teaching and learning at the primary school level (Yanez & Coyle, 2011; Turel, 2012, Bahadur & Oogarah, 2013; Chen & Tsai, 2013), secondary school (Aytekin, AbdulAziz, Barakat, & Abdelrahman, 2012; Kocak & Gulcu, 2013), and even at the tertiary level (Kilic, Guler, Celik, & Tatli, 2015). As preschool or childhood early education is the most important stage in children's growth, it is vital to examine how the integration of technology affects children's learning and social development. In this study, a systematic review of the literature was carried out to gain insight into the benefits and drawbacks of the interactive whiteboard integration in preschool settings.

3. Research Question

The purpose of this study was to examine the advantages and disadvantages of integrating the interactive whiteboard in the preschool context.
This study aimed to answer two research questions:
(i) What are the benefits of the interactive whiteboard integration at the preschool level? and
(ii) What are the drawbacks of the interactive whiteboard integration at the preschool level?

4. Methodology

4.1 Background

The systematic review method adopted to gather the necessary information was designed to be comprehensive, transparent, and replicable while minimizing information bias in selection (Woods, Agarwal, Jones, Young, & Sutton, 2005). With these requirements in mind, a qualitative content analysis was employed.

4.2 Criteria for considering studies for the review of literature

To answer the research questions, the researchers collected relevant information from recent journal articles and reports and even those published as far back as 2010. Studies related to the integration of the interactive whiteboard in preschool settings were the main focus. The information was gathered over a three-month period from the academic database subscribed by the university's library and also from free databases such as Google Scholar and Research Gate.

4.3 Data Analysis

A systematic grounded theory analysis was employed whereby the data extracted from the journal articles and reports were analyzed. The articles were read and re-read at least twice in order to have a better understanding of the content before the coding and process memo procedures were initiated. A thematic analysis was carried out to sort the data into categories and to make connections among them, as suggested by Charmaz (2006).

5. Findings

The benefits of the interactive whiteboard integration in preschool settings

Two themes that emerged from the analysis enabled the first research question to be answered: What are the benefits of the interactive whiteboard integration at the preschool level? Four benefits to children and two benefits to teachers were identified. According to the studies reviewed, the interactive whiteboard is beneficial to children as it (i) enhances their motivation, (ii) develops their conceptual understanding, (iii) provides variety to the learning environment, and (iv) supports collaborative learning. As for the teachers, the interactive whiteboard helps them (i) improve the quality of pedagogy and (ii) carry out administrative tasks more easily.

5.1.1 The benefits of the interactive whiteboard to children

(i) Enhances Children's Motivation

Research finding found that the ability of the interactive whiteboard to increase children's motivation to learn is one of the special features of this innovation. These findings are congruent with other studies on the interactive whiteboard that can be used to support all levels of education (Kershner, Mercer, Warwick, & Staarman, 2010; Smith et al., 2012). According to Sweeney (2013), the interactive whiteboard's ability to provide space for teachers to diversify activities and learning styles makes the innovative tool a dynamic medium for instruction. Apart from that, the use of the interactive whiteboard as a teaching tool can improve the student's attention (Kershner, Mercer, Warwick & Staarman, 2010) as well as stimulate interaction among students and between teachers and students. In such an environment, students are more motivated to learn (Smith et al., 2012; Bourbour & Bjorklund, 2014). Thus the integration of the interactive whiteboard lays a solid foundation to the culture and learning style of the future. Motivation is the internal energy that controls one's emotions. If a person is motivated, he or she will act in a positive way (Baker & Wigfield, 1999; Reeve & Jang, 2006). Hence, the use of the interactive whiteboard in the preschool classroom is believed to yield positive results for the student in the long run.

(ii) Develops Children's Conceptual Understanding

One of the benefits of the interactive whiteboard is its ability to help build conceptual understanding in children. In a study conducted by Linder (2012), the researcher showed how the various functionalities that exist in the interactive whiteboard can be used to explain complex mathematical concepts to children. According to Wong, Russo and McDowall (2013), use of the interactive whiteboard in the classroom facilitates the demonstration of concepts. It makes instructional delivery clearer and more easily understood. The interactive whiteboard is able to build understanding in children because there is stimulation of the various senses (Warwick, Tercera, Kershner, & Staarman, 2010; Bourbour, Vigmo, & Samuelsson, 2015). This educational tool can be used not only as an audio, video, or multimedia teaching aid, but it can also serve as an excellent book for training writing skills. The interactive whiteboard is hence a tool that can be exploited for multisensory approaches to learning (Warwick et al., 2010;

Bourbour et al., 2015). Stimulation of the different senses would enhance learning in children, especially in their early phases of development (Bourbour & Bjorklund, 2014).

(iii) Provides Variety to the Learning Environments

Previous research studies have found that the interactive whiteboard is able to provide users with a variety of learning environments. In other words, with the aid of the interactive whiteboard, the teacher is able to bring in a variety of situations and atmosphere from the outside world into the classroom (Bourbour & Björklund, 2014; Bourbour, et al., 2015; Epstein, 2015; Masoumi, 2015). Such a state of the art technology enables children to "experience" even high risk situations in the real world. For example, the teacher might want to teach about the process of volcanic eruptions. By using a video on the interactive whiteboard, children are able to witness a volcanic eruption without being exposed to any risk.

The use of the interactive whiteboard in the classroom also improves the quality of the teaching process (Barak, Nissim, & Ben-Zvi, 2011; Yang, Wang, & Kai, 2012). Masoumi (2015) in his research reported how preschool teachers used the interactive whiteboard to introduce multicultural issues in their classrooms. His study showed how the teachers integrated several technologies to encourage children to share their cultures. Subsequently, Masoumi (2015) found that understanding cultural diversity made the children more positive and sensitive to their environment. Such a positive development is very much needed for many of today's children who are brought up in a digital environment.

(iv) Supports collaborative learning

This literature review of relevant studies also found that the interactive whiteboard has the potential to promote collaborative learning (Linder, 2010; Smith et al., 2012). One of the useful features of the interactive whiteboard is its large touch-sensitive screen that can be manipulated. This characteristic allows teachers and students to write, draw, and move objects on the screen by using their fingers or a special stylus pen. As such, the interactive whiteboard can be shared by many users at any one time. Its large size allows students to collaborate and present their respective views (Higgins, 2010; Warwick, Mercer, Kershner, & Staarman, 2010). Facilitating the sharing of information and allowing a two-way interaction would increase children's confidence as well as make them more appreciative of the ideas and views of other learners. Moreover, such collaborative activities help improve communication skills (Linder, 2012). Bourbour et al. (2015) explain that a learning environment that encourages collaboration would also shape a tolerant personality in a child. In other words, use of the interactive whiteboard not only helps to make learning more effective but it also enhances communication skills and fosters tolerance as well as other positive personality traits.

5.1.2 The benefits to teachers

Besides children, teachers also benefit from having the interactive whiteboard in their classrooms (Morgan, 2010; Swan & Marshall, 2010; McDowall, 2012). Among the benefits reported by various related studies are: (i) the improvement of the quality of pedagogy and (ii) facilitating of classroom management and administrative tasks.

(i) Improves the quality of pedagogy

Scholars have found that the interactive whiteboard is one of the best enablers for teachers to improve teaching (Morgan, 2010; Murcia & Sheffield, 2010; Wong et al., 2013; Bourbour & Björklund, 2014). As teaching is the teachers' core business, they are always searching for ways to make their effort more effective. The invention of the interactive whiteboard as a pedagogical tool is a boost to teachers' endeavor to teach more successfully. Integration of the interactive whiteboard in the educational system enables teachers to manage their class activities according to the ability of their students. Wong et al.

(2013) are of the view that the interactive whiteboard helps teachers give clearer explanations as well as capture the attention of their students.

Interestingly, the interactive whiteboard can be utilized also for more specific needs. Research conducted by Murcia and Sheffield (2010) and Swan and Marshall (2010) indicated that use of the interactive whiteboard helped to improve learners' skills in mathematics and science. In these two subjects, the interactive teaching style enabled children to control the pace of their learning. Murshia and Sheffield (2010) observed that by using hands-on pedagogical methods, students were exposed visually to the concepts being taught. Accordingly, these researchers suggested that the use of graphics on the interactive whiteboard would encourage learner participation. In another study, Drigas and Papanastasiou (2014) noted that the interactive whiteboard improved the quality of literacy. They found that combining a variety of learning methods helped improve the performance of children in reading and writing.

The interactive whiteboard has also been found to help diversify language education pedagogy (Kitson, 2011; Kersher, 2010). A study conducted by Kitson (2011) described how this innovation was used by teachers to diversify the model text in English learning to teach students with different levels of language proficiency. According to Kersher et al. (2010), use of the interactive whiteboard provides space for teachers to focus more on the content of the lesson as well as the appropriateness of the pedagogical practice to impart understanding. This is because the interactive whiteboard can be combined with a variety of technologies, thus allowing teachers to manipulate its use. As such, it is not only a time-saver for teachers but it also assists in lesson planning using other auxiliary materials (Kersher et al., 2010).

(ii) Facilitates classroom management and administrative tasks

Other than improving the pedagogical aspects of delivery, the interactive whiteboard also supports teachers in managing classroom activities such as carrying out course assessments. According to Morgan (2010), this technology enables teachers to manage all assessment activities of their students in the classroom and record all the data obtained. In a more recent study, Masoumi (2015) found that teachers used this technology to share relevant materials with their counterparts. This is made possible by the Internet facility which is connected to the interactive whiteboard. Such measures stimulate the professional development of teachers.

Studies also show that the interactive whiteboard eases administrative work by teachers. Management is part of the daily work of teachers and it is fundamental to the effectiveness of teaching and learning in the classroom. Among the tasks are the preparation of lesson plans, designing appropriate teaching aids and planning classroom activities. Scholars agree that standardized policies in schools regarding the use of the interactive whiteboard would serve as a catalyst to exploit this equipment in facilitating teachers' administrative tasks (Morgan, 2010; Masoumi, 2015).

The drawbacks of using interactive whiteboard in early education

While it cannot be denied that the interactive whiteboard is an innovation that offers numerous benefits, one should also consider the negative aspects of its use. Hence, in this study, the second research question is: "What are the drawbacks of the interactive whiteboard integration at the preschool level?" Some scholars have highlighted the adverse effects of integrating the interactive whiteboard in early education (Morgan, 2010; Wong et al., 2013). The two major drawbacks of such a move are: (i) it is not child friendly and (ii) pupils have limited access to the interactive whiteboard.

5.1.3 Lacks child-friendliness

Some researchers are of the view that it is inappropriate to use the interactive whiteboard in the classroom as it could distract children. A study conducted by Wong et al. (2013) found that teachers complained about problems arising from its use in the classroom. For example, there was the need to put the interactive whiteboard near an electrical socket. This often resulted in the interactive whiteboard being placed in a position that distracted the children. Moreover, in certain positions, the interactive whiteboard position limited the field of view of the children. As a result, they were not able to focus on their lesson and learning activities were disrupted. This is a major concern since children have a relatively short attention span (Healy, 2004). Inattentive learners would result in ineffective participation in learning activities.

Another issue that is also linked to the position of the interactive whiteboard is its height. A study conducted by Wong et al. (2013) found that when the whiteboard was placed high relative to the child's height and physical size, its use became limited. The interactive whiteboard is meant to facilitate interactive learning (Karsenti, 2016). However, a relatively short child would not be able to utilize fully all the functions of the interactive whiteboard.

5.1.4 Pupils have access to the interactive whiteboard

The development of a child is affected by play and discovery activities (Samuelsson & Carlsson, 2008; Hsiao & Chen, 2016). Having an interactive whiteboard in the preschool classroom provides a space for children to enjoy learning while playing (Wong et al., 2013). However, children's needs may not always be met. A study conducted by Morgan (2010) found that excessive teacher control often resulted in children having limited access to the interactive whiteboard. The teachers were afraid that children might vandalize the interactive whiteboard, and so they controlled and limited its use. Hence the children were denied free access to explore and learn from the interactive whiteboard. Excessive control by the teacher also made activities more teacher-centered (Morgan, 2010). Therefore, if teachers are too cautious, pupils will have limited interaction with the interactive whiteboard. This would in turn interfere with their learning process.

6. Conclusion and Recommendations

This study was aimed at providing an understanding of the impact of the interactive whiteboard on pupils and teachers in the preschool classroom. Its benefits and drawbacks were examined. The information gathered for this study was from theoretical and empirical studies conducted in preschools or schools of a similar context, mostly in developed countries. From the literature review, the researchers found that there were strong reasons to provide the interactive whiteboard in the preschool classroom. Four benefits for children were identified. The interactive whiteboard enhances children’s motivation to learn, develops children’s conceptual understanding, provides variety in the learning environment, and supports collaborative learning. However, there are also major drawbacks, including the size and positioning of the interactive whiteboard in the classroom, and children having limited access to the interactive whiteboard. Although the cost of this technology might be one of the main factors contributing to its limited integration in preschools nationwide, investment in this innovative technological tool would pay off in the long run. As the preschool is the first stage of a child’s school career, it is a vital stage during which the child is exposed to new concepts. Ideally, a multisensory approach to learning should be adopted. Nevertheless, more studies need to be carried out in developing countries where limited funds and prevailing pedagogical styles might influence the acceptance of an innovation such as the interactive whiteboard.

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Preliminary Study: The Challenges of Integrating Interactive Whiteboards in Teaching and Learning among KEMAS Kindergarten Teachers

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Abstract: The purpose of this study is to determine the challenges encountered by KEMAS kindergarten teachers when they integrate interactive whiteboards (IWB) in their classroom. Besides that, this study also intends to investigate on how teachers overcome the challenges that arise on a day-to-day basis. This is a qualitative study where data were collected through semi structured interviews, non-participatory classroom observations, and documents analysis. Two kindergarten teachers participated in this study, identified through the purposive sampling technique From the analysis, five main themes emerged in relation with the challenges faced by the kindergarten teachers when they integrate interactive whiteboard in their classroom. They are (i) lack of technical support, ii) maintenance cost, iii) classroom management, iv) technical failure, and v) lack of technological knowledge. Despite of the challenges aroused, the teachers had taken several initiatives to resolve the challenges including launching fund collections from student's parents or guardian, getting support from their own family and the community, setting rules enforcement in the classroom, and increasing their technological skills and knowledge through self-learning.

Keywords: Interactive whiteboards, IWB, challenges, difficulties, solutions, kindergarten teachers, KEMAS kindergarten teachers, Malaysian kindergarten, teaching and learning

1. Introduction

There is no doubt that technology has been increasingly and widely used in our education system today. Technology such as computers, televisions, tablets, and other instructional media have been used at the school to meet the demands of 21st Century education. Previous studies had proven that the use of technology in the teaching and learning process can enhance teaching and learning environment (Linder, 2010). Among others, technology can be used as a way to create hands-on and meaningful lesson (Herron, 2010). Another study also shown technology can be used to restructure the classroom to promote the development of higher order thinking skills (Kurt, 2010). Undeniably, technology is one of the essential tools that can be used for effective and permanent learning (Costley, 2014).

Aspiring to become a world leading country which promotes an education system that actively pursue technologies and innovations that fulfil 21st Century learners' needs, the Malaysian government has taken steps to improve the education system starting from its preschool. This is because children are the most valuable assets for a nation; as "today's children are leader for tomorrow" (Dahari & Ya, 2011). Advanced education system will inspire creativity and provides children with the necessary skills to be able to compete in the modern world (Ministry of Education Malaysia, 2012). This is in line with the preamble stated in the Malaysian Education Act (1996), "the purpose of education in Malaysia is to enable Malaysian to have knowledge, skills and values to survive in highly competitive and globalized future" (p. 11).

Because of that, it is important to ensure high quality education is provided to all Malaysian beginning from its preschool programme. The Malaysian government has taken one more step further through its programme by supplying interactive whiteboards to the preschool institutions. As such, in 2010, there are 126 interactive whiteboards supplied to 126 KEMAS kindergarten schools in Malaysia (KEMAS Annual Report, 2010). To ensure this programme can be successfully implemented, the KEMAS Information and Communication Technology (ICT) Unit has been entrusted to provide expertise and responsibilities to monitor the ICT infrastructures at every kindergarten. This step is taken to ensure that all infrastructures can be fully utilized and used optimally by the teachers and the students.

Generally, there are three ministries involved in the Malaysian preschools which are the Ministry of Education (MOE), the Ministry of Rural and Regional Development, and the Department of National Unity and Integration (Mustafa & Azman, 2013). Preschool, which include nurseries and kindergartens, is an institution that provides early exposure to children before they enroll in the formal education system. Usually, children will start going to kindergarten at the early age of four years old until six years old before they enter year one of primary school. In this study, the chosen kindergartens which are supplied with the interactive whiteboards are known as KEMAS. KEMAS is an abbreviation for *Kemajuan Masyarakat* or Community Development. They are under the responsibility of the Ministry of Rural and Regional Development.

Specifically, the KEMAS programme started in the 1970 and it is one of the government funded pre-schools in Malaysia. There are about 11,131 of KEMAS kindergarten was built in Malaysia on 2014 (KEMAS, 2014). Interestingly, these numbers keep growing year-by-year in order to provide accessible early education to all Malaysian children. This is from the facts that only 9,533 kindergartens were built on 2011 and 10,816 kindergartens were built on 2012. The idea of this establishment is to give education to children who come from rural and remote areas with low income family (Mustafa & Azman, 2013). National Preschool Curriculum was also enforced to unify the early education system in Malaysia. For that, every preschool institution must have specific and standardized syllabus that need to be followed.

2. Background of the Study

Interactive whiteboard is one of the technologies that have been widely used in today's classroom. The use of it has created a variety of interactive and engaging activity in teaching and learning process (Haldane, 2007). Research done by Smith, Higgins, Wall, and Miller (2005) also suggested that interactive whiteboards can have positive effects on both teaching and learning. Apart from that, learning environment has shifted more towards student-centered and has transform the teacher's role as an educator. The interactive whiteboard technology has also replaced the traditional chalkboards which enable students to draw, write, move and manipulate the objects on the screen by using their hands (Schmid, 2006). With the use of the Internet on the interactive whiteboard, teachers are able to bring the outside world into their classrooms.

Currently, there are 126 of interactive whiteboards supplied to KEMAS kindergartens by the Malaysian government. The programme has come into its sixth year implementation since its establishment in 2010. Billions of money has been spent by the government to ensure its successful implementation. However, the uses of these interactive whiteboards are still not remarkably noticed by the society. Most of the teachers found that integrating the interactive whiteboard in the teaching and learning process has helped them deliver the instruction in a more meaningful way. The use of ICT in the classroom also provides teachers with huge opportunities to enhance their delivery instruction and enable greater learner participation in the classroom activities (Hennessy, Deaney, Ruthven, & Winterbottom, 2007).

However, there are teachers who had encountered challenges or difficulties in using the interactive whiteboard. The complexity to deal with the tools and unfamiliar technology are among reasons that were found in the previous studies conducted by Karasavvidis (2009). Similarly, previous research studies had confirmed that many teachers tend to encounter problems when they are incompetent in the technology knowledge (Mohamed & Khamis, 2014). For that, the teachers prefer to use a traditional approach in teaching such as chalk-and-talk or pencil-paper assessment in their classroom rather than using the interactive whiteboard. This situation would lead to an issue when the teachers prefers to deliver the instruction in lecture-style teaching thus reduced the student-centered learning approaches in the classroom (Md. Khambari, Hassett, Thomas, & Wong, 2014).

Mastering the use of the interactive whiteboard in the classroom has become a new challenge for the teachers. Korkmaz and Cakil (2013) claimed that utilization of technologies might depend on various factors including cost, teaching and training, technology physical condition and the superior management. For these reasons, this study was carried out to determine the kinds of challenges faced by teachers when they integrate the interactive whiteboard in their classroom. Besides that, this study also intends to investigate how teachers overcome those challenges.

3. Research Questions

This study focuses on exploring the challenges faced by teachers when they integrate interactive whiteboard in their classroom and how they overcome those challenges. Specifically, this study aims to answer these questions, "What are the challenges faced by KEMAS kindergarten teachers when they interactive whiteboard in their classroom?" and "How do KEMAS kindergarten teachers overcome the challenges that arise when they integrate interactive whiteboard in their classroom?"

4. Methodology

4.1 Participants and Research Context

To ensure that all research participants have prior knowledge in using the interactive whiteboard, the purposive sampling technique was used in this study. This technique was employed because it is regarded as one of the effective ways when the researchers need to study about certain cultural domain (Tongco, 2007). A total of two teachers from Tabika KEMAS Anjung Bistari, which is located in Shah Alam, are chosen as research participants. Tabika KEMAS Anjung Bistari is a pseudonym given by the researchers in order to prevent research participants from being individually recognizable. This is in line with the study carried out by Kaiser (2009), which stated giving pseudonym is considered as one of the ways to protect participants in a qualitative research. Their consent has been obtained through phone calls after the researchers explained about the purpose of the study. The research participants are also regarded as frequent users of the interactive whiteboard in their classroom for the teaching and learning sessions.

The school is located in the developing area and is surrounded by residential area. It has two classes which comprises of five-year-old students and six-year-old students. Although it has two classes, the interactive whiteboard is only installed in the class for the five-year-old students. But the technology is shared among the teachers and students of both classes. Whenever they use the interactive whiteboard, the teachers will either combine their classes or exchange classrooms when only one of them needs to use the interactive whiteboard.

4.2 Procedure

This is a qualitative research design where data were collected through semi structured interviews, non-participatory classroom observations, and documents analysis. Data were gathered to investigate on the challenges faced by teachers when they integrate interactive whiteboard in their classroom and how they overcome those challenges. The researchers first meet the research participants on 5th April 2016. The researchers later visited the school to conduct interviews following the non-participatory observation. The observation, which was videotaped, lasted for approximately four hours starting from approximately 8 am until noon. Each interviews session took approximately around one hour and was audio recorded. During the classroom visit, related documents such as teacher's lesson plans and student's worksheet were also collected for the purpose of further analysis.

The meetings with the participants have given opportunities to the researchers to explore on how they used interactive whiteboard in the classroom, the kind of activities conducted by the teachers, and how they utilize the interactive whiteboard to prepare their lesson plan. The researchers used open-ended questioning technique in order to get an in-depth exploration of a particular topic that is useful to the researchers (Charmaz, 2006). Besides that, the researchers also had the opportunity to grasp a better understanding of the teacher's situation and their experiences on how they integrate the interactive whiteboard in the classroom activities. The data collection was carried out on the 3rd, 9th, 10th May and 12th July. Taking heed of Charmaz's (2006) suggestion whereby researchers tend to lost access to conduct data collection if they do not establish rapport with the research participants, the researchers had visited the preschool and had casual conversations with the teachers before the research started. This had allowed the participants to feel comfortable to share their stories and experiences, and allowed the researchers to learn about their views and understand them from their perspectives.

5. Data Analysis

The systematic grounded theory analysis was adopted to analyze the data gathered in this study. This technique requires the researchers to study all the early data collected, and then sort and synthesize them through qualitative coding (Charmaz, 2006). Firstly, the audio-recorded interviews were transcribed by using verbatim technique. Each of the interview session between the researchers and the teachers lasted for about 30 to 60 minutes. Next, the researchers read and re-read all of the transcripts for at least two times as a mean to familiarize themselves with the data (Ary, Jacobs, Razavieh, & Sorensen, 2006).

The data were analyzed by using the open coding method (Strauss & Corbin, 1998). Then, the data were categorized by giving them a short name and the researchers sorting them in the related category. The purpose of adopting this data analysis technique is to look for patterns and trends in the data (Northcote, Mildenhall, Marshall, & Swan, 2010). Several themes were revealed during the coding process and they are used to answer the outlined research questions in the forthcoming section. In order to protect the identity of research participants, the researchers have given pseudonyms to both participants as Sophia and Suzanna.

6. Findings

6.1 Challenges Integrating Interactive Whiteboard in the Classroom

This section will discuss the findings related to the first research question, "What are the challenges faced by KEMAS kindergarten teachers when they integrate interactive whiteboard in their classroom?" Five main themes have emerged from the data analysis, namely (i) lack of technical support, (ii) cost maintenance, (iii) classroom management, (iv) technical failure, and (v) lack of technological knowledge.

Theme 1: Lack of Technical Support

From the data analysis, the researchers have found out that the teachers experienced lack of technical support from the technical expertise. When the researchers asked if there is any technical expertise came to fix the interactive whiteboard, the research participants commented:

> No technician has ever came. We fixed it ourselves. We informed them that the interactive whiteboard was broken, but no such action was taken. We have to build our own financial support and fix it ourselves. [Sophia]
>
> The people (technician) came just to monitor. Then he said we have to wait. But, there is no action taken to fix the interactive whiteboard until today. [Suzanna]

These interviews excerpts are evidences that technical support is lacking and the teachers have to find their own initiatives to overcome this challenge. Both teachers reported that there is no official technical expertise available to solve the issues. Thus, adequate technical support should come along when new technologies are introduced in the classroom.

Theme 2: Cost Maintenance

The analysis also revealed that teachers are having problems with the high cost of fixing the interactive whiteboard when it is not functioning. According to Sophia, there is no specific allocation provided by the administration for the interactive whiteboard's cost maintenance. She added, they have to find their own money and resources to fix the interactive whiteboard.

> The interactive whiteboard can't be used for today. The RAM was broken and we need around RM200 to repair it … and people in charge of this IWB also said that the cost to change the bulb itself may cost from RM700 to RM800. [Sophia]

> A broken interactive whiteboard demands a high cost to get it fixed. Last time, the projector was broken and now the printer also can't be used. This happened for the second time in this year … and I think it is better for me to find a new one. It's not worth to fix it. [Sophia]

This finding is similar with the previous study conducted by Jones and Vincent (2006) who suggests that the integration of the interactive whiteboard in the classroom is closely related with the significant financial input required to purchase, install and maintain the use of it. From the above excerpts, the teachers required a substantial amount of budget to fix the interactive whiteboard. This situation continues to deteriorate because there is no specific fund allocation provided to help them overcome this issue.

Theme 3: Classroom Management

The teachers also experienced challenges with classroom management in two areas, namely dealing with student's behavior and time constraint to integrate the interactive whiteboard in the classroom. According to Suzanna, there are students who are playing around with the interactive whiteboard's screen which is touch-sensitive and it may disrupt the learning session.

> Since the students know that the screen can be touched, they will keep touching the screen even when their friend is doing the exercise on the interactive whiteboard. [Suzanna]

Besides that, the teachers also claimed they have other workloads to complete and do not have enough time to prepare learning materials by using the interactive whiteboard. They added, a packed schedule has been one of the challenges for them to teach everything listed in the curriculum especially when technical problems happen.

> The time is limited because there will not be enough time to let every student to try the activities on the interactive whiteboard. Sometimes, the lesson got interrupted when the computer is suddenly jammed. [Sophia]

Theme 4: Technical Failure

Another theme that revealed from the analysis is technical failure, be it hardware or software. Both research participants reported that there is no official technician who would come to assist them whenever they are having problem with the interactive whiteboard. Suzanna added that she sometimes felt discouraged to use the interactive whiteboard when this situation happened. This is in congruent with Erduran and Tataroglu (2009) who concluded that technical problems occur in technology integration will discourage teachers from using it. Other studies conducted by Hall and Higgins (2005) also highlighted the same findings.

Kocak and Gulcu (2013) reported that technical failure including software, material and resource deficiency are seen as unpleasant things happening in the classroom. Technical and installation difficulties are also among the major findings related with the interactive whiteboard integration (Manny-ikan, Dagan, Tikochinski, & Zorman, 2011).

> The screen sensor is not functioning well. Plus we can't calibrate the interactive whiteboard because the program in not available in the computer ... because of that, when we write something on the interactive whiteboard it will appear slowly or at the other area and not exactly on the surface that we write or touch. [Sophia]

> It is so frustrating because the students can't touch the screen to manipulate the objects. So, I had to alternatively use the mouse to move the objects on the screen. [Suzanna]

> I have to find the learning materials on my own at my house because we do not have Internet connection here. We do not subscribe to the Internet because we want to reduce the cost. [Suzanna]

The teachers' frustrations and concerns are is in line with the study conducted by Warwick, Mercer, Kershner, and Staarman (2010) that emphasized major influencing factor relates on how teachers use the interactive whiteboard is highly dependent on the interactive whiteboard's ability used as a learning tool to assist instructional process. Thus, it is important to make sure that the interactive whiteboard is always in a good condition so that instructional delivery process can be conducted swiftly.

Theme 5: Lack of Technological Knowledge

The last theme that emerged shows that the teachers are lacking technological knowledge especially in using the interactive whiteboard. Insufficient ICT training has made this situation even worse. Both research participants claimed that they only attended one training course and no other professional trainings or refresher courses are conducted since then. Advanced trainings are needed because teachers' efficiency in using interactive whiteboard is one of the contributing factors on its effective integration (Higgins, Beuchamp, & Miller, 2007). Apart from that, the teachers also require a significant amount of experience to become technical and pedagogical experts in using the interactive whiteboards.

> For me, the only training that we had attended was not enough to make us competent in using the interactive whiteboard … it (the training) lasted for only three days. On the first day, we introduced ourselves and then we were divided into several groups. We were given tasks to create the learning materials in groups, not individually. That's it. [Sophia]

> Truthfully, I'm still in the learning process to use the interactive whiteboard. There are a lot of things that I need to learn. But for now, I still can teach the students but with simple use of the interactive whiteboard such as playing video and others. [Sophia]

These interviews excerpts shown the teachers received inadequate training to incorporate the interactive whiteboard in their lesson. From their perspectives, the training is like an introductory courses and it is not emphasize on the interactive whiteboard interactivity. In fact, they suggested that KEMAS should conduct subsequent training in the future so that the teachers can fully utilize the interactive whiteboard in their classroom.

6.2 Ways of Overcoming the Challenges

This section will discuss the findings related to the second research question: "How do KEMAS kindergarten teachers overcome the challenges that arise when they integrate interactive whiteboard in their classroom?" Among the effort taken by the teachers are (i) launching fund collections from student's parents or guardian, (ii) getting support from the community and their own family, (iii) setting rules enforcement in the classroom, and (iv) increasing their technological skills and knowledge through self-taught.

Launching Fund Collection

Several approaches have been taken by the teachers to overcome the problems arise when they integrate interactive whiteboard in the teaching and learning process. The first solution that has been identified is teachers will gather fund collection from the student's guardian. For example, Suzanna reported that they have collected money from the student's guardian to help them pay for the cost of fixing the projector. The teachers reported:

> Like I have said before, I will inform the student's parents or guardians first in the Whatsapp group that we are going to make a fund collection. Or sometimes, I will just ask them nicely when I met them at the kindergarten. [Sophia]

> Usually, we will ask the student's parents or guardians to give some donation if we do not have enough money to pay the maintenance cost. We will put one big container outside the classroom so that they can put the money inside it. [Suzanna]

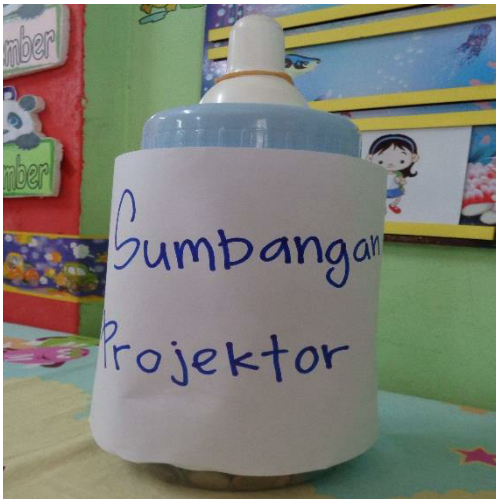

Figure 1. The container used to collect money from student's parents or guardians which reads "Sumbangan Projektor" or "Donation for Projector" in the Malaysia native language.

The action taken by the teachers shown they have received community support which will be discussed further in the next section. Undoubtedly, this initiative somewhat helped them get extra money to help them fix the interactive whiteboard.

Getting Support from Own Family and Community

Technically, it is a common situation when teachers are having problem in the classroom that integrates technology. For that, technical support is considered as an influencing factor for successful technology integration for teaching and learning process (Mohamed & Khamis, 2014). Both research participants agreed that support from colleagues would be helpful when they encountered problem using the interactive whiteboard. Suzanna added, she even gets help from her husband whenever the technical problems happen. For example, her husband helped to reset the interactive whiteboard's calibration program and changed the computer's RAM when it breaks down.

Besides that, the teachers also share information with their colleagues from other kindergartens to deal with the technical failure. This action is possible because according to Sophia, they have created Whatsapp group when they attended the training course last time. She commented:

I used to share problems related with the use of interactive whiteboard with my colleagues. For example, there is only one interactive whiteboard in the Shah Alam district and it is installed at this kindergarten. So if I have problems, I will just contact my colleagues to help me. [Sophia]

The warranty for this interactive whiteboard had expired mid of 2014. After that, I used to call my husband to fix it whenever it breaks. Like last time, my husband had changed the computer's RAM with a new one. [Suzanna]

That time we collect money from the student's parents and guardian because the cost to fix the projector is nearly RM500. So we had to get help from them to top up the cost with the existing fund from this kindergarten. [Suzanna]

Figure 2. Suzanna's husband seen giving a hand on the interactive whiteboard, is the unofficial technical support received by the teachers at KEMAS Anjung Bistari.

Setting Rules Enforcement

In order to increase the control over student's behavior, Suzanna has set several rules to manage the students in the classroom. She claimed that students will be in their best behavior if the rules were enforced when conducting activities using the interactive whiteboard. She commented:

For example, when I carried out an activity in the classroom, I will set the rules to ensure that the classroom is well-managed. For instance, I will only pick up students with good behavior which is when they sit at their place, not making noise and not playing around with their friends. In that way, students will automatically start to behave. [Suzanna]

From this interview excerpt, the use of interactive whiteboard in the classroom can bring positive impact toward student's behavior. This finding is similar with previous research conducted by Northcote et al. (2010) that stated interactive whiteboard integration can encourage positive influence on children's behavior. Md. Khambari, Hassett, and Wong (2015) also stated that rules enforcement can help the teachers to achieve the desired goals and objective. Developing good routines and following them is an initiative taken to handle the classroom. In conclusion, it is suffice to say that rules enforcement can control student's behavior and indirectly, enhance the learning environment by having a good classroom management.

Self-Taught

According to the teachers, both of them agreed that they received insufficient training after attending the interactive whiteboard's training course. They added, attending the training for only three days was not enough because they do not get opportunities to explore and familiarize themselves with the interactive whiteboard's functions. They also said that they are still in the 'learning processes' to integrate interactive whiteboard in the teaching and learning process. For example, they commented:

> I explored a lot by myself. In fact, I had my laptop installed with the interactive whiteboard software when I'm attending the training; so that I can practice more on how to use them and integrate it with the interactive whiteboard in the classroom. [Suzanna]

> During the training, we are only introduced to the available functions embedded in the interactive whiteboard, buttons and program installed in it. For that, I have to refer to the user manual book provided to learn more or use it as reference in case I forgot what I had learnt. [Suzanna]

Hence, these excerpts show that self-taught is one of the initiatives taken by the teachers to increase their existing technological skills and knowledge. During the interviews, the teachers agreed that they can learn more about functions embedded in the interactive whiteboards when they explore it by themselves.

7. Conclusion and Recommendations

Based on the findings gathered, the KEMAS kindergarten teachers faced several challenges when they integrate interactive whiteboard in their classroom. Lack of technical support and maintenance cost are the two prominent challenges found in this study. Besides that, the difficulties to manage student's behavior in the classroom also become one of the challenges the teachers faced. Even though the use of the interactive whiteboard had sparked excitement among students, this has also become a challenge as their over-excitement makes them became more difficult to control. Packed schedules and other managerial workloads also prevented the teachers to utilize the interactive whiteboards to the fullest. Apart from that, the teachers also faced trouble to troubleshoot the problems with interactive whiteboard themselves because of their lack of technical knowledge and skills.

Nevertheless, despite all challenges that they encountered, the teachers do find their own way of solutions to overcome the problems. This situation proved that the teachers have the effort to ensure a quality classroom instruction powered by advanced technology. The teachers are aware that today's children are digital learners and the use of interactive whiteboards in the classroom can support them in their learning activities. Thus, this study recommends adequate training and technical support to assist teachers in using the interactive whiteboards. It can be seen clearly that ongoing technical support provided is insufficient as for now. The related parties or the top management should be aware that teachers may have different kind of computer literacy and technological skills. For that, they should conduct more tailored professional development courses and trainings, and supervise the teachers from time to time to ensure that the teaching and learning process are carried out efficiently.

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A Two-phase Study of Investigating Lao PDR Preservice Physics Teachers' Perceptions toward the Use of Computer Simulation in Physics Education

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Abstract: The teaching of physics in Lao People's Democratic Republic (Lao PDR), generally, offers conceptual ideas to students by using mathematical equations, rather than core ideas of physics. Many researchers reported that this way of instruction made students memorization of scientific facts, rather than understand its concepts, and they may have no motivation to learn physics. According to the mentioned problem, this paper reported a two-phase study investigating preservice physics teachers' prior conceptual understanding and physics motivation, and perceptions toward simulation-based learning in physics of electricity. The participants were 32 sophomore students in Department of Physics, Faculty of Education, Savannakhet University, Lao PDR. In phase I, they were investigated preconception of electricity concepts and their physics motivation using 12 two-tier multiple- choice items and 25 items of 5-point rating scale, respectively, and it was observed that the preservice physics teachers held many misunderstanding about electricity and they had low level of physics motivation. In phase II, they were, then, examined their perceptions toward the use of computer simulation for physics learning after interacting in a simulation-based inquiry learning activity, and it was examined that they expressed positive perception on the learning, where the highest perception scores was on enjoyment (E), perceive of usefulness (PU), perceive of satisfaction (PS), perceive learning (PL), Flow (FL), and perceive ease of use (PEU), respectively. Moreover, the qualitative results showed that they can interact with computer simulation and learn physics concepts of electricity from the activity. The main implications of this study is the rethinking of pedagogy used for teaching physics of electricity in order to improving the preservice physics teachers' conceptual understanding, fostering their physics motivation, and enhancing pedagogical ideas and performance on how to teach physics with computer simulation.

Keywords: Teacher education, preservice, physics education, perception, understanding, motivation

1. Introduction

In present day, technology has profound and lasting impacts in school classrooms as being a powerful instructional tool (Srisawasdi, 2015). Researcher, educators, and developers believed that several technologies including probeware, computer simulations, software applications, programmable instruments, mobile devices, and laptop/notebook computers could be used effectively to impact student learning in science subject. As such, digital technologies became effective tools to support teaching and learning in today classroom (Vreman-de Olde, 2013; Srisawasdi & Sornkhatha, 2014). Recently, computer simulations, which contain visualization and features for representing an authentic system or phenomena, have a number of instructional features that has been recognized as a pedagogical tool for teaching and learning in science (Blake & Scanlon 2007; Wellington 2004). In addition, computer simulations are influential tools which can make unobservable phenomena being visual representation and also could support students' conceptual learning in science. Researchers reported that the pedagogical use of computer simulation can help student reducing and eliminating alternative- or misconceptions in science, and review and also can improve scientific conceptual understanding and advanced mental model of scientific phenomena (Srisawasdi & Kroothkeaw, 2014; Suits & Srisawasdi, 2013).

In context of Lao PDR country, there is very important for science teaching and learning to use innovative learning technology, such as computer simulation, as a potential tool for students learning in science. However, science teachers in Lao PDR rarely used computer simulation in their class ranking from elementary school to college or university, even it adds several educational values to science learning activities. In fact, science teaching in Lao PDR seemed to focus on content represented on textbooks and by teachers rather than student-centered learning approach and learning science as way of knowing. In term of physics teaching, most of physics teachers in Lao PDR taught physics subject in class by emphasizing mathematical equations for explaining physical phenomena and lecturing theoretical physics without situational and authentic contexts. In context of teacher education program at University of Savannakhet in Lao PDR, preservice physics teachers have not a positive perception to study physics because physics is difficult and hard to understand, due to its abstraction and complexity by nature. As such, there is a need and call for development of preservice physics teachers' teaching performance for supporting and enhancing physics learning with the use of technology-enhanced learning tool such as computer simulation. In this research, the researchers conducted a two-phase study for investigating sophomore preservice physics teachers' conceptual understanding of electricity and their physics motivation, and also examined their perception toward simulation-based learning on electricity at Department of Physics, Faculty of education, Savannakhet University, Lao PDR.

2. Literature Review

In several decades, computer technology can play important roles in the science classroom and laboratory, and one type of computer application in science education is computer simulation or simulation. To enhance the learning of scientific phenomena, computer-based modelling tool, such as computer simulations, have been used extensively as a visual representation tool to advocate presenting dynamic theoretical or simplified models of real world components, phenomena, or processes (Srisawasdi et al., 2016). Many instructional qualities of computer simulation are potentially useful for promoting conceptual development in science and inducing cognitive dissonance of conceptual change (Srisawasdi & Kroothkeaw, 2014; Srisawasdi & Panjaburee, 2015). In science education community, computer simulations are promising area for enhancing the development of conceptual comprehension and inducing the change of misconceptions in science (Bell, 2012). Recent research indicated that computer simulation can effectively support teachers' efforts to integrate inquiry instruction in their science classrooms (Higgins & Spitulnik, 2008; Varma et al., 2008). Smetana and Bell (2012) pointed out that computer simulation can be effective instructional practices in promoting science content knowledge and developing process skills. However, to be most effective, computer simulation should be situated in a substantial and flexible framework of knowledge of content, pedagogy, and technology.

In order for teachers to develop professional teaching performance for successful integration of computer simulation, it is important for them to understand what such instructional practices involve and consider how they may be of value to teaching and learning. Moreover, positive perceptions toward simulation-based learning in science were a necessary for professional development of preservice and in-service science teachers. Therefore, the effective use of computer simulations requires teachers' positive perceptions as well as how to specifically use to the curriculum, students, and classroom setting.

3. Methods

3.1 Participants

The participants in this study were 32 sophomores preservice physics teachers at Department of Physics, Faculty of Education, Savannakhet University, Lao PDR. In phase I, they were recruited to explore physics conceptual understanding of electricity and their motivation to learn physics in the first semester of academic year 2015. After, they were, in phase II, recruited to interact with a physics lesson of simulation-based learning of electricity, and examined their perceptions toward the simulation-based learning experience in another semester later.

3.2 Research Instruments

In phase I, the researchers aimed to explore current status of sophomore preservice physics teachers' conceptual understanding of electricity and their physics motivation. As such, the researchers used 12 of two-tier multiple-choice items measured physics conceptual understanding of electricity, including (i) electric circuit, (ii) current law in series circuit (iii) current law in parallel circuit, (iv) voltage law in series circuit, (v) voltage law in parallel circuit, and (vi) Ohm's law. In order to investigate their physics motivation, 25 items of 5-point rating scale questionnaire measured intrinsic motivation (IM), career motivation (CM), self-efficacy (SEC), self-determination (SDT), and grade motivation (GM). In phase II, 21 items of 5-point rating scale questionnaire measured perceived learning (PL), flow (FL), enjoyment (E), perceived ease of use (PEU), perceive of usefulness (PU), and perceive of satisfaction (PS).

3.3 Data Collection and Analysis

In order to explore the preservice physics teachers' conceptual understanding of electricity and their physics motivation in the phase I, they were administered the 12 two-tier multiple-choice conceptual understanding test and the 25 items of physics motivation questionnaire for 60 and 15 minutes, respectively. For the multiple-choice test, each two-tier item was scored by 1 point and total score was 12 points. The students' responses were calculated by frequency and percentage of the complete score. For exploring their physics motivation, the questionnaire classified into five motivational constructs and total score for all motivational constructs was 125 points, 25 points each construct. Their responses to the questionnaire were calculated into mean and standard deviation. In phase II, the preservice teachers were administered the 21 items of perception questionnaire for 15 minutes after their interaction with a lesson of simulation-based physics learning of electricity in 60 minutes. The perception questionnaire classified into six perceptual constructs, and total score for all perceptual constructs was 105 points. To analyze their perception scores, percentage was used to indicate their perceptual status after interacting with the simulation-based physics learning. Figure 1 shows a pilot implementation of simulation-based physics learning of electricity. Moreover, the preservice physics teacher was assigned to interact with simulation in dyads and each dyad was assigned to interact and collect data into an experimental work sheet.

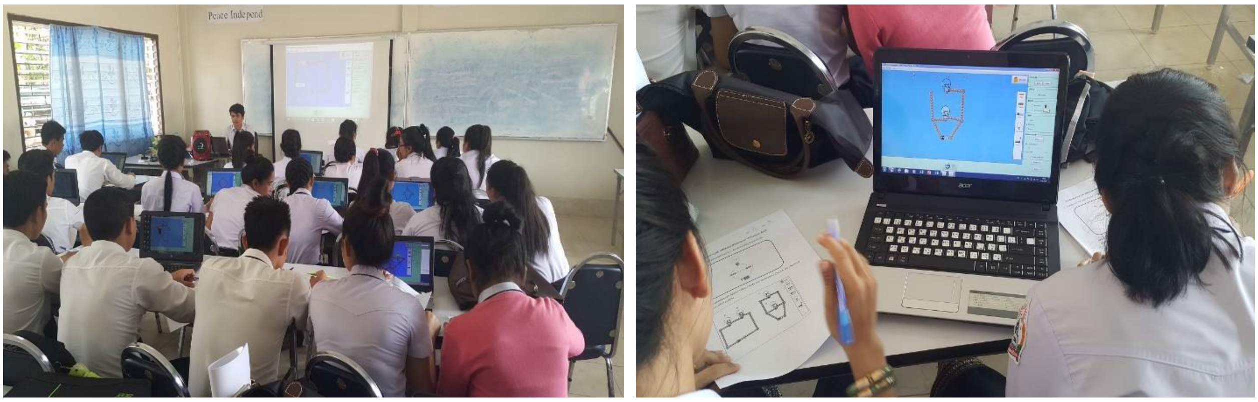


Figure 1. Illustrations of simulation-based learning activity: teacher introduced how to learn physics of electricity with simulation (Left) and preservice physics teachers interacted to collect experimental data with the simulation (Right)

4. Results

In this section, the researchers present the results into two phases. The results of phase I study indicated current status of the preservice physics teachers' conceptual understanding of electricity and their physics motivation. Another, the evaluation of the preservice physics teachers' perceptions toward simulation-based physics learning of electricity in phase II was reported in this section.

4.1 Phase I: Conceptual Understanding of Electricity and Physics Motivation

4.1.1 Conceptual Understanding of Electric Current

Figure 2 reports the percentage of the preservice physics teachers' conceptual understanding scores classified into misunderstanding and scientific understanding on six concepts, i.e. C1-electric circuit, C2-current law in series circuit, C3-current law in parallel circuit, C4-voltage law in series circuit, C5-voltage law in parallel circuit, and C6-Ohm's law.

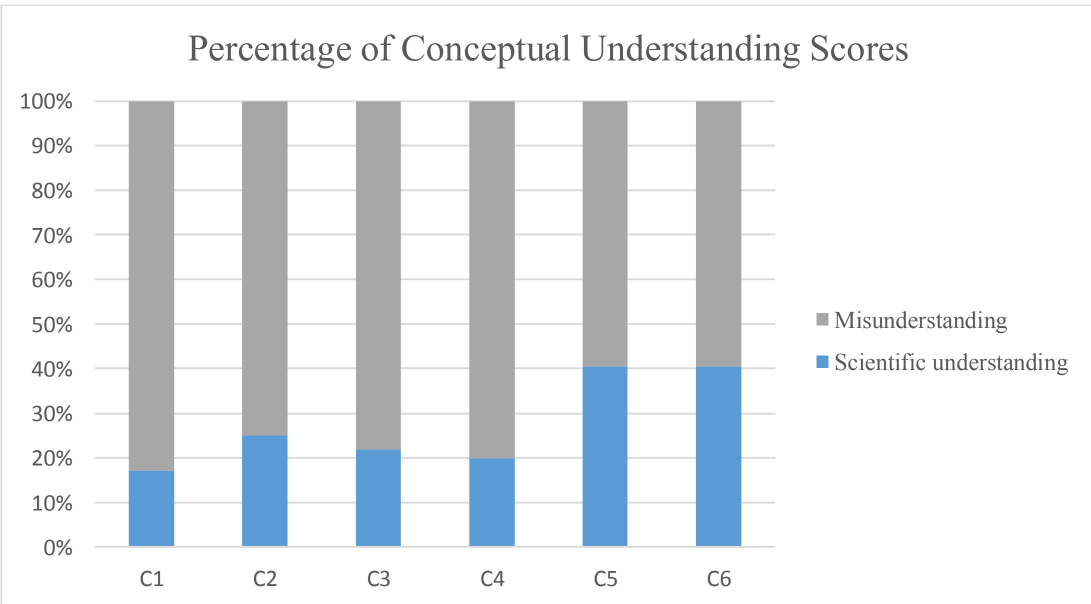


Figure 2. Percentages of mean score of conceptual understanding

In Figure 2, the highest percentage of misunderstanding was relied on C1(82.81%), C4(80.21%), C3(78.13%), C2(75.00%), C5 and C6 (59.38% both), respectively. In addition, the percentage of misunderstanding on all concepts indicated that the preservice physics teachers hold unscientific conceptions or understanding on physics of electricity in school science level.

4.1.2 Physics Motivation

Figure 3 displays the percentage of the preservice physics teachers' physics motivation scores classified into five motivational constructs, i.e. intrinsic motivation (IM), career motivation (CM), self-efficacy (SEC), self-determination (SDT), and grade motivation (GM).

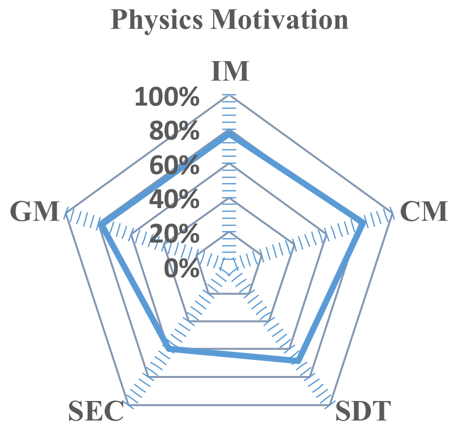


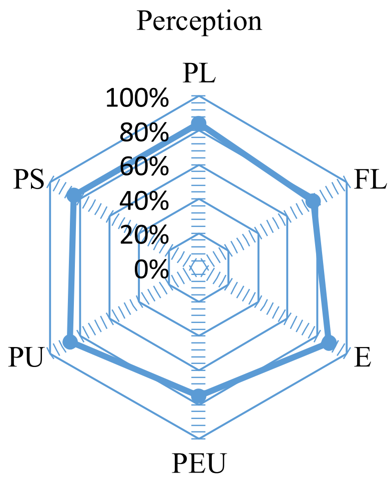
Figure 3. Mean score of 5-point rating scale physics motivation

For the results of physics motivation displayed in Figure 3, the highest score was relied on CM (82.13%), GM (78.00%), IM (77.13%), SDT (68.50%), and SEC (59.75%), respectively. The Figure 3 reveals a different level of motivation on each motivational constructs. This indicated that the preservice physics teachers had a high level of extrinsic motivation, i.e. CM and GM, and a middle level of intrinsic motivation, i.e. IM, SDT, and SEC, to learn physics.

4.2 Phase II: Perceptions toward the Learning Experience of Simulation-based Learning in Physics and Performance to Learn with Simulation

4.2.1 Perceptions toward Simulation-based Learning

To evaluate the preservice physics teachers' perceptions toward simulation-based physics learning of electricity, six perceptual constructs have been used to frame their perceptions. Figure 4 shows the percentage of their perceptions on perceived learning (PL), flow (FL), enjoyment (E), perceived ease of use (PEU), perceive of usefulness (PU), and perceive of satisfaction (PS).



In Figure 4, the highest percentage score of their perceptions were relied on E (87.92%), PU (86.67%), PS (84.17%), PL (84.06%), FL (77.25%), and PEU (75.00%), respectively. The Figure 4 allows to see a positive trend of their perceptions on each perceptual constructs. This indicated that the preservice physics teachers had a high level of perceptions towards simulation-based learning in physics of electricity.

4.2.2 Performance to Learn with Simulation

During they interacted with simulation, each dyad received an experimental work sheet and was assigned to complete the work sheet within 60 minutes. To explore their learning performance with simulation, the researchers analyzed and interpreted their worksheet and found that most of them are able to interact and then extracted scientific understanding of electricity from the simulation. However, a few of them still encountered with difficulty to learn with the simulation. Figure 5 illustrates examples of the preservice physics teachers' experimental data sheet obtained from the interaction with simulation.

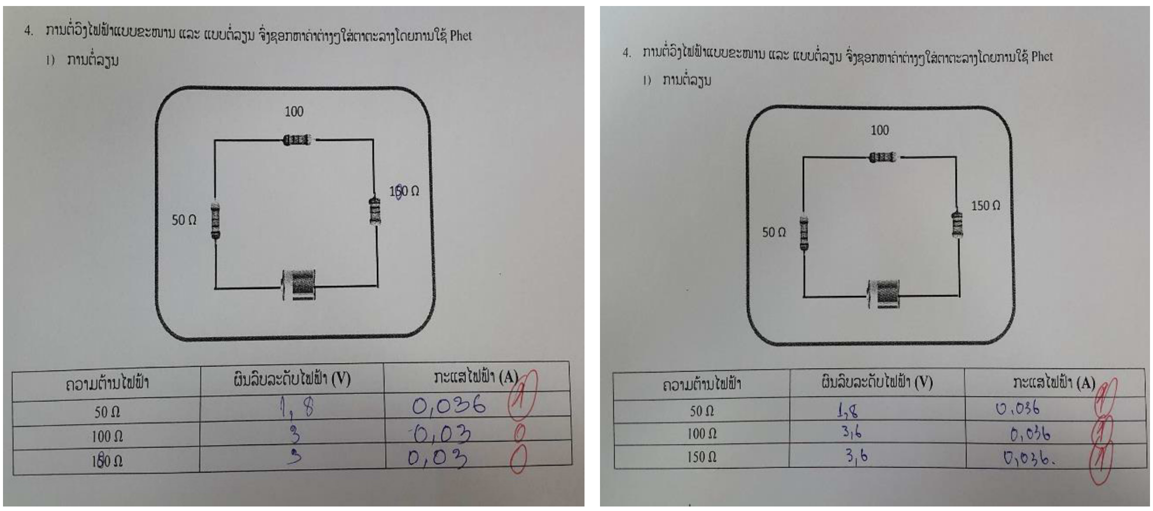


Figure 5. An illustration of preservice physics teachers' experimental data sheet: an example of a wrong answer (Left) and a correct answer (Right) obtained from the simulation-based learning

5. The Design of Simulation-based Guided Inquiry Learning for Physics of Electricity

In order to enhance the preservice physics teachers' conceptual understanding of electricity and promote their motivation towards physics, the researchers propose a learning design of simulation-based guided inquiry on physics of electricity. Figure 6 illustrates a representative diagram of the learning design regarding a harmonization of conceptual physics of electricity, computer-simulated experimentation or simulation, and a pedagogic approach of guided inquiry.

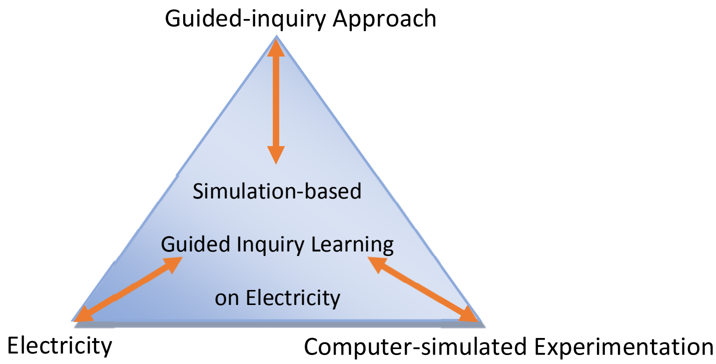


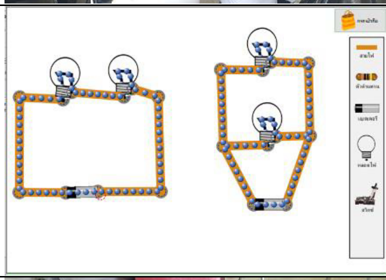
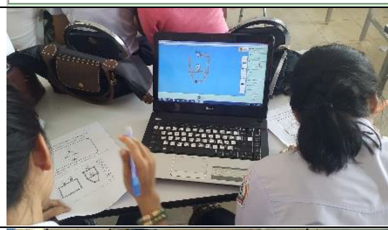
Figure 6. A learning model of simulation-based guided inquiry on electricity

In this proposed learning design, the researchers aim to promote preservice physics teachers' active conceptual learning in the concepts of electricity by visualizing the abstract and complicated physics phenomena, and also encourage them to participate with simulation through way of inquiry learning for improving their physics motivation. This learning design begins with an open-ended driving question targeted to alternative conceptions commonly found in conceptual physics of electricity. To assist the process of hypothesis generation addressed the driving question, essential scientific backgrounds or information are provided to learners. Then, a series of testable hypotheses are presented to them activating their prior experience and supporting a conceptual connection between preconception and the new-coming information. To create a space for their thinking, they are required to perform designing of an investigative experiment with simulation, analyzing the data, communicating results of experiment, and drawing a conclusion based on evidence for testing of their own selected hypotheses (see Table 1.)

6. Conclusion and Future Work

This two-phase study demonstrates current status of Lao PDR preservice physics teachers' conceptual understanding of electricity, physics motivation, and perceptions toward simulation-based learning with simulation. The results suggested that the preservice physics teachers held many misunderstanding or unscientific conceptions on electric circuit, current law in series and parallel circuit, voltage law in series and parallel circuit, and Ohm's law. The results, also, suggested that they had low level of intrinsic motivation, career motivation, self-efficacy, self-determination, and grade motivation. Due to interacting with new experience of simulation-based learning, they expressed positive perception on the perceptual constructs of perceived learning, flow of experience, enjoyment, perceived ease of use, perceived usefulness, and perceived satisfaction. According to the results, the main implications of this study is the rethinking of pedagogy used for teaching physics of electricity in order to improving the preservice physics teachers' conceptual understanding and fostering their physics motivation. As such, a learning design of simulation-based guided inquiry approach would be implement in a physics coursework for Lao PDR preservice physics teachers. The future work is to develop a module of the approach and then implement into a real context of coursework in Lao PDR.

Table 1. Components of simulation-based guided inquiry learning on electricity

<table>
<tr><th colspan="2">Components of simulation-based
guided inquiry learning</th><th>Examples of learning process</th><th>Examples of learning activity</th></tr>
<tr><td rowspan="2">Pre-lab</td><td>Open-ended inquiry question</td><td>Teacher provides an open-ended inquiry question: If we have two lamps (A and B) on a parallel circuit, and the lamp A is lost, what would happen to another lamp? Explain.</td><td></td></tr>
<tr><td>Scientific background/ information</td><td>Teacher induces collaborative discussion toward the definitions and pictorial diagram of electricity.</td><td></td></tr>
<tr><td rowspan="2">Lab practice</td><td>Procedure/design</td><td>Teacher presents a series of hypotheses, the simulation, and then introduce the experimental procedure to students. Moreover, teacher also explains what kinds of the experimental data that the students should collect from the simulation.</td><td></td></tr>
<tr><td>Data and result analysis</td><td>After the interacting with simulation, students make a decision to analyze obtained experimental data from their own design and interpret it into results</td><td></td></tr>
<tr><td rowspan="2">Post-lab</td><td>Result communication</td><td>Students have to select the way to present, communicate, and discuss the meaning of data and experimental results to others</td><td></td></tr>
<tr><td>Conclusion</td><td>Students have to collaboratively make a relationship between each group results and then draw it into a conclusion as the best answer to the provided inquiry question</td><td></td></tr>
</table>

Acknowledgements

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An Extensible Multilingual Corpus of DFA Construction Problems

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Abstract: In a country with linguistic diversity, academic instruction may occur in a language in which learners and instructors lack fluency. In such a situation, learners may struggle to answer problems posed by instructors not because they lack the requisite technical skills, but because they are unable to precisely comprehend what is being asked. In this work-in-progress paper, we demonstrate a semi-automated technique to translate a specific category of problems in the undergraduate Computer Science curriculum (the construction of deterministic finite automata) into multiple languages. We show how a corpus of problems (specified in a recently proposed mathematical representation) can be extended in two ways. First, new languages can be targeted by manually translating elements of this mathematical representation into each new language. This is a one-time effort per target language. Second, new problems can be added to the corpus in the mathematical representation at any time, and these are translated into all target languages automatically. We are currently evaluating our technique with English (the language of instruction at our institution) as well as Kannada and Hindi (a majority of our instructors and learners are fluent in at least one of these), and we describe the results of a small-scale ($N = 38$) study which shows promising results.

Keywords: Language translation, Computer Science education, Deterministic Finite Automata (DFA).

1. Introduction and Related Work

English has emerged as the *lingua franca* in technical domains such as engineering (Riemer, 2002). In an increasingly global work environment, a premium is placed on graduates with strong English communication skills, and fluency in this language can result in a competitive advantage (Kapur and Ramamurti, 2001). It is therefore common for technical educational institutions around the world to use English as a medium of instruction, and successful students require proficiency in English (Rauchas et. al, 2006; Qian and Lehman, 2016). In a linguistically diverse country such as India, a substantial fraction of people are not native English speakers[1], and poor educational standards mean that command over English is weak even for those with formal training in the language. As a result, instructors and learners may be compelled to communicate in a language in which neither group is fluent. India's National Knowledge Commission recommends that "translation should play a critical role in making knowledge available to different linguistic groups" (Pitroda, 2009). Although translation cannot compensate for poor English fluency, we believe that "making knowledge available" in a familiar language will benefit learners who otherwise need to cross two mental hurdles: (1) parsing English, and (2) understanding technical concepts. Learners who cannot cross the first of these two barriers often have no chance to demonstrate their technical understanding. For pedagogical purposes, it may therefore make sense to provide learners with "training wheels" in the form of translation tools to help them cross former barrier and hone their technical skills, and then gradually withdraw such tools.

Machine Translation (MT) has made rapid advances over the past few years, with translations to and from English receiving the bulk of attention. Existing techniques appear to perform well with

[1] In India, the census of 2001 recorded 29 Indian languages with more than 1 million native speakers each, but less than 0.25 million native English speakers.

simple sentences, and translations between linguistically proximate languages. For technical content, Chen et. al (2016) examined the quality of Google Translate on English-language medical educational materials and found that "the likelihood of incorrect translation increased when the original sentence required higher grade levels to comprehend", and that humans significantly outperformed MT when the target language was Chinese, but not when it was Spanish.

In this paper, we consider problems from the undergraduate Computer Science curriculum that ask learners to create deterministic finite automata (DFA) that accept a particular set of strings. As an example, consider the following problem: Construct a DFA for the regular language *L* consisting of the set of all binary strings *w* that *start with* '10' *and end with* '01'. The unique minimum-state DFA for this problem is shown in Figure 1.

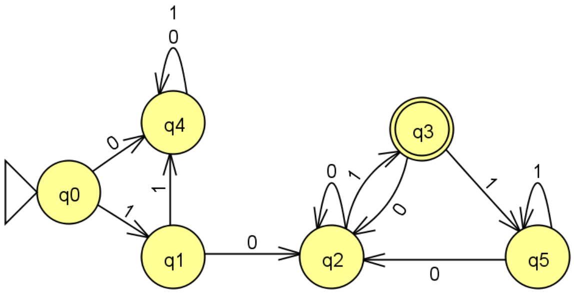

Figure 1. A DFA for the given language *L*.

begin with '10' and end with '01'	'10' के साथ शुरू करते हैं और '01 ' के साथ खत्म
w has at least as many occurrences of (110)'s as (011)'s	डब्ल्यू (110) के रूप में (011) के लिए कम से कम के रूप में कई घटनाओं है

Figure 2. The Google translation of two DFA construction problems from English to Hindi. The simpler example (top) is translated accurately, whereas the translation for the more complex example (bottom) is almost wholly meaningless.

In order to solve such a problem, it is crucial for learners to parse the italicized description unambiguously. This sentence is easy enough for Google Translate to generate accurate Hindi (Figure 2, top). In contrast, consider a more complex problem: Construct a DFA accepting all binary strings *w* such that *w has at least as many occurrences of* (110)'s *as* (011)'s[2]. If a learner uses Google Translate to convert this into Hindi (Figure 2, bottom), the result is impossible to comprehend. For example, the term "occurrences" refers to the number of times a pattern appears, but this is incorrectly translated into घटनाओं, the Hindi word for "incidents". Our goal in this paper is to demonstrate a simple and accurate method for translating DFA construction problems into several languages. Instead of translating from English, our technique relies on a mathematical representation of DFA problems that has recently been proposed (Shenoy et. al, 2016). The remainder of this paper is organized as follows. In Section 2, we review this representation for DFA construction problems and explain how problems can be easily translated from this representation into other languages. Next, we present results of a small-scale pilot study to assess the effectiveness of providing translations for learners in Section 3. Finally, we discuss classroom applications and limitations of this approach in Section 4, together with our plans for future work.

[2] This problem was adapted from the Graduate Aptitude Test in Engineering (Computer Science), 2014. This high-stakes test is taken annually by approximately one million students in India.

2. Representation and Translation of DFA Construction Problems

Shenoy et. al (2016) describe a tree-representation of DFA construction problems. Internal nodes of this type of tree correspond to functions, and leaves refer to the input string, constants, etc. The root of this tree is a Boolean-valued function. As an example, Figure 3 shows this mathematical form of the DFA construction problem for the language *L* defined in Section 1.

The set of functions is rich enough to represent most of the DFA construction problems found in popular textbooks for the relevant undergraduate Computer Science course, and a corpus of 17,537 such problems has been automatically generated (Shenoy et. al, 2016). Each such problem is persisted as a file in JSON (JavaScript Object Notation) format, which captures the hierarchical tree-structure.

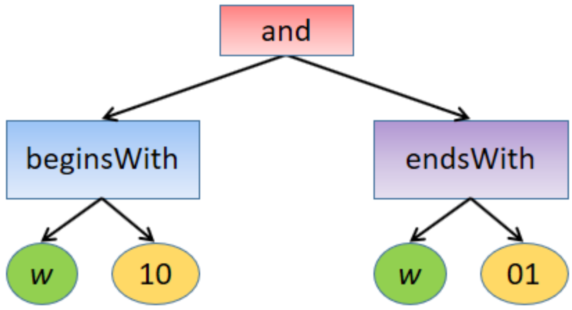

Figure 3. The DFA construction problem for the language *L* represented mathematically.

Each of the functions in the mathematical representation above leads to a simple translation rule in every target language. For example, **beginsWith**(*w*, *x*) translates to "*w* begins with *x*" in English. In Hindi, the translation has a slightly different structure: "*w x* से शुरू होता है". In contrast, **and**(*x*, *y*) has the same structure in both English ("*x* and *y*") and Hindi ("*x* और *y*"). There are about 40 functions that need to be translated (additional functions can always be added to enhance the expressiveness of the problems), so the one-time effort to translate from the tree representation to any new language is manageable. Also note that our translation mechanism allows problems to be translated in "segments" that can vary from individual functions to whole sub-trees. We are particularly interested in this capability, because several of our instructors and learners are (at least) bilingual, and constructions that are somewhat ambiguous to them in one language may be clearer in another.

For rapid translation, our implementation persists the rules for translating functions in a locally stored JSON file (one for each target language). For each new target language, it is only necessary for users to download this small, language-specific JSON file and update the list of supported languages.

3. Experimental Evaluation

In order to assess the benefit of such translations, we performed a small-scale pilot study with $N = 38$ undergraduate volunteers (18 male, 20 female; all were fluent in Kannada but English fluency varied).

Table 1: Three regular languages for which learners were asked to classify strings.

Language	Binary strings *w* such that…	Kannada translation (English transliteration)	Strings to classify
L_1	*w* starts with '01' or ends with '10'	*w* '01' rinda shuruvagabahudu athava *w* '10' rinda anthyagolabahudu	001, 010, 011, 100
L_2	*w* contains exactly three 1's and *w*'s length is at least 4	*w* nalli '1' mooru saari maatra barabeku mattu *w* vina udda 4 kintha kadime ira baradu	111, 1111, 0111, 010101

Language	Binary strings w such that…	Kannada translation (English transliteration)	Strings to classify
L_3	w has an equal number of 0's and 1's and w's length is at most 5	w nalli '0' mattu '1' ra sambhavisuva enike samavaagirabeku mattu w vina udda 5 kintha hecchu ira baradu	empty string, 01, 1100, 011100

All volunteers had taken the appropriate "Theory of Computation" course in the prior semester. Based on self-reported grades in this course, the volunteers were split into four groups of approximately equal size so that each group had nearly the same distribution of A, B and C grades in this course. Next, each volunteer was asked to indicate which of a given set of four strings belonged to each of the given languages, as shown in Table 1. The 9 volunteers in group A were given only English descriptions for each language. The 10 volunteers in group B were additionally given Kannada descriptions for languages L_1 and L_2, the 9 volunteers in group C were given additional Kannada descriptions for languages L_1 and L_3, and the 10 volunteers in group D were given additional Kannada descriptions for all languages. Thus, for each language, some volunteers had only the English text whereas other volunteers had both English and Kannada text. Each volunteer's answers were evaluated by assigning a score of 1 for each correctly classified string. Thus, a volunteer could obtain a maximum score of 4 for each language. The scores obtained are listed in Table 2.

Table 2: Scores obtained by volunteers on the three languages.

Language	English-only text	English + Kannada text
L_1	Average score: 2.89 Standard deviation: 1.17 Count: 9	Average score: 3.72 Standard deviation: 0.53 Count: 29
L_2	Average score: 2.72 Standard deviation: 0.83 Count: 18	Average score: 2.85 Standard deviation: 0.81 Count: 20
L_3	Average score: 3.11 Standard deviation: 1.39 Count: 19	Average score: 3.05 Standard deviation: 1.27 Count: 19

We note that the English-only and English + Kannada groups both scored lowest on language L_2. The English-only group performed better on language L_3 than L_1, but this difference is not statistically significant ($p > 0.66$). In contrast, the English + Kannada group performed much better on language L_1 than L_3 ($p < 0.04$). This initial finding suggests that the benefit of additional translations may depend on the problem being solved.

There is no significant difference in scores between the English-only and English + Kannada groups for languages L_2 and L_3, but for language L_1 the result is marginally significant ($p < 0.067$). We were somewhat surprised by this, so we analyzed the results more carefully for individual strings. Notice that strings in language L_1 satisfy the disjunction of two conditions (w starts with '01' or w ends with '10'). The string '010' satisfies both these conditions, and therefore belongs to the language. For the English-only group, 6 out of 9 volunteers answered this question correctly. In contrast, 28 out of 29 volunteers answered this question correctly in the English + Kannada group, a statistically significant difference ($p < 0.03$). This finding suggests that the availability of translations for certain words ("or" in this case) may be more important than wholesale translations. These findings need to be investigated more carefully, however.

We make one final observation regarding the "empty string", which belongs to the language L_3 since it contains an equal number (zero) of 0's and 1's, and has length zero which is at most 5. Based on our experience, we know that learners often find it difficult to reason correctly about the empty string, and we hypothesized that translating "empty string" into Kannada (or any other language) would not provide learners much help. Our results bear this out: 14 out of 19 volunteers in the English-only group answered this question correctly, whereas 12 out of 19 volunteers answered it correctly in the English + Kannada group ($p > 0.45$).

4. Discussion and Future Work

We are presently exploring ways in which to present translations to instructors and learners. As stated in Section 2, it is possible for our system to perform piecemeal translations. Our initial findings presented in Section 3 suggest that learners may find it helpful to view the entire question in the language of instruction (English, in our case) and request translations only for certain "tricky" portions of the question. Instructors, too, may find this facility useful in a computer-based examination environment. Here, translations can be made available to learners for a small penalty to ensure that they attempt to understand problems as originally presented, but do not get entirely stuck merely because they are struggling with the language.

Our automated translations are fairly rudimentary, and certain problems in our mathematical representation are poorly translated. For example, a tree whose root and several immediate descendants are **or**() functions represents a disjunction of several sub-properties. A human may translate this as: strings satisfying at least one of the properties P_1, P_2, …, P_n. Our translation will be more cumbersome with several nested parentheses that are unnecessary in this case, but are required to specify precedence in the presence of other functions such as **and**(). Our system would produce a translation of this form: strings that satisfy ((P_1) or (P_2 or P_3)) or (…). Our initial tests have revealed that learners find this form extremely difficult to follow. Therefore, we are considering ways to implement new types of translation rules that apply at a larger granularity than individual functions. In our example above, such a new rule would apply to the entire sub-structure of **or**() functions below the root of the tree.

We are also investigating ways in which our approach can extend to other problem domains (not just DFA construction problems). Note that our only requirement is to map a representative collection of domain problems to a suitably rich mathematical representation. From this representation, the same approach as ours can be used to translate problems into other natural languages. We believe that it may be possible to specify problems from other introductory courses in Computer Science in this way, and we are specifically examining CS1 and CS2 courses.

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Self-paced Learning among Undergraduates: Exploring the Relationship between ICT Utilization and Motivation, Mastery, and Subjective Norm

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Abstract: In this digital era, Information and Communication Technology (ICT) has allowed students to design learning at their own pace. For that reason, this study aims to explore the relationship between ICT utilization and motivation, mastery and subjective norm for self-paced learning among undergraduate students. This research was carried out using the quantitative approach. There were 60 undergraduate students who participated in the survey. Findings from this study show a significant positive correlation between ICT utilization and motivation (r = .27), mastery (r = .36) and subjective norm (r = .34) for self-paced learning among undergraduates. Findings suggest that mastery followed by subjective norm and motivation need to be emphasized in tertiary education to maximize the impact of ICT on students' self-paced learning.

Keywords: Self-paced learning, ICT utilization, motivation, mastery, subjective norm

1. Introduction

Self-paced learning is the student autonomy to decide on the timing and speed of content delivery (Magill, 2008). Learning could be more valuable when the students learn at their own pace and abilities rather than a pace that is determined for them. Learning is effective if the student is able to self-guide his study time (Tullis & Benjamin, 2011) and effective learners have the ability to manage and pace their own learning (Finley, Tullis, & Benjamin, 2009). Studies found that the learners' autonomy to decide on the subjects to study and re-study has positive effects on learning (Benjamin & Bird, 2006; Toppino, Cohen, Davis, & Moors, 2009) and it makes learning a personalized experience that is effective for individuals (Edgar, 2012). Self-paced learning enables the students to enjoy greater personalization of their learning experience with the autonomy to explore and pursue subjects of their interest (Ministry of Education, 2012). With the establishment of online resources, students can access materials on-demand to enable self-paced learning.

ICT is no longer perceived as novelty but it is being observed as a standard feature in the learning process (Moses, Tey, Cheah, Teo, & Wong, 2014). Self-paced learning using ICT allows the student to have learning flexibility from anywhere at any given time at own convenience. ICT utilization refers to processing and sharing of information using any forms of technology tools for communication (Apagu, & Wakili, 2015). Studies on student adoption of technology have found that learners' perception of the education potentials of technology determines whether they are going to adopt these tools for learning (Lai & Gu, 2011; Clark, Logan, Luckin, Mee, & Oliver, 2009; Davis, 1989).

Successful learning requires students to be motivated. Motivation is one of the predicators of students' learning and motivated learners are likely to achieve higher levels of success (Hu, 2008; Mezei, 2008). Motivation refers to "the reasons underlying behaviour" (Hu, 2008) or in other words it is the characteristic that makes us to do or not to do something". Without or with little motivation, self-paced learning might be ineffective. Hashemyolia, Asmuni, Daud, Ayub, and Shah (2014) viewed that motivation is one of the key factor that contributes to use ICT for learning. Previous studies found a positive correlation between motivation and ICT usage for learning among students (Shonfeld & Aharoni, 2015; Hassanzadeh, Gholami, Allahyar, & Noordin, 2012). They concluded that the higher one's motivation, the greater the chances of students using ICT in their learning.

There is a need to prepare learners for participation in an information society because knowledge is the most crucial resource for social and economic development in the future (Hakkarainen, Ilomaki, Lipponen, Muukkonen, & Rahikainen, 2000). ICT skills are necessary in to solve increasingly complex problems in a variety of knowledge-rich domains, participate in knowledge work and engage in various networked activities. Mastery can be inferred from evident performance on a set of items or tasks related to a particular concept, skill, or subject (Thomas & Eric, 2014). Mastery or competence skills are significantly important for the good utilization of ICT for learning purpose (Vidanagama, 2016; Priyangika & Jayasundara, 2013; Saba, 2013). Students are able to learn according to their capabilities using ICT in higher education institutions (Edgar, 2012 & Hakkarainen et al., 2000). Tasir, Abour, Halim, and Harun (2012) found that mastery of ICT skills had a high positive correlation with ICT usage. They also concluded that 56% of the actual use of ICT can be explained through ICT competence. Another similar study conducted by Buabeng-Andoh (2012) also showed positive correlation between ICT competence and ICT usage.

Another element that plays an important part in the students' independent learning is the subjective norm. Ajzen and Fishbein (1975) defined subjective norm as a person's perception that most people who are important to them think they should or should not perform the behavior in question. People will generally intend to perform a behavior when they have a positive attitude toward it and when they believe that important individuals think they should do so (Ajzen, 1988; Huang, Davison, & Gu, 2008). A meta-analysis by Schepers and Wetzels (2007) reported a correlation between subjective norms and ICT behavioral intention. If a student thinks the family and friends accept and appreciate him engaging in e-Learning, he is more likely to enact it (Schepers & Wetzels, 2007).

2. Purpose of the study

This study aims to explore the relationship between ICT utilization and motivation, mastery and subjective norm for self-paced learning among undergraduate students. The following hypotheses were formulated based on the literature review:

H1: There is a significant relationship between ICT utilization and motivation.
Ho: There is no significant relationship between ICT utilization and motivation.

H2: There is a significant relationship between ICT utilization and mastery.
Ho: There is no significant relationship between ICT utilization and mastery.

H3: There is a significant relationship between ICT utilization and subjective norm.
Ho: There is no significant relationship between ICT utilization and subjective norm.

3. Methodology

3.1 Participants

The sample of this study consists of 60 undergraduate students from a private university in peninsula Malaysia. Purposive sampling method was used as basis for selecting the sample to represent the undergraduates studying in a private university. Purposive sampling is used to focus on people of specific characteristics who will be able to assist in the study (Creswell & Clark, 2011).

The breakdown of undergraduates according to their respective gender is 23 males and 37 females (Table 1). Thus, majority of the undergraduates involved in this study were females (61.7%) compared to males (38.3%).

Table 1: Distribution of Participants by Gender

Gender	Frequency	Percentage (%)
Male	23	38.3
Female	37	61.7
Total	60	100

Table 2 provides a summary of the undergraduates' age. The age of the respondents varied from 19 to 23 years old. The mean age of the participants is 20.50 with a standard deviation of 1.32.

Table 2: Distribution of Participants by Age

Age	Frequency	Percentage (%)
19	13	21.7
20	26	43.3
21	8	13.3
22	4	6.7
23	9	15
Total	60	100

3.2 Instrumentation

The questionnaire consisted of two parts: Section 1 gathers demographic information of the students and Section 2 focuses on the scale items which elicits information on student's usage of ICT for self-paced learning. The students were required to answer the survey using the five point Likert scale. The Likert scale ranged from strongly disagree (1), disagree (2), neutral (3), agree (4) to strongly agree (5).

The questionnaire consists of ICT utilization (7 items), motivation (7 items), mastery (12 items), and subjective norm (6 items). ICT utilization and mastery items were adopted from Albirini (2006), and subjective norm scale was adopted from Venkatesh, Morris, Davis, and Davis (2003). Permissions were sought from the authors to adopt and modify the items. The changes made were to some words and phrases so that the items suit the investigation. However, the scale for motivation was formulated by the researchers based on literature review due to the deficiency of relevant scale for this study.

A panel of experts in education technology field reviewed the questionnaire for its face validity and content validity. The experts examined the items and provided constructive comments on the items that can actually measure the intended measure. Based on their expert feedback, some of the items were further revised and removed from the questionnaire owing to their unclear and ambiguous nature. This was done to avoid confusion among the participants and the questionnaire was revised to be more comprehensible by the participants who were from an undergraduate background.

In this study, 65 questionnaires were manually administrated to the undergraduates. Out of the 65 questionnaires, 60 questionnaires were obtained with complete data. The reliability of the complete instrument was analyzed using Cronbach Alpha to determine the internal consistency coefficient of this study as it is used widely by researchers (Hair, Black, Babin, Anderson, & Tatham, 2006). The reliability value derived for each scale is presented in Table 3. The Cronbach's Alpha coefficient for this study ranges from .763 to .903. As a result, this questionnaire had a very good internal consistency as every alpha level of the scale was higher than .70 (Pallant, 2006).

Table 3: Instrument Reliability

Scales	Number of Items	Cronbach's Alpha
ICT Utilization	7	.763
Motivation	7	.853
Mastery	12	.903
Subjective Norm	6	.808

4. Results and Discussion

4.1 ICT Utilization for Self-Paced Learning

Respondents were asked on their amount of time spent using ICT for self-paced learning. Table 4 shows the distribution of the respondents on ICT usage for self-paced learning per day. A large number of students (46.7%) reported that they use ICT for self-paced learning for more than 30 minutes a day but less than two hours. Some students (30%) spent more than two hours to four hours in self-paced learning using ICT. Nonetheless, a few students (5%) spent more than four hours to six hours whereas others (6.7%) spent more than six hours in using ICT for self-paced learning. The data finding also showed that some students (11.7%) seldom engage in using ICT for self-paced learning.

Table 4: Distribution of Participants According to Amount of Time Spent for Self-paced Learning using ICT Per Day

Amount of Time Spent for Self-paced Learning using ICT	Frequency	Percentage (%)
Seldom	7	11.7
>30 minutes < 2 Hours	28	46.7
> 2 hours < 4 hours	18	30
> 4 hours < 6 hours	3	5
> 6 hours	4	6.7
Total	60	100

4.2 Relationship between ICT Utilization and Motivation, Mastery and Subjective Norm for Self-paced Learning

Scatter plots were used in this study to test out the assumptions and distribution of the variables. The scatter plots show high scores, indicating positive relationships between the variables involved; suggesting that the high scores on the ICT utilization are associated with the high scores on motivation (Figure 1), mastery (Figure 2), and subjective norm (Figure 3).

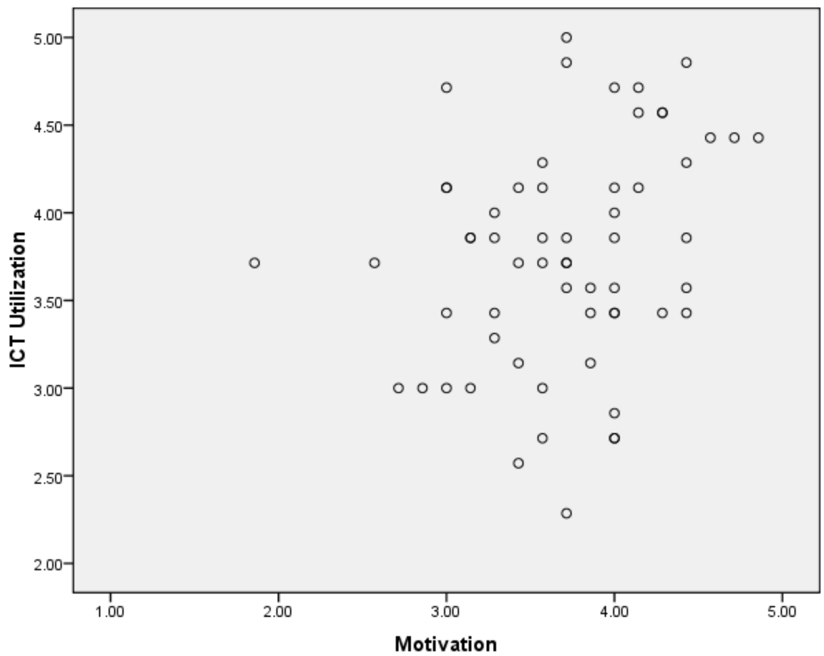

Figure 1. Distribution of ICT Utilization and Motivation for Self-paced Learning among Undergraduates

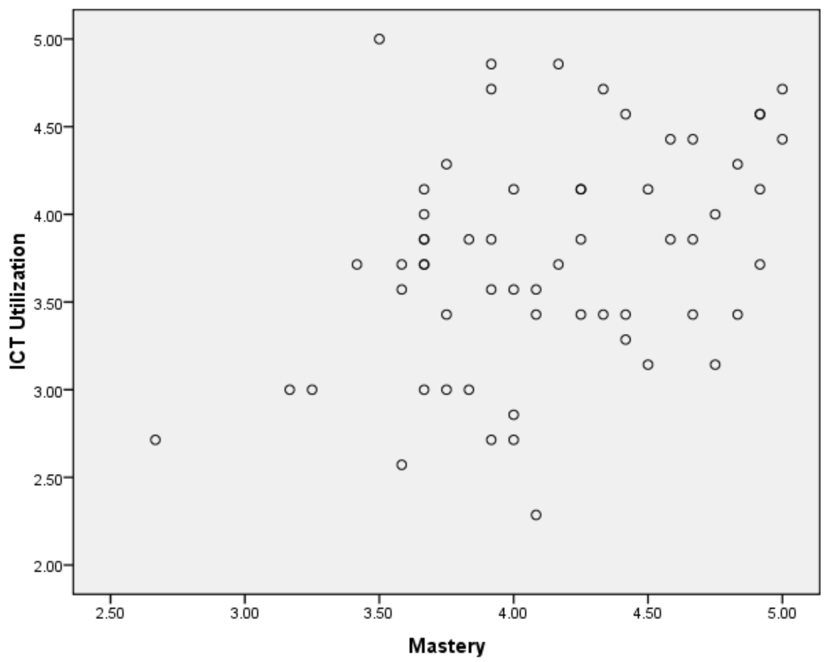

Figure 2. Distribution of ICT Utilization and Mastery for Self-paced Learning among Undergraduates

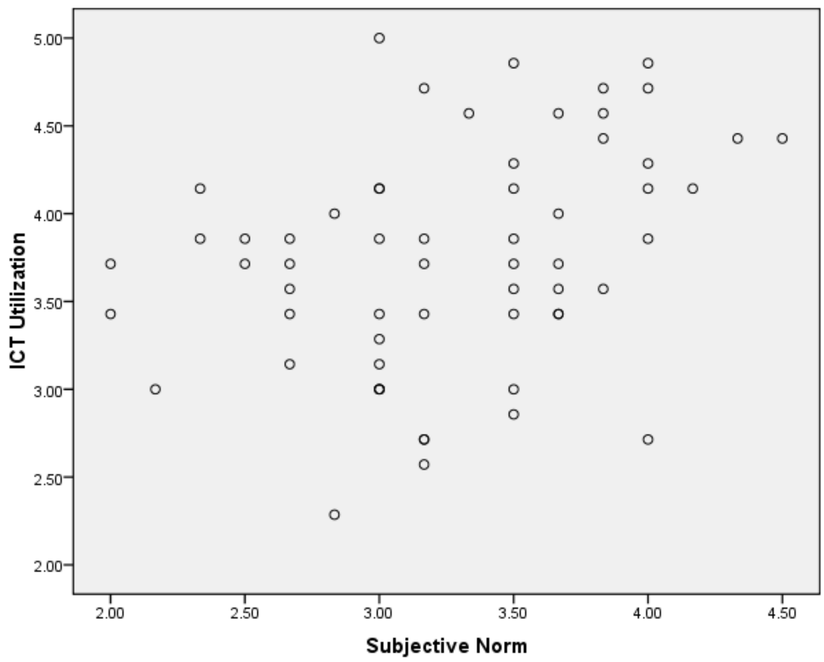

Figure 3. Distribution of ICT Utilization and Subjective Norm for Self-paced Learning among Undergraduates

The relationship between the ICT utilization and the three variables were identified using Pearson product-moment correlation coefficient. The results of the correlation are presented in Table 5. The findings revealed there was a small (Cohen, 1988), positive correlation between undergraduates' use of ICT for self-paced learning and motivation (r = .27, n = 60, p < .05). The correlation coefficient of 0.27 indicates that there is a small linear correlation between ICT utilization and undergraduate students' motivation. It shows as the scores for motivation gradually increases, so will the scores for the utilization of ICT for self-paced learning among the undergraduates and vice versa.

It was found that there was a medium (Cohen, 1988), positive correlation between undergraduates' use of ICT for self-paced learning and mastery (r = .36, n = 60, p < .01). The correlation coefficient of 0.36 indicates that there is a medium linear relationship between both the variables. Thus, as the scores for mastery increase, so do the scores for the utilization of ICT for self-paced learning. Conversely, the mastery skills among the undergraduates decrease when the ICT use decreases.

As for the subjective norm, the results showed that there was a medium (Cohen, 1988), positive correlation with undergraduates' use of ICT for self-paced learning (r = .34, n = 60, p < .01). The correlation coefficient of 0.34 in subjective norm signifies that there is a medium linear association with ICT utilization. As the scores for subjective norm increases, so will the scores for the utilization of ICT for self-paced learning among the undergraduates and vice versa.

Table 5: Pearson Product-Moment Correlation between ICT Utilization and Motivation, Mastery and Subjective Norm for Self-paced Learning among Undergraduates (n=60)

	Motivation	Mastery	Subjective Norm
ICT Utilization (Pearson Correlation)	.274*	.364**	.340**
Sig. (2-tailed)	.034	.004	.008

** Correlation is significant at 0.01 level (2-tailed).
* Correlation is significant at 0.05 level (2-tailed).

The analysis using the Pearson product-moment correlation coefficient in this study produces expected results as supported by earlier studies. The present findings are consistent with findings of previous studies by Shonfeld and Aharoni (2015) as well as Hassanzadeh et al. (2012) which supported the notion that the higher the students' motivation, the greater the probability of them using ICT in their learning process. The present findings are also parallel with studies carried out by Tasir et al. (2012) and Buabeng-Andoh (2012) which found positive connection between mastery and ICT utilization. Furthermore, this study supported the findings by previous researchers (Schepers & Wetzels, 2007)-which suggested that students will be inclined to use ICT if they feel encouraged from people having any association with them such as their family members or friends.

Based on the overall results, each and every hypothesis tested in this study was proven significant. Hence, there is a significant relationship between ICT utilisation and motivation, mastery and subjective norm. This suggests that all the three variables investigated play important roles in persuading the undergraduates to use ICT for self-paced learning. However, mastery and subjective norm reported a stronger relationship with ICT utilization for self-paced learning among the undergraduate students if weighed against motivation which merely revealed a small correlation with ICT usage. This study suggests that mastery followed by subjective norm and motivation needs to be emphasized in tertiary education in order to maximize the impact of ICT on students' self-paced learning.

5. Conclusion

Mastery and subjective norm play more vital roles in determining the use ICT for self-paced learning among the undergraduate students compared to motivation. By knowing the mastery level of ICT among undergraduates by the university practitioners, some measures can be introduced to tackle and overcome it. As a result, it may help to improve and increase the integration of ICT in students' self-paced learning. With the appropriate competency skills and support of certain personnel, it will definitely allow undergraduates to perform better in exploring and acquiring knowledge independently during their self-paced learning process.

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Electricity's in Visible: Thai Middle School Students' Perceptions toward Inquiry-based Science Learning with Visualized Simulation

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Abstract: Computers have been used in education in many ways from the very beginning of their history and computer simulations which contain visualizing features for representing authentic system or phenomenon and it has been recognized as an effective tool for teaching and learning in science. This pilot study investigated an effect of simulation-based inquiry learning on students' perceptions. A total of 18 middle school students in an urban public school at Northeastern region of Thailand were recruited in this study. They interacted with a physical science lesson of simulation-based inquiry learning on light refraction and then they were administered 21 items of 5-points rating scale questionnaire measuring perceived learning (PL), flow (FL), enjoyment (E), perceived ease of use (PEU), perceive of usefulness (PU), and perceive of satisfaction (PS), after the interaction. The result showed that the highest percentage of their perceptions were E, PS, PL, PU, PEU, and FL, respectively. The finding revealed that they prevalently have positive perception towards the simulation-based inquiry learning. However, the simulation-based inquiry learning experience is needed to be improved for the flow of learning and to assisting them to learn with the simulation.

Keywords: Visualization, computer simulation, inquiry, science education, electricity, perception

1. Introduction

In the fast changing world of the early 21st century, digital technologies have become important tool in improving and advancing the practice of science education because of their potential of bringing about change in ways of teaching and learning (Srisawasdi, 2012). Several researchers mentioned, in the past decades, that digital learning environments are important in improving quality of education and preparing new generation workforce to gain essential skills in this 21st century society (Srisawasdi & Panjaburee, 2015; Vreman-de Olde et al. 2013). Those researchers have concluded pedagogic potential of digital technologies that students could improve their learning performance, skills, and attitudes through digital learning activity with digital game, augmented reality, computer simulation, web-based environment, and so on.

In case of computer simulation, shortly called simulation, it is an effective digital technology which assists to visualize abstract, complex, and unobservable phenomena for students learning (Srisawasdi, 2015). The simulations have a number of features that has been recognized as an effective tool for teaching and learning method in science (Blake & Scanlon 2007; Wellington 2004). In science-based education, the physical science area of electricity is complex phenomena and the development of theoretical understanding of the electrical phenomena through practical manipulation could be problematic (Hennessy et al., 2006; Jaakkola & Nurmi, 2008). In the domain of electricity, there is a large body of research evidence that shows that students in all school levels have severe difficulties and misconceptions in their understanding of electric circuits even after formal instruction has taken place (Cohen & Ganiel, 1983; Osborne, 1983; Shipstone, 1984; McDermott & Shaffer, 1992; Shepardson & Moje, 1999). The learning difficulty of electricity was that students were unable to grasp the underlying processes and mechanisms that are invisible in natural systems and important for theoretical understanding (e.g. current flow), and they can only see what is happening on the surface level of the electrical phenomena (Jaakkola & Nurmi, 2008). Therefore, the learning of electricity often requires not only acquisition of new knowledge, but changes in students' deeply entrenched intuitive conceptions as well (Limon & Mason, 2002). According to the aforementioned, the aim of this study was to explore students' perceptions toward simulation-based inquiry learning in electricity, before developing a physical science module of electricity to enhance their learning performance of electricity in secondary school education.

Based on the aforementioned, this study investigates an effect of inquiry-based science learning with visualized simulation on middle school students' perceptions on degree of perceived learning, flow, enjoyment, perceived ease of use, perceive of usefulness, and perceive of satisfaction. The proposed question of this study is "Do the middle school students who learn with simulation-based inquiry learning in electricity show positive perceptions towards the learning experience?".

2. Literature Reviews

2.1 Computer Simulation

Computer simulation or simulation has been used extensively as a visual representation tool to simplify dynamic and theoretical models of real world phenomena or processes (Srisawasdi et al., 2016). Learners can formulate hypotheses about the simulated environment and test the hypotheses by changing parameters in the simulation and observing the way in which the simulation responds to these changes (Lee, Plass, & Homer, 2006). Computer simulations support activities of observation, and reflection help in facilitating the learning of abstract concepts (Chen et al., 2011; Colella, 2000; Bell & Trundle, 2008), that it works with remedial by producing change to student's misconceptions. Computer simulations also improve scientific process skills (Geban, Askar, & Ozkan, 1992), performance of gaining more qualitative knowledge (Staggers & Norcio, 1993), coherent understanding of the concepts (Russell et al. 1997), and advanced mental model (Carlsen & Andre, 1992).

2.2 Simulation-based Inquiry Learning in Science

Computer simulation is currently considered as a cognitive visualized tool for effective support of student learning in science by presenting dynamic theoretical or simplified models of real-world components, phenomena or processes, enlarging students to observe, explore, recreate and receive immediate feedback about real objects, phenomena and processes (Srisawasdi, 2015). Inquiry-based learning with computer simulation is generally seen as a promising area for science ideas. In addition, visualization features of computer simulation facilitated cognitive process of new knowledge and existing knowledge, and improve conceptual understanding in science phenomena (Cook, 2006; Srisawasdi and Sornkhatha, 2014). Moreover, simulation-based inquiry has been becoming a pedagogical approach for enhancing student's conceptual learning in the school science. By interacting with this approach, students practice scientific knowledge of the concept modeled by the simulation (de Jong et al, 2013; Lazonder et al., 2010; Vreman-de Olde et al., 2013; Srisawassdi & Kroothkeaw, 2014).

2.3 Perception toward Learning Technology

Perception toward learning technology is an important factor which refers to the quality of teaching or learning environment. It could be used to indicate the significant of learning and the significance refers to making learning meaningful and important to learners, drawing connections with prior knowledge and contexts outside of the classroom and facilitating multiple ways of knowing cultural perspectives (Xu & Moloney, 2011). Currently, there are many perceptual constructs that researchers employ in educational research and development. Caspi and Blau (2008) mentioned to the perceived learning that it refers to a set of beliefs and feelings one has regarding the learning that has happened. Flow is a perceptual construct that describes a state of deep concentration in which thoughts, intentions, feelings, and all of the senses are focused on the same goal and it happens when learners engage with challenging activities (Csilszentmihalyi, 1990). Enjoyment could be another perceptual construct which happened in the process of interacting with new learning environment and refers to conditional effect of positive reactions toward media and its contents (Fang & Zhao, 2010). Cheng (2014) mentioned that there are another two key factors in determining acceptance of using new technology for a specific purpose. Firstly, perceived ease of use is a person believes degree that using a particular system would be free of effort (Davis, 1989). Another construct is perceived usefulness that is defined as a degree of a person believes that using a particular system would enhance job performance (Fang and Zhao, 2010). In addition, perceived satisfaction is the individual awareness of how well a learning environment supports academic success, and it has been defined as the pleasure or contentment one feels when person performs a required or desired action and experiences the result (Shee & Wang, 2008).

3. The Context of Simulation-based Guided-inquiry Learning in Electricity

To enhance middle school students' scientific understanding and inquiry-based practice of science, a scientific laboratory activity of guided-inquiry learning (Buck et al., 2008) was employed into the context of electricity learning activity in this study. This simulation-based guided-inquiry learning was aimed to afford students' active conceptual learning in the concept of electricity. In this study, a physical science lesson of electric circuit has been designed regarding the simulation-based guided-inquiry learning process that they have never experienced in science classes before. To promote their learning with simulation, an interactive computer-simulated experimentation on "Circuit Construction Kit" obtained from Physics Education Technology (PhET) research group at University of Colorado, Boulder, was used as inquiry tool for the students. Previous researches showed that students who used this simulation demonstrated higher mastery of electrical concepts than students who did not use the simulation, and they were also able to perform better on challenge learning task of electricity (Finkelstein et al. 2005). Figure 1 displays an example of the PhET Circuit Construction Kit simulation.

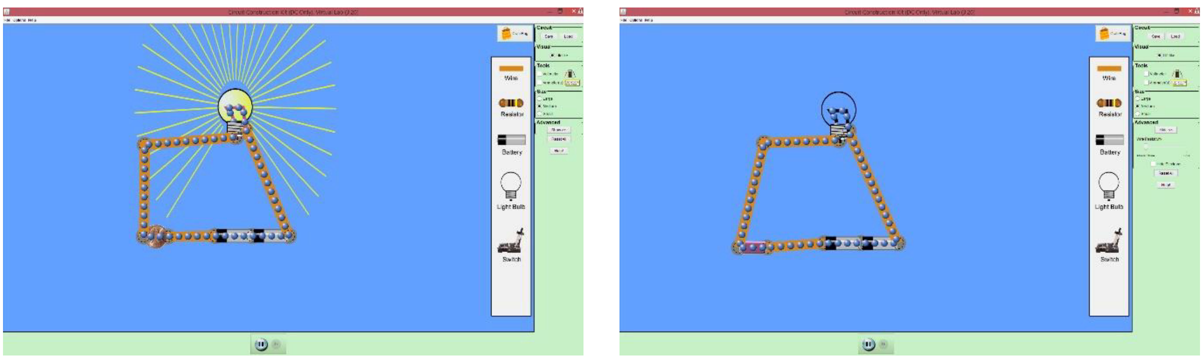

Figure 1. An illustrative interface example of the Circuit Construction Kit simulation by PhET: visualizing scientific concept of conductor (Left) and insulator (Right)

This learning activity begins with an open-ended driving question targeted to alternative conceptions commonly found in conceptual physics of electricity. To assist the process of hypothesis generation addressed the driving question, essential scientific backgrounds or information was provided to the learners. Then, a series of testable hypotheses were presented to them activating their prior experience and supporting a conceptual connection between preconception and the new-coming information. To create a space for their thinking, they were required to design an investigative experiment with simulation; analyzing the data, communicating results of experiment, and drawing a conclusion based on evidence for testing their own selected hypotheses (see Table 1.)

Table 1. Components of simulation-based guided-inquiry learning and examples of learning process

Components of simulation-based guided-inquiry learning	Examples of learning process
Pre-lab	
Question/Problem	Teacher provided an open-ended inquiry question: "What will happen to the light bulb if we replace a penny with a rubber?"
Theory/Background	Teacher induced an open forum discussion about definition of conductor and insulator, and pattern of electron flow in electric circuit.
Lab	
Procedures/Design	Teacher presented a series of experimental hypotheses, the simulation, and then introduces the experimental procedure to students. Moreover, teacher also explained what kinds of the experimental data that the students should collect from the simulation.
Results analysis	After the interacting with simulation, students make a decision to analyze obtained experimental data from their own design and interpret it into results.
Post-lab	
Results communication	Students have to select the way to present, communicate, and discuss the meaning of data and experimental results to others.
Conclusions	Students have to collaboratively make a relationship between each group results and then draw it into a conclusion as the best answer to the provided inquiry question.

4. Methods

In this study, the researchers conducted an exploration to middle school students' perception toward simulation-based guided-inquiry learning pedagogy. The findings of the exploration provided us as a basis in order to design a novel learning experience for physics learning of electricity.

3.1 Participants

This study was conducted with a total of 18 middle school students who are studying in seventh grade and range of age is between 13-14 years in a local public school at the Northeastern region of Thailand. The participants in this study have not experienced yet with the use of computer simulation in science education, but they have good using experience with computer. In addition, they have not been taught on the concepts of electricity in regular physical science class before participating in this study.

3.2 Research Instrument

After interacting with simulation-based guided-inquiry learning in electricity, the students were administered to complete a 21 items of 5-points Likert scale perception questionnaire. The perception questionnaire was divided into six motivational constructs e.g. perceived learning (4 items), flow (5 items), enjoyment (3 items), perceived ease of use (3 items), perceived usefulness (3 items), and perceived satisfaction (3items), and its reliability on each motivational construct were ranging from 0.737 to 0.842. For each item, respondents were assigned to rate how much the respondent agree of five scale, from 1-strongly disagree to 5-strongly agree. The data was analyzed using SPSS 17.0 to depict their perceptions toward the inquiry learning.

3.3 Data Collection and Analysis

In order to explore the middle school students' perceptions, they were administered the 21 items of perception questionnaire for 30 minutes after their interaction with a lesson of simulation-based learning in physics of electrical conductor and insulator for 60 minutes. The perception questionnaire was classified into six perceptual constructs, and total score for all perceptual constructs was 105 points. To analyze their perception scores, mean, standard deviation, and percentage were used to indicate their perceptual status after interacting with the simulation-based physics learning. Figure 2 shows a pilot implementation of simulation-based learning in physics of electricity. Moreover, eight students participated in individual interview for investigating qualitatively their perceptions toward the learning experience.

Figure 2. Students' participation with simulation-based inquiry learning in physical science class

4. Results and Discussion

To evaluate the middle school students' perceptions toward simulation-based inquiry learning in electricity, six perceptual constructs have been used to frame their perceptions. Table 2 shows the calculation of mean, standard deviation (S.D.), and percentage of their perceptions on perceived learning (PL), flow (FL), enjoyment (E), perceived ease of use (PEU), perceive of usefulness (PU), and perceive of satisfaction (PS). The statistical analyses of the data suggested that they prevalently have positive perceptions toward the simulation-based inquiry learning and there were some degree of difference between their perception scores.

Table 2. Mean, standard deviation (S.D.), and percentage of students' perceptions toward simulation-based inquiry learning of electricity

Statistics	**Perceptual Constructs**					
	PL	**FL**	**E**	**PEU**	**PU**	**PS**
Mean	15.06	16.61	11.83	10.72	11.22	11.61
S.D.	2.48	3.03	2.38	1.90	2.41	2.52
%	75.28	66.44	78.89	71.48	74.81	77.41

A graphical representation of the Table 2 is visualized in Figure 3, which allows to see some degree of difference of their perceptions.

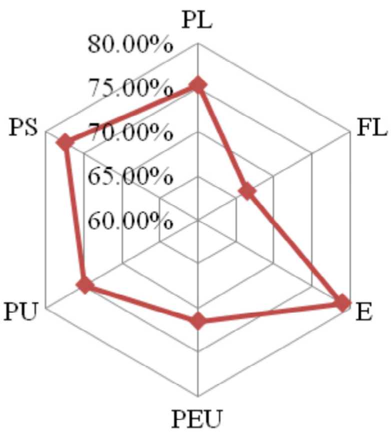

Figure 3. A graphical representation of middle school students' perceptions toward simulation-based inquiry learning of electricity

In Figure 3, the highest percentage of students' perceptions toward simulation-based inquiry learning were enjoyment (E) (78.89%), perceived satisfaction (PS) (77.41%), perceived learning (PL) (75.28%), perceived usefulness (PU) (74.81%), perceived ease of use (PEU) (71.48%), and flow (FL) (66.44%), respectively.

In addition, the qualitative data obtained from individual interview after participating with the simulation-based inquiry learning represented positive degree of their perceptions. The results are presented as synthesized findings addressed each motivational construct. For the flow of learning experience, most of the interviewees mentioned a limited time for performing an experiment with simulation as follow examples:

"We need more time to conduct the experiment with simulation following the provided work sheet. I could not complete the assignment on time."

"There was a limited time for doing experiment. I am still want to do the computer-based experimentation because it is very fun."

For the enjoyment, all of interviewees expressed their positive emotion to the inquiry learning as follow examples:

"Yes, I like it. This activity is a new learning experience that I never have before."

"Yes, I like to do experiment with simulation. It is very fun."

The interviewees suggested that they perceived a new way of learning and they can observe the electricity on screen. This indicated their perception on the motivational construct of perceived learning as shows in the follow examples.

"It is very good. I can see electron flow in electrical circuit and the illumination of light bulbs in computer"

"I can understand how to do experiment on conductor and insulator and I can also see electric current."

For perceived satisfaction, the interviewees revealed their positive perceptions on the learning activity, as display in the following examples.

"I like this class. I like to interact with simulation."

"I like this because I can do experiment by a new way that I never think before."

Moreover, they expressed positive perception on the usefulness of this learning activity that they can learn physical science experiment easier, as display in following examples.

"I can understand electrical conductor and insulator by doing experiment on computer screen."

"I can see electric current and how the light bulb illuminates by the flow of electric current."

Finally, their perceptions on the perceived ease of use towards the inquiry learning activity has been reported by the interviewees as display in following examples.

"Learning with simulation was not difficult. It is fun."

"It seems to be difficult at the first experience. However, I can do experiment via computer by myself after having an interaction with it"

5. Conclusion

This study reported a pilot study investigating an effect of simulation-based inquiry learning of electricity on middle school students' perceptions of perceived learning, flow, enjoyment, perceived ease of use, perceived usefulness, and perceived satisfaction. The findings indicated that they prevalently have positive perceptions after interacting with the simulation-based inquiry learning and the highest percentage of their perceptions were enjoyment, perceived satisfaction, perceived learning, perceived usefulness, perceived ease of use, and flow, respectively. According to the results, the main implications of this study is the redesign of simulation-based inquiry pedagogy for physics teaching of electricity in order to improving middle school students' learning performances both cognitive and affective domain. However, the learning design of simulation-based guided-inquiry approach was perceived positively by students and it could be an effective teaching strategy in physical science course. In future work, the researchers would develop a learning module of the approach and then implement in physical science class for improving the middle school students' learning performances on electricity.

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The Implementation of Blended Learning Instruction by Utilizing WeChat Application

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Abstract: This paper discusses about the implementation of blended learning through the use of WeChat application as a primary communication tool. In this study, ADDIE model which consist of 1) Analysis, 2) Design, 3) Develop, 4) Implement, and 5) Evaluate are the 5 stages followed by the researchers to create blended learning model approach. The results of the study were analyzed using quantitative methods in the form of a quasi-experimental design. The researchers used Non-equivalent Control Group Design which included control group classroom and experimental group classroom. The findings of this study shows that 1) there is no significant difference between control group and experimental group on average of learning outcomes for the blended learning implementation (32 ≈ 31.75), 2) a learning outcome in both classes were observed, and 3) average learning outcomes for the classroom that implement blended learning is higher than the classroom that does not implement blended learning (85.5> 63.25). Besides that, the findings show that the majority of students managed to get the highest value in the blended learning classroom environment. Thus, this situation shows that the distribution of knowledge can be equally distributed to the students with the use of WeChat application.

Keywords: Blended Learning, WeChat, ADDIE.

1. Introduction

Learning methods are always evolving with the development of information technology. Learning in this information and digital age has a tendency towards active learning style, sequential learning style, sensing learning style, and visual learning style (Felder & Soloman, 1993). Active learning style encourage students to be able to conveniently access and search for learning resources independently. Sequential learning styles will facilitate the absorption of the material provided in a coherent, logical sequence, and clearly related to one another. Sensing learning style tends to give clear application and expecting relevance to the every day world. Visual learning style will help students with the use of visual learning tools such as charts, schematic and flow diagram.

Due to the rapid human mobility and the development of new technologies, blended learning has become a new trend in our educational system as an innovation in addressing the learning challenges of the times. Blended learning is a term of combining conventional learning models with the internet-based learning model that is commonly known as e-learning (Uno, 2011).Blended learning requires interactive communication system so that there is enough space for discussion outside the classroom. Communication is also necessary to provide sufficient instructions to the students to do the tasks and give guidance of searching learning resources independently. Besides that, interactive communication system also ideal for providing a delivery service of audio, photos, video and documents. For flexibility to access, we also need to have mobile communication system as a new medium to face with the challenges emerged as the result of rapid human mobility (Lin & Lu, 2011; Karpinski, Kirschner, Ozer, Mellott, & Ochwo, 2013; Goa & Zhang, 2013).

WeChat application is considered as one of mobile-based communication tools that has been used as an alternatives for instructional delivery medium. (Yuan, Chen, & Zhang, 2012; Li, 2013; Bai and Hao, 2013). This application is available for all smartphone platforms including iPhone, Android, Windows Phone and Symbian. WeChat provides opportunities to conduct group discussions (chat) among its users and support the delivery of voice, images, video and text messaging. Theapplication can be downloaded for free and can also be integrated with student' campus life (Chun Mao, 2014).

This research was conducted to investigate on 1) How the implementation of blended learning classroom could be done through the use of WeChat application and 2) What are the learning outcomes from the application of blended learning instruction by using WeChat. For that, the evaluation of the blended learning classroom through the use of WeChat application included these questions: 1) Is there a significant difference in learning outcomes for the classroom that implement blended learning environment?; 2) Is there a significant difference in learning outcomes for the classroom thatdoes not implement blended learning environment? ; and 3) Is there a significant difference in learning outcomes between blended learning classroom environment and non- blended learning classroom environment?

2. The Design of Blended Learning

The blended learning instruction was designed by using the ADDIE model. It is one of the instructional design model that shows the stages of design which is intuitive and easy to learn. ADDIE model can serve as guidelines in building a more effective, dynamic and supportive learning environment. This model has five stages of development, namely 1) Analysis, 2) Design, 3) Develop, 4) Implement, and 5) Evaluate (Sukenda, Falahah, Fabian, & Lathanio, 2013).

2.1 Stage 1: Analysis

Analysis is the first stage that consists of performance analysis and the of student's learning needs analysis. Performance analysis aimed to identify problems in the learning process. From previous researches that have been done, the main problem found is there a lot of students having problem to focus in their lectures.

Student's learning needs analysis aim to identify the solutions that can be used to overcome learning problems found in the performance analysis. Some solutions include the use of communication media to provide an overview of material before the students attending the lectures. This is because some syllabus that have been shared by the instructors may not enough. Media communication used to become a suitable medium for learners because they are easy to use. In this study, media selected is a WeChat application and Weebly blog to share the learning materials so that students can get access to it whenever and wherever they are.

2.2 Stage 2: Design of Learning

Design of learning aims to design a conducive learning experience that is suitable for students for the learning purposes. The learning experience includes descriptions of learning media, learning materials, and kind of evaluations used to evaluate the students. Indicators of successfull learning process can be measured through the achievement of learning objectives created and agreed between the course instructor and the students at the beginning of the term.

The researcher has developed a conceptual model that has been used in study. The process of learning design begins when the course instructor started to plan and organize the course content according to the student's needs. The instructor later upload the learning materials earlier so that students can get access to it in advance. Learners can access the learning materials uploaded online via computers orsmart phones. Figure 1 illustrates the flagship of blended learning model used in this study.

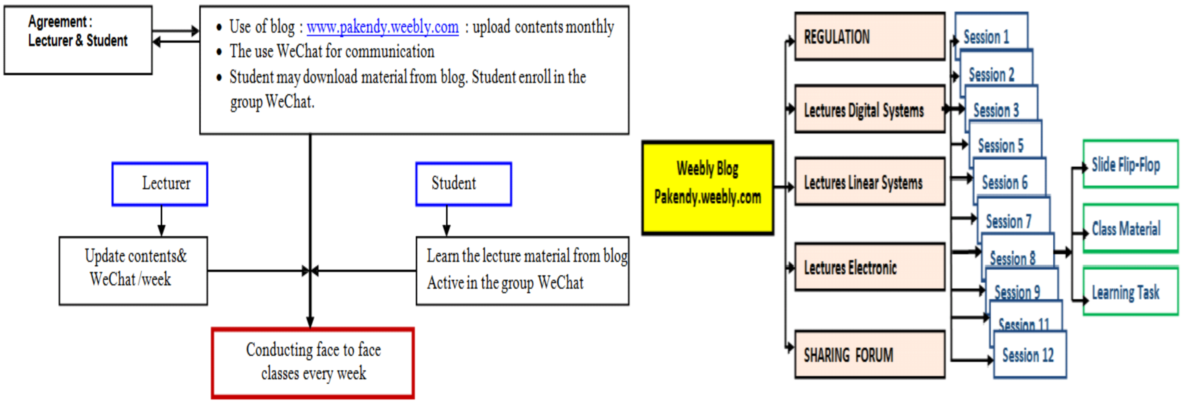

Figure 1. The Design of Learning and the Story Board for Blended Learning Instruction

2.3 Stage 3: Develop

The instructors has developed their own Weebly blog to save all learning materials for the students. During the first meeting between the instructor and the students, general overview on how to access learning materials is conducted to facilitate the learning process. The learning materials are made up from several folders that have subfolders in it. Besides that, the regulations part is also written and should be read by all students. The learning materials of each meeting are presented in the specific folders so that students can have an easy access to the desired materials. For the purpose of guidance and consulting, the instructor has created WeChat group classes so that they can conduct group discussion of each topic whenever necessary.

2.4 Stage 4: Implementation

The next stage is the direct application of blended learning to the learners. The implementation of blended learning classroom has been running for twelve meetings between the course instructor and the students. Generally, the meetings have been successfully implemented in accordance with the agreed plan at the beginning of the term. The WeChat group created is always active and up-to-date with the discussion and consultation. The logs of each WeChat group during each meeting are saved in the instructors' email as well as in the Blog. After each face-to-face meeting was held, the WeChat group will usually become active.

2.5 Stage 5: Evaluation

In the last stage of the ADDIE model, an initial evaluation of the blended learning classroom was obtained through the feedback received from the students. Some students reported that they are having problem to access the learning materials uploaded in the Weebly blog especially from outside the campus area. This situation against the aims of blended learning classroom which can provide easy access to learning materials so that learners can learn anywhere and at anytime without the need to wait for lecturers come into the classroom.

Realizing the problem faced by the students, the instructor has taken an initiative to overcome this problem with the use of classroom-based WeChat group as an interactive communication tools among them. The use of this group is not only limited for the discussion of lectures, but also can be used for distribute learning content in the conventional classroom setting.

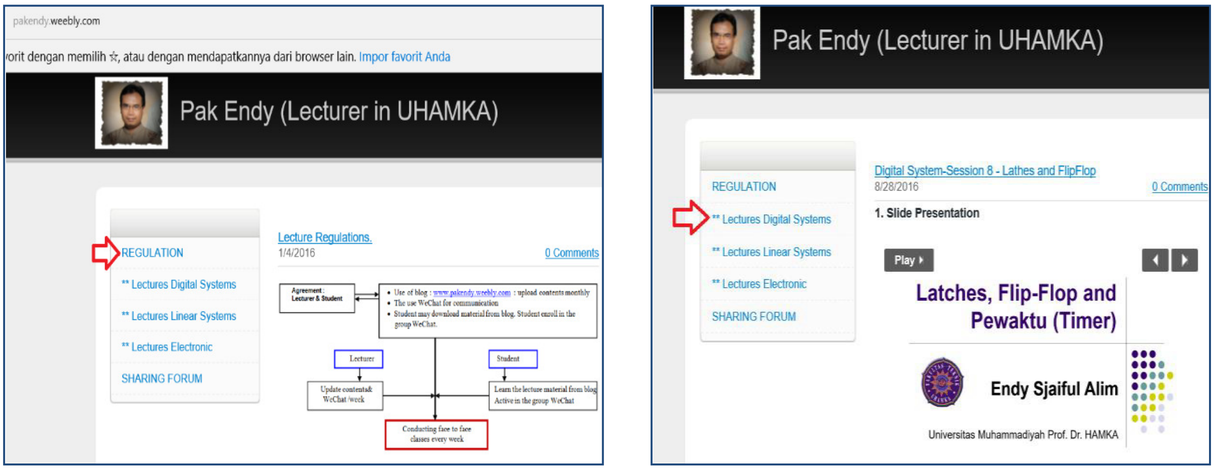

Figure 2. The Interface of the instructor's Weebly blog

Figure 3. The Interface of the WeChat group invitation and uploaded materials on WeChat

3. Research Method

This study was conducted among the students of the Informatics Engineering programme. The research sample for this study was taken from two classes. There were 20 students each for the experimental group classroom and control group classroom. A quantitative method in the form of a Non-equivalent Control Group quasi-experimental design was employed.

The first group, which is the experiment group, consisted of 20 students who received the blended learning instruction. Pre-test was carried out before the implementation of blended learning instruction to determine the existing knowledge on related topics owned by the students. After that, the researcher has carried out post-test on the same topics to determine whether there is any significance different after the students have received the treatment, which was the blended learning instruction.

While for control group classroom, the students did not get any treatment of blended learning instruction. The same approach applied to experimental group classroom has been taken to this control group whereby the researchers has conducted pre-test before conventional learning begins to determine the existing knowledge on related topics owneds by the students. Post-test was also conducted to determine whether there is any significance different after the students received the treatment of conventional learning environment.

In this study, the data analyzed consisted of primary data and supporting data. Primary data were gathered from the student's test data while supporting data collected from the interviews conducted with the faculty and students in response to the implementation of blended learning instruction. The data analysis technique used by the researcher is non-parametric statistical test developed by Mann Whitney and Wicoxon.

4. Results

4.1 Control Group Classroom

Pre-test results in control group classroom demonstrates that students has an average value of 32 with a standard deviation of 3.77. The lowest scoreof pre-test results obtainedis 25 from two students while the highest value for pre-test achieved is 40 from one student . Pre-test scores attained by most students in the control group is 30 which come from nine students.

Post-test results in the control group classroom demonstrate the result of students after getting the treatment of conventional learning. Post-test in the control group has an average value of 63.25 with a standard deviation of 7.83. The lowest score obtained for post-test result is 50 from two students and highest score for post-test is 80 achieved by one student. Post-test scores attained by most students in the control group is 70 which come from six students.

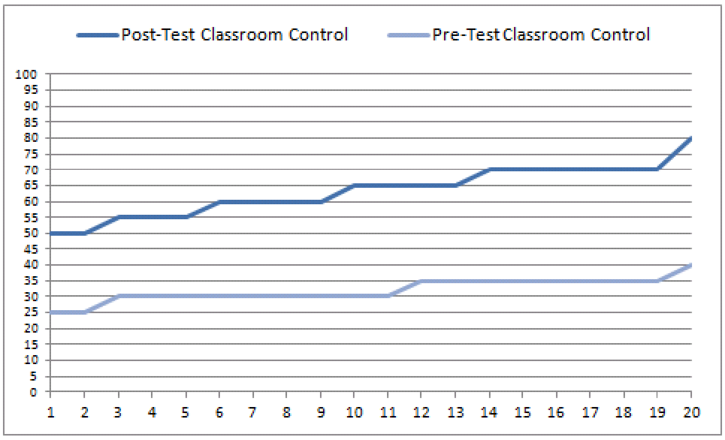

Figure 4. Comparison between Pre-Test and Post-Test in the Control Group Classroom

4.2 Experimental Group Classroom

Pre-test results in the experimental group classroom shows that existing knowledge possessed by the students have an average value of 31.75 with a standard deviation of 4.67. The lowest score obtained for pre-test is 20 from one student while the highest score for pre-test in this experimental group is 35 from 12 students. Pre-test scores achieved by most students in the experimental group is 35 which come from twelve students.

Post-test results in the experimental group classroom demonstrate whether there is any significant different in term of student's achievement after received the treatment of blended learning environment. The average value for post-test in an experimental group classroom can be considered high which is at value of 85.5 with a standard deviation of 7.59. The lowest score for post-test is 70 come from three students in this experimental group while the highest score for post-test is 90 that came form fourteen students.

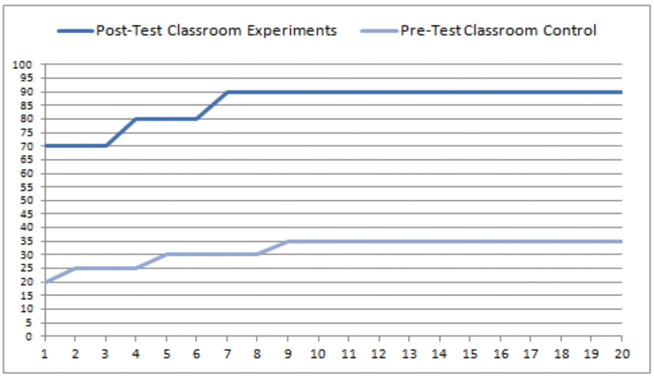

Figure 5. Comparison between Pre-Test and Post-Test in the Experimental Group Classroom Experiment

4.3 Discussion

The average score for pre-test in the control group classroom and experimental group classroom is almost the same. The lowest score for pre-test in the control group is higher than the lowest score in the experimental group (25 > 20). Similarly, the highest value for pre-test in the control group classroom is higher than the highest score in the experimental class (40 > 35). This indicates that even the average value for both group is similar, but the control group classroom has a great potential advantage compared to the experimental group classroom.

Table 1: Comparison of the results between pre-test and post-test for both groups

VARIABLE CLASSROOM	PRE TEST			POST TEST		
	Mean	Low Score	High Score	Mean	Low Score	High Score
Control	32	25	40	63.25	50	80
Experiment	31.75	20	35	85.5	70	90

The lowest score for post-test in the experimental group classroom is higher than the control group classroom (70 > 50). Similarly, the highest score for posttest in the experimental group classroom is higher than the control group classroom (90 > 80). From the data analysis conducted, the researcher found that there are significance different in learning outcomes in the experimental group classroom compared with control group classroom. This is the evidences that the implementation of blended learning in the classroom could help students to accomplish the desired learning outcomes much better compared with the conventional classroom.

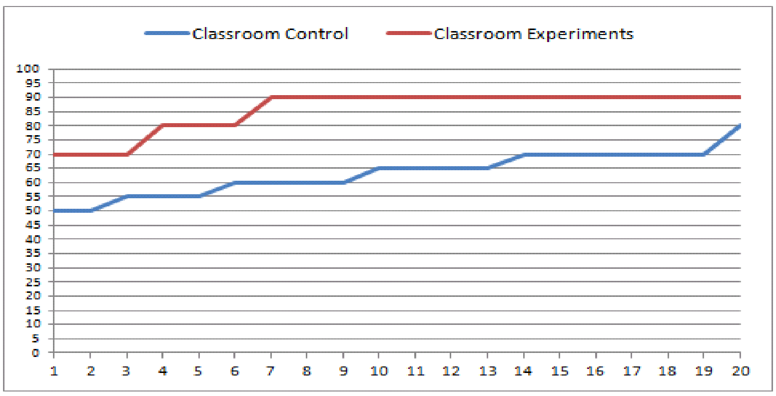

Figure 6. Comparison of Post-Test Scores between the Experimental Classroom and the Control Classroom

From the data analysis, the four hypothesis testing has proven that: 1) There are no significant differences in term of pre-test result between control group and experimental group, 2) There are significant difference (increase) in the conventional classroom learning outcomes (control group) but the difference are relatively small, 3) There are significant difference (increase) in term of learning outcomes in the experimental group classroom, and 4) There are significant difference in learning outcome achieved between blended learning classroom (experimental group) and conventional classroom (control group).

The results of detailed observations also shown that there is no decline in value between pre-test and post-test in the classroom that implement blended learning. It can be concluded that all students in the classroom have improved their knowledge when blended learning take place in their environment. Besides that, the researcher also suggest that the success rate ofstudent's achievement are distributed evenly because there are 14 students in the classroom who are able to achieve the high score.

5. Conclusion

The conclusion that can be drawn from this research is the implementation of blended learning through the use of WeChat application had successfully improve the student's learning outcomes. Moreover, the result also shows that the distribution of information and knowledge can be distributed evenly among the students in the classroom. The use of instructional media is highly dependent on learning resources. Because of that, more research on the development of teaching methods needs to be done since most students can easily influence by the use of technologies in their learning process. The researcher has selected WeChat application in this study because it has many advantages including have high speed and can easily distribute the information. Besides that, WeChat application also provides flexible learning environment where students can have the freedom to study at their own time. Instructors of blended learning classroom must carefully select all the learning materials provided to students so that the educational value remains dominant in the formal education setting.

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Data Collection in Open Ended Learning Environment for Learning Analytics

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Abstract: As the development and use of Open-Ended Learning Environments (OELEs) continues to increase, supporting students' learning in these environments with Intelligent Tutoring is rapidly becoming an important area of research. Many existing learning environments guide students in step-by-step processes to reach their learning goal; consequently, data preprocessing is well defined. In OELEs, in contrast, students may achieve task goals through multiple pathways, and there exist multiple ways to assess performance. We present a simulation OELE designed to teach students decision-making in a complex problem solving task. To provide Intelligent Tutoring Support, we are required to track performance along several dimensions. We present our approach to extract data for performance assessments that can be leveraged to provide Intelligent Tutoring Support. We generalize our approach and present guidelines applicable for similar OELEs.

Keywords: Learning Analytics, Open Ended Learning Environment, Data Processing, Data collection.

1. Introduction

Adaptive learning environments or Intelligent Tutoring Systems (ITS) tune learning content to learners' needs and preferences, which are identified from their interactions with the system recorded in log files. To help learners to achieve their learning goals, data from log files are analyzed, for the purpose of modeling the learner and provide support targeted as specific student needs..

Most adaptive learning system help students by supporting their problem solving step-by-step. Such forms of scaffolding are possible in domain with well-defined learning goals geometry or addition. Examples of popular adaptive learning systems are Cognitive Tutor[1], or Wayang outpost[2]. Recent work, however, has begun to develop adaptive learning systems to support learners through metacognitive tutoring in complex problem solving, learning processes that many education researchers consider an essential element for education (ISTE 2007; UKEd 2013). Metacognitive skills are critical processes involving the structuring of the solution process, searching for information, interpreting it, exploring alternate solution paths, and constructing and testing potential solutions (Brophy 2013 & Winne 2010). A recent development in supporting learning of metacognitive skills are open-ended learning environments (OELE) (e.g. Biswas et al. 2016). In general, OELEs provide students with a complex problem to solve, and with tools and resources that support the problem-solving task (Jonassen et al. 2002). Examples of OELE are MetaTutor (Azevedo et al., 2012), Betty's Brain (Leelawong and Biswas, 2008), and Crystal Island (Jonathan et al., 2011). OELEs are distinct from adaptive learning systems in that students benefit in terms of the development of metacognitive skills that go beyond the acquisition of domain-specific cognitive skills (Hannafin et al., 1994).

[1] http://www.carnegielearning.com/learning-solutions/software/cognitive-tutor/
[2] http://wayangoutpost.com/

Developing automated support for learning metacognitive skills represents a novel challenge to developers of adaptive learning systems. In many adaptive learning systems the task goals and the paths through which the goals can be achieved are well defined. In OELEs, in contrast, students can achieve task goals through multiple pathways. Students may, for example, chose paths that involve sacrificing short-term advantages for long-term benefits. Hence, the students' interaction generates huge log data compared to traditional adaptive learning systems, and opens the question of which data to extract from log records to be used directly as performance measures, or as the basis for making inferences on performance.

In this paper we present the approach we developed to track performance in an OELE called *UrbanSim*, a turn-based simulation environment, where a counterinsurgency scenario evolves in an urban environment. In *UrbanSim,* students make moves to achieve the goals of the mission that is primarily defined with regard as reducing insurgent activities and creating a viable economic, social, and political environment for the local population. At each turn, students select a set of operations to conduct in different regions of the operating theater, and then observe and analyze their effects. *UrbanSim* simulates a complex social and political environment where operations can have multiple short-and long-term effects. Effective problem solving in this complex domain requires several skills, such as conducting operations in line with prescribed generic strategies, matching operations to the conditions of individual regions, selecting operations in line with general operational guidelines, and advancing the key goal of counterinsurgency operations: to gain the support of the local population. We take on the challenge of tracking student performance by analyzing the actions students take in the environment and the effects generated by these actions. We follow the sequence of turns that students make, compare how they adjust their turns to analyze the situations that occur as the game progresses, and how well they align their actions to achieve pre-defined goals.

UrbanSim includes logging processes that create records of the players' action as well as almost all of the data generated in the simulation, i.e., the game state. Our work evolved as our understanding of the simulation and the domain improved. With this understanding we were able to develop performance indicators that allow us to assess students. A critical task of this evolving work was to identify those log data that are the basis for automated performance assessment. This paper describes in detail the process through which the understanding of a domain and of a simulation can be the basis to select records of student activities in OELEs for performance assessment.

2. Approach

Tracking performance in UrbanSim is a non-trivial task because the key goal of counterinsurgency – to increase the percentage of the population supporting a legitimate government – can be achieved along several paths and requires several competencies. As in many other instances of complex problem solving, UrbanSim requires competencies that in their own right are insufficient to advance towards the goal state, but need to be combined to achieve an overall goal. Key to our approach is to specify several sub-components of what is meant by performance in *UrbanSim*. Students may excel in one skill but may show sub-optimal performance in another; thus, by defining performance along several dimensions, a basis to provide targeted support for students' learning is available.

Specifying sub-components of performance tells us which data to extract from log records, as well as how to pre-process log data so that inferences can be made. Some measures require the aggregation of log data, while others function as the basis for inferences toward more general performance measures. We exemplify our approach now by describing in detail how performance is measured in counterinsurgency/UrbanSim.

3. Counterinsurgency and the UrbanSim Open-Ended Learning Environment

Counterinsurgency is the comprehensive civilian and military effort designed to simultaneously defeat and contain insurgencies and addresses their root causes. Legitimacy – fostering effective governance by a legitimate government – is its main objective. Counterinsurgency operations, therefore, aim to defeat insurgents while also working with local political and religious leaders to increase population support, separate (to protect) the population from insurgents, and ultimately install Host Nation (HN) governance that promotes self-sufficiency and economic growth.

In *UrbanSim* (McAlinden et al., 2008), shown in the Figure 1, users assume command of a counterinsurgency operation in a fictional Middle-Eastern country. Users have access to information about the area of operation, including intelligence reports on individuals and groups; variables representing the operational environment; indicators of how well they are doing in relation to the Superior's commands (Lines of Effort); and the Population Support meter. When students select counterinsurgency operations to conduct, they must take into consideration the following constraints: the state of the urban area, the values of the Lines of Effort (i.e. how well they are progressing with respect to the Superiors' directives), the state of the operational environments in individual regions where the operations are conducted (PMESII) and the values of the Population Support meter.

Further, students need to follow a counterinsurgency approach called **C**lear, **H**old, **B**uild (CHB). CHB is a broad strategy with three distinct phases. First, military forces *clear* an area of insurgents. Second, they focus on *holding* the cleared area and preventing further insurgent infiltration. Third, they focus on building up the area's government, police forces, and infrastructure such that the local population is able to safeguard the area independently, develop local governance, and focus on economic improvement.

Students conduct their operations by assigning operations as Operation Orders to available units in the Synch Matrix (the Figure 1, lower left). Once committed, the simulation executes the orders and models its effect on and the key values. During this phase, *additional* events caused by other agents (e.g., the insurgents, the local population) can occur (e.g., the detonation of an IED) that are displayed at the beginning of a new turn. The combination of all activities may result in net changes to the local population support and LOE scores.

At each turn, students are informed about the effect of operations committed in the previous turn. Operations typically affect LOE, PMESII and Population Support values, both of which can be inspected on the map or by activating information pages.

Figure 2. *UrbanSim*: city map; Synch Matrix (lower left), LOE values (lower right); SITREPs, SIGACTs (left border), Intel Officers S2, S3 (right border)

4. Tracking Performance in UrbanSim

To track performance and make inferences on students' strategies, we distinguish between 1) performance values (e.g. scores on the Lines of Effort, the percentages of Population Support) and game state variables (e.g. number of turns completed), which we leverage to infer 2) more general structures directing behavior. These structures represent domain-specific strategies, such as implementations of aspects of the Clear-Hold-Build doctrine.

An example of an instantiation of a strategy is detecting whether students conduct operations in line with the CHB strategy: by analyzing values of all regions over a few turns, we obtain the number of regions in the Clear, Hold or Build phase, thus measuring students' ability to conduct operations aligned with CHB: if the CHB strategy is conducted appropriately, the number of regions in the Clear phase will decrease, while the number of regions in the Hold and Build phase will increase When CHB is detected as a strategy, inferences on students' analysis and interpretation of region values can be made.

At each turn, we leverage log data to detect students' performance and strategies by computing the values of the metrics presented now.

<u>CHB Count:</u> Once students have obtained and analyzed information, they are expected to conduct operations in line with the CHB strategy. PMESII analyses, and especially the M value (representing the degree of military control over a region), play a particularly important role in executing the strategy. We detect whether students' follow the CHB strategy by counting the number of regions in the Clear, Hold or Build phase at each turn.

<u>Lines of Effort:</u> the trend of the LOEs at each turn is tracked to obtain a measure of students' adherence to the Superior's command.

<u>Population Support:</u> Population Support is logged as *for*, *against*, and *neutral* percentages, adding up to 100%. It is the key measure to assess student performance. *UrbanSim* scores performance at the end of the game with the formula: (*For* * 2) + *Neutral* – *Against*.

<u>PMESII Match:</u> the measure represents students' ability to select the most effective operations, given the PMESII values of a region. The measure is the sum of Match values for all operations in a turn. Match of an individual operation is calculated by summing its effect on 3 PMESII values (Military, Information, and Social) and identifying the most effective operation. Match is the difference between the sum of effects of the conducted operation, and the sum of effects of the most effective operation. The calculation of the effect is weighted by the magnitude of PMESII values.

<u>Mission Goals:</u> The Mission Description of the scenario explicitly requires the achievement of three specific mission goals: 1) increase the support of the town's Mayor; 2) prevent the influx of insurgents from the Mountains in the North, hence secure the Northern area and 3) repair the airport to facilitate the movement of personnel and goods. The measure is the sum of the number of operations at each turn conducted to further the specific mission goals.

5. Discussion and Conclusion

In this paper, we have described the development of performance measures in a complex simulation environment. Our approach consists in developing detailed definitions of what is meant by performance in solving a complex problem. This necessarily to develop an understanding of the domain and the multiple ways in which problems in the domain may be solved. Defining performance and identifying approaches to solving the problem gives directions in identifying which log data to analyze. We have shown examples of performance measures that 1) require the aggregation of log data (e.g. 'PMESII Match'), or 2) require including general game state data (e.g. number of turns completed) or 3) can be computed with reference to specified problem solving goals ('Mission Goals'). We believe that our approach is generalizable to other environments where students learn by solving complex problem; and that the approach will be a useful basis for other researchers to guide the analysis of log data in OELEs.

Acknowledgements

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The Principle of Data Protection by Design and Default as a lever for bringing Pedagogy into the Discourse on Learning Analytics

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Abstract: Bringing pedagogy and learner agency to the forefront of the design of learning analytics systems is the central concern of this paper. With the new European data protection regulations now in place we consider their potential to influence systems design from this perspective. In particular, the principles of Data Protection by Design and Date Protection by Default are explored to see if conforming to these principles will bring the focus of learning analytics systems back to the learner. The emerging understanding leads to a model of the relationship between data minimisation and utility within contexts of data sharing, which allows constructing scenarios that highlight how pedagogy and data protection are related and could inform the design of LA solutions. Our analysis suggests that the new data protection regulations will influence development and implementation of learning analytics systems and that the pedagogical grounding of these systems will be strengthened.

Keywords: Learning analytics, Data protection, Data protection by design, Data protection by default, Learning analytics systems design, Privacy by design

1. Introduction

In translating learning into numbers there is a risk to throw the baby out with the bathwater: The learning analytics (LA) dashboards show the answers, but what were the pedagogical questions that initiated the data collection and measuring in there first place? And how do we reconnect with the learner whose agency is essential for even start thinking of objectifying the learning trajectories in a learning grap

In a pedagogically grounded LA design there is a need to identify requirements that put learner agency and pedagogical questions to the forefront of system development (Friend Wise and Williamson Schaffer, 2015). After the metrics for the data collection are decided upon it is easy to lose track of the individual when designing how data should be collected, stored and processed, what models should be used for analysis, and how results should be visualised. When feeding back the results to the learners the individual may be seen merely as a member of class described with traffic light colours (e.g., red = at risk) unless there are requirements requiring tools for a balanced conversation between learner and teacher, or learner and institution. Data protection regulations might be an example of such a requirement that could bring the focus in LA systems design back to the learner. In this paper we will explore the requirements coming out of the recent revision of the European Data Protection Regulations. We ask if these regulations could be used as a lever to bring pedagogy into the LA systems engineering discourse.

Privacy is posed as a potential show-stopper for LA (Hoel and Chen, 2016a). A review of current issues and solutions by the LACE project (Griffiths et al., 2016) gives examples of projects that have been stopped or given a red flag because of concerns over privacy and data protection. Some developers have chosen to define privacy out of scope, like the groups that have specified how activity streams should be expressed, exchanged and stored (ADL, 2015; IMS Global, 2015). This may be a risky approach. If issues of ethics and privacy are not given sufficient consideration new solutions could easily backfire when questions are asked if they can be trusted.

In May 2016 a four year European Union revision process of the 1995 Data Protection Directive (95/46/EC) was concluded with the publishing of the General Data Protection Regulation (GDPR). Now the EU/EEA countries have until May 2018 to transpose these regulations into their national law. The introduction of the new GDPR coincides with an interesting and decisive moment in time for the emergent field of LA now soon ready to move out of the research labs into large-scale adoption. When scaling up LA architectures identity management, data storage, anonymisation and peudonymisation, etc. need to be developed and put in place. The GDPR will no doubt influence this development. In particular, the principles of "data protection by design" and "data protection by default" (DPbD&D) now written into the regulations may prove to be influential. However, these principles need to be further specified, and there is a need to understand how DPbD&D may change how we design LA tools and architectures.

A key aim of this paper is to explore the background of the DPbD&D principles and explore their possible impact in the context of LA. This context is obviously more narrow than the scope area of GPDR, and given the particular characteristics of learning, education and training (LET) the principles guiding this regulation might have unmapped effects on learning technology design.

2. Data Protection by Design and by Default in the EU Regulation

The GDPR defines DPbD&D as one of several general data protection principles, i.e., purpose limitation, data minimisation, limited storage periods, data quality, legal basis for processing, processing of special categories of personal data, measures to ensure data security, and the requirements in respect of onward transfers to bodies not bound by the binding corporate rules (EU, 2016, Article 47, d). However, the regulation does not give a clear definition of DPbD&D. Article 25 (EU, 2016) is dedicated to the principle (stated in the title). The first paragraph sets out the challenges a data processing implementer is facing (state of the art; cost, nature, scope, context and purposes of processing, etc.) and points to certain measures to take, e.g., pseudonymisation. The second paragraph reminds the data controller of his/her duties of implementing appropriate technical and organisational measures; and the third paragraph notes that the requirements set out in the previous paragraphs may be demonstrated using an approved certification mechanism.

In order to understand the underpinnings of the DPbD&D principle one needs to search for its roots in the discourse leading up to the GDPR. DPbD&D is premised on Privacy by Design (PbD), a term first coined by the Canadian information and privacy commissioner of Ontario, Ann Cavoukian (2012). In 2009, PbD was introduced by the Article 29 Working Party (a European Advisory Body set up by the EC) as an additional principle to innovate the data protection framework when the European Commission launched its consultation (Article 29 Working Party, 2009).

Privacy by Design is based on 7 "foundational principles" formulated by Cavoukian (2012): 1) Proactive not reactive – preventative not remedial, 2) Privacy as the default setting, 3) Privacy embedded into design, 4) Full functionality – positive-sum, not zero-sum, 5) End-to-end security – full lifecycle protection, 6) Visibility and transparency – keep it open, and 7) Respect for user privacy – keep it user-centric.

When discussed by Article 29 Working Party, the idea of embedding privacy "already at the planning stage of information-technological procedures and systems" (Article 29 Working Party, 2009) is highlighted. Implementing PbD would require evaluation of several, concrete aspects or objectives, the advisory body explains, in particular, when making decisions about the design of a processing system, its acquisition and the running of such a system. The aspects or objectives mentioned are

- *Data Minimization*: data processing systems are to be designed and selected in accordance with the aim of collecting, processing or using no personal data at all or as few personal data as possible.
- *Controllability*: an IT system should provide the data subjects with effective means of control concerning their personal data. The possibilities regarding consent and objection should be supported by technological means.
- *Transparency*: both developers and operators of IT systems have to ensure that the data subjects are sufficiently informed about the means of operation of the systems. Electronic access / information should be enabled.

- *User Friendly Systems*: privacy related functions and facilities should be user friendly, i.e. they should provide sufficient help and simple interfaces to be used also by less experienced users.
- *Data Confidentiality*: it is necessary to design and secure IT systems in a way that only authorised entities have access to personal data.
- *Data Quality*: data controllers have to support data quality by technical means. Relevant data should be accessible if needed for lawful purposes.
- *Use Limitation*: IT systems which can be used for different purposes or are run in a multi-user environment (i.e. virtually connected systems, such as data warehouses, cloud computing, digital identifiers) have to guarantee that data and processes serving different tasks or purposes can be segregated from each other in a secure way. (Article 29 Working Party, 2009)

In 2012, the same year the EU put forward its data protection reform "to make Europe fit for the digital age" (Reform of EU data protection rules, nd), Sarah Spiekermann published a viewpoint article stating,

> "heralded by regulators, Privacy by Design holds the promise to solve the digital world's privacy problems. But there are immense challenges, including management commitment and step-by-step methods to integrate privacy into systems" (Spiekermann, 2012).

Spiekermann welcomed that privacy impact assessments were to become mandatory in the new European data protection legislation.

> "However, they must be accompanied by a clear set of criteria for judging their quality as well as sanctions for noncompliance. (..) Most important, [they] need to be made mandatory for the designers of new technologies—the IBMs and SAPs of the world—and not just data controllers or processors who often get system designs off the shelf without a say" (Spiekermann, 2012).

The GDPR holds no criteria, not even a definition of DPbD&D, but nevertheless, states "the principles of data protection by design and by default should also be taken into consideration in the context of public tenders" (EU, 2016, Recital 78). In order to act upon the principles, a definition is needed. Spiekermann defines PdD as "an engineering *and* strategic management approach that commits to selectively and sustainably minimize information systems' privacy risks through technical and governance controls" (Spiekermann, 2012).

When it comes to LET technologies and learning analytics it is important to address the engineering challenges, as we have described the field as open for innovation (Hoel and Chen, 2016b). This was acknowledged by Spiekermann in 2012 when she observed that privacy scholars still put too much focus on information practices only (such as Web site privacy policies). "Instead, they should further investigate how to build systems in client-centric ways that maximize user control and minimize network or service provider involvement" (Spiekermann, 2012).

The remainder of this paper is dedicated to exploring how the principles of PbD and DPbD&D could be harnessed to develop more privacy proof and more pedagogically grounded LA applications. Firstly, we search the literature for examples of privacy engineering; secondly, we use a simple LA process lifecycle model to scaffold a discussion what impact PbD engineering will have for the LA domain. Finally, we discuss to which extent this direction of design will impact on the pedagogical grounding of the development of LA systems.

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3. Related Work

It seems that the momentum caused by the EU revision of the data protection framework and other recent developments (e.g., the Edvard Snowdon case) has created an interest in defining *privacy engineering* as a discipline (Finneran Dennedy, Fox, and Finneran, 2014; Oliver, 2014; Spiekermann and Cranor, 2009), building on the thesis "that privacy will be an integral part of the next wave in the technology revolution" (Finneran Dennedy, Fox, and Finneran, 2014). Spiekermann and Cranor (2009) distinguished two approaches for building privacy-friendly systems, "privacy-by-policy" and "privacy-by-architecture". The former approach focuses on the implementation of the notice and choice principles of fair communications, while the latter minimises the collection of identifiable personal data and emphasising anonymisation and client-side data storage and processing. These authors argue that "notice and choice are needed to implement "privacy-by-policy" only where “privacy-by-architecture” cannot be implemented" (Spiekermann and Cranor, 2009). The question is how far the PbD principles goes in supporting the *privacy-by-architecture* approach?

Gürses, Troncoso and Diaz find PbD to be vague and leaving many open questions about their application when engineering systems (Gürses, Troncoso, and Diaz, 2011). They even see the definition given by Cavoukian as recursive ("privacy by design means apply privacy by design"), communicating "to the reader that something needs to be done about privacy from the beginning of systems development, but it is not clear what exactly this privacy matter is nor how it can be translated into design" (Gürses, Troncoso, and Diaz, 2011). Gürses et al. claim that PbD can be reduced to "a series of symbolic activities to assure consumers' confidence, as well as the free flow of information in the marketplace" (Gürses, Troncoso, and Diaz, 2011). Their solution for applying PbD to systems is to include *data minimisation* as the foundational principle because of "the risk inherent in the digital format" (Gürses, Troncoso, and Diaz, 2011).

Discussing *Privacy and Data Protection by Design – from policy to engineering* the EU Agency for Network and Information Security (ENISA) observed, "deploying privacy by design methods might limit the utility of the resulting system. Hence the designer needs to find a trade-off between privacy and utility w.r.t. a certain metric" (Danezis et al., 2014). The example ENISA uses is privacy-friendly statistical databases. Using the PbD principle of prior privacy gives anonymised data with little analytical utility. Even if this approach is popular among the computer science academic community, ENISA claims it is seldom used. What is used, is posterior privacy using utility preservation features and different methods of risk assessment. It is no surprise that ENISA then concludes "anonymisation is a key challenge for the next decade because this tension between privacy and utility will be at the core of the development of the big data business" (Danezis et al., 2014).

One recommendation of ENISA is that standardisation bodies need to include privacy considerations in the standardisation process. In 2014, OASIS (Organization for the Advancement of Structured Information Standards) published a standard on Privacy by Design Documentation for Software Engineers by a committee chaired by Ann Cavoukian (OASIS, 2014). The specification translates the seven PbD principles to conformance requirements for documentation, "to demonstrate that privacy was considered at each stage of the software development life cycle" (OASIS, 2014). Even if the specification clarifies the PbD principles in a number of sub-principles that are mapped to documentation requirements, it is a way to go to derive succinct engineering principles. However, it is specified that "purposes must be specific and limited, and be amenable to engineering controls", and that the documentation "shall clearly record the purposes for collection and processing, including retention of personal data". Of the engineering controls, it is required that "strict limits should be placed on each phase of data processing lifecycle (..) including limiting collection" (OASIS, 2014).

4. Directions for design of LA systems

In an exploration of the implications of the European data protection regulations for learning analytics design Hoel and Chen (2016c) used the LA process lifecycle model (Figure 1) of ISO/IEC JTC 1/SC36 as a template for discussing how GDPR requirement would influence systems development. The conclusion was that GDPR had specific requirements that would influence each process (possibly with the exception of Visualisation).

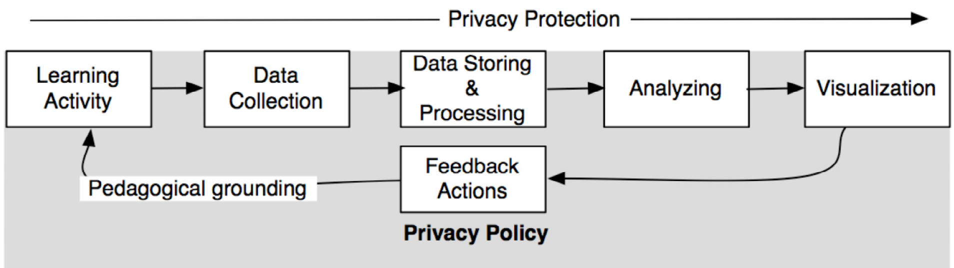

Figure 1. Learning analytics processes as defined in forthcoming ISO/IEC 20748-1 standard with highlighting of processes that need pedagogical grounding.

Table 1 gives a summary of the findings of Hoel and Chen (2016c), where provisions of the GDPR are mapped to each LA process (column 2). Data protection by design and default is an all-encompassing requirement that influences all the LA subprocesses. If this requirement should be more than symbolic statements (Hoel and Chen, 2016c) DPbD&D needs to be translated into engineering principles and design actions guided by the GDPR requirements identified in Table 1. Data protection, however, is not an end in itself; it is a means to make a pedagogical tool safer to use. In designing the tool one therefore needs to know where pedagogy comes into play in a LA process cycle. In the 3rd column of Table 1 we have explored pedagogical requirements related to each LA subprocess.

Table 1. Summary of analysis of GDPR and pedagogical requirements related to LA processes

LA Processes	*GDPR Requirements*	*Pedagogical Requirements*
Learning Activity	Give information of processing operation and purpose	What is the pedagogical scope of the LA process? Choose metrics that give answers to the pedagogical questions initiating the LA process.
Data Collection	Affirmative action of consent to data collection	Support of learner agency
Data Storing & Processing	Access to, and rectification or erasure of personal data. Exercise the right to be forgotten. Pseudonymisation and risk assessment	Support of learner agency
Analysing	Meaningful information about the logic involved. Information of profiling, e.g., predictive modeling	Support of learner agency and understanding of learning context
Visualising	General requirements about transparency and communication	Selection of salient issues for pedagogical intervention
Feedback Actions	Information about the significance and envisaged consequences of data processing	Pedagogical intervention, relating actions to pedagogical goals

As indicated in Figure 1 the pedagogical grounding of a LA process is centered around selecting which Learning Activities to analyse and deciding about Feedback Actions. However, the other processes are not pedagogical neutral. If Data Collection, Data Storing and Processing, and Analysis are designed well, they could contribute to build learner agency and a better understanding how data are used in a modern society.

In defining a set of *by default* principles systems development should be built upon we see that pedagogical grounding fits well DPbD&D. One needs to specify which questions to address in LA; and this aligns well with purpose specificity and data minimisation, two concerns identified in the review of related work (Section 3) as key principles of DPbD&D. To further unpack the relationships between these concepts we have developed a model describing the relationship between data minimisation and utility in different contexts of data sharing (Figure 2).

With a un-reduced dataset the utility of analysis would be high according the model described in Figure 2. To make a design decision on the trade-off between data minimisation and utility, it is, in particular in the design of LA systems, useful to bring in the concept of a *data sharing context*. This context may be broad or narrow, depending on the size and characteristics of the group having access to data. As an example, when running a LA application for a limited session in a school class the need for data minimisation is low (the personal information is already known to the group), and context of sharing is narrow (the information stays in the group), and one can expect high utility as one can use an unreduced dataset.

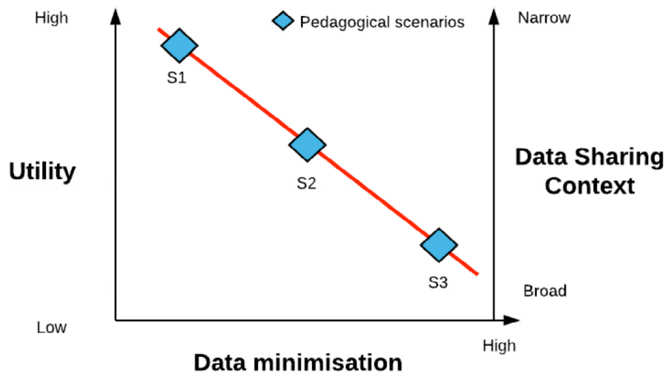

Figure 2. Relationship between data minimisation and utility within contexts of data sharing

What do the principles of data protection by design and default imply when widening the data sharing context? For example, when moving the analytical focus from the class, to the school, to the district, and further to the ministry of education, – how do we decide about the trade-offs between privacy and utility – with respect to what metrics? For LA design the answers to these questions do not lie in advanced anonymisation techniques – at least not as a starting point. Where we would suggest to start is to go back to the pedagogical grounding of the different analytical operations.

This approach is illustrated by some scenarios that have different characteristics according to the model described in Figure 2.

Scenario 1. School class with extensive data sharing: This scenario targets primary education, which is organised in school classes where the students are known to each other and the data comes from systems controlled by the school authority (e.g., learning management systems, learning content systems, subject related tools for math and physics education, etc.).

Aims of LA usage: Allowing a variety of tools to collect rich sets of data.

Pedagogical grounding: Learner agency, with the goal of empowering the student being able to manage own data and understand the benefits and risk of sharing personal information.

DPbD&D implementation: Instead of focussing on limitation of purpose and minimisation of data the focus is on controllability, transparency, and user friendliness.

Requirements for design solutions: Privacy features should be an integral part of school apps. These features should not only give the learner control over own data (where it is used, consent to share with other systems, etc.), but also support learning objectives set out in the curriculum on how to handle and understand data. The solutions should allow experimentation and learning exploration in data management in a data-driven and networked world.

The low level of data minimisation in this scenario should be compensated by architectural features that limit the longevity of the data and use sandboxing technologies keeping the learning and education space separate from life areas that are ruled by other ethical standards. For example, data from pre-university education should not end up in commerce, workplace, military, etc.

Scenario 2. Publisher / vendor / content provider with apps for STEM education: This scenario targets secondary education; however, the data processing is managed by third party vendors that sign up individual students. The vendors want to improve their tools and services by adding data from sources controlled by the students as well as by the school authorities.

Aims of LA usage: To support adaptive learning, giving students immediate and continuous feedback on achievements; giving the teachers a picture of how each students are doing at all time; and giving providers input to improve learning design and content.

Pedagogical grounding: Learner centered approach, giving the learner learning objectives, content and instructions that fit the competency level and unique needs of each learner.

DPbD&D implementation: In addition to the criteria of user controllability, transparency, and user friendliness, this scenario needs to consider issues of data minimisation, data confidentiality, and use limitation.

Requirements for design solutions: One direction of design could be to put all personally identifiable information (PII) under the control of the user (e.g., in a Personal Learning Record Store (PLRS) (Kitto et al., 2015), which the vendor system communicates with using different anonymisation techniques). By using standardised interfaces for competency gap queries, learning objective fulfilment, etc. the vendor tool could make queries to the PLRS without being exposed to any PII. In giving the user full control over own data the principles of purpose limitation and data minimisation are followed. It is up to the vendor tool to ask precise questions using a well defined formats in order to come up with the appropriate learning content, choose the right tests, and give the proper support.

An alternative direction of design would be to use a trusted API broker to handle PII serving certified vendors tokens that make it possible to use different datasets for learner-centered analytics. As there are always possibilities for re-identification using pseudonymised data also these solutions should provide tools for consent and management of learning activity data.

Scenario 3. School authority quality assurance system: This scenario targets school principals, politicians, parents and others that want to influence the contexts in which learning and teaching occur. The relevant data sources are many and varied; however, the need of PII is non-existent.

Aims of LA usage: To monitor the development of learning and education contexts in order to be able to allocate resources, adjust aims, facilitate planning for persons or groups, etc.

Pedagogical grounding: Quality assurance, based on metrics developed by local authorities, ministry of education, and others.

DPbD&D implementation: Removal of PII using state-of-the-art pseudonymisation techniques.

Requirements for design solutions: The design must balance the need for anonymity and analytical utility. A solution with centralised data warehouse where different interests could be allowed to probe the data without prior hypothesis is not in line with the DPbD&B principles. A solution with *a priori* data protection guarantee is also seen as less valuable as the anonymisation techniques will reduce the data quality too much. Instead, a service is proposed based on the following requirements: 1) defined analytical questions and specified groups of users, 2) dynamic brokerage of data sources of relevance, also from distributed PLRSs, and 3) dynamic anonymisation techniques based on advanced risk assessment analysis, which also considers the context of use of the analytics.

The three scenarios give requirements for different designs depending on the constraints described in Figure 2. We see that design decisions based on pedagogical and DPbD&D principles have potential to override the more technical or theoretical relationship in the model between a high degree of utility and low degree of data minimisation. This is an important finding supporting the assumption captured in the title of this paper.

5. Discussion

Legal requirements are potentially decisive in influencing which tools will be implemented in the educational market, especially for primary and secondary education (Hoel and Chen, 2016a). Whether DPbD&D is a legal term or not depends the point of view. It is included in the legal regulations of the European Union; however, the term is ill defined and in order to understand what it means one has to include engineering and management theories. Even if DPbD&D is hard to understand these principles could change the direction of LA tools development. When looking at how legal requirements have been met by learning technologies till now we see a practice of looking for the lowest bar and just doing enough, but no more, to pass that threshold. The use of LMS is a case in point; students tick a box in a usage agreement form the first time they open the tool and that is the first and last time they are exposed to questions about handling of their data. With DPbD&D developers of LA tools will not escape with a simple form with a checkbox; they have *by default* to dig deeper and open up each subprocess for discussion related to data protection.

Our exploration of directions for design of LA systems has shown that there is a need for pedagogical perspectives when DPbD&D is turned into technical requirements. In an educational setting data protection is more than technical issues about limits to anonymisation, encryption algorithms, and data security mechanisms; it is also a matter of supporting learner agency, teaching of learning of 21st century skills, and a more active learner teacher dialogue. The DPbD&D principles raise the questions; however, the educational community has to provide the pedagogical scenarios to make it possible to design LA solutions that transform learning and teaching, not merely pass the legal threshold of handling PII safely.

The three scenarios constructed in the previous section draw on background information we have from participating in Norwegian, European and international work in learning analytics. Many other scenarios could have been constructed. Nevertheless, it is interesting to reflect upon the ideas for solutions that are indicated following a pedagogically inspired DPbD&D approach.

First, it seems that we are looking at local, temporal and distributed solutions, especially in scenarios with extensive sharing of complex datasets. The idea of a national data warehouse where all learning activities are stored and processed is not supported.

Second, technologies that allow the data subject to manage his/her own data, e.g., cloud-based Personal Learning Record Stores, should be explored. The pedagogical requirements strengthen this direction of design even if personal e-portfolio systems (Stefani, Mason, and Pegler, 2007) and personal learning spaces (Dabbagh, and Kitsantas, 2012) have not been a great success neither from a market nor a technical perspective. The introduction of cloud based services in education might make this approach more promising.

Third, trusted 3rd party organisations may play an important role in providing API gateway services that allow both vendors, students and teachers to exchange information without compromising PII. This approach could also be question driven services, where activity data are not exchanged, only the answers to specific questions (e.g., how is the result of this quiz related to the student's performance in general). From a pedagogical perspective the challenge for these kinds of solutions is to prevent them from being a black box you just have to trust, not understanding how it works.

Fourth, governmental engagement may be necessary to develop LA infrastructures as described above. 3rd party organisations may be hard to establish without support from ministries of education. And as the responsibility to amend new data protection regulations rests with the government, awareness raising about the benefits of DPbD&D in supporting good pedagogical solutions should also be undertaken by ministries of education.

6. Conclusions and Further Work

Design and implementation of privacy requirements in systems requires translation of complex legal, social, ethical, and also pedagogical concerns into systems requirements. The new GDPR of the European Union will serve as a guideline on how to address these concerns. In this paper we have sought to trace the background for the principles of Data Protection by Design and by Default and explored how this principles should be handled by stakeholders of learning analytics systems, a new and emergent field of learning technologies.

The principles of DPbD&D are only two of a number of data protection measures that are now prescribed by law in Europe. Combined they represent an opportunity to make the design of data protection features in LA systems more driven by pedagogical considerations. This paper has explored how GPDR requirements and pedagogical requirement could influence the understanding of the different parts of a learning analytics process cycle. To help this exploration a model was developed of how a central aspect of data protection, data minimisation, is related to utility within different data sharing contexts. Furthermore, a scenario template was developed and three scenarios of different LA systems were presented.

Our analysis suggests that data protection regulations could change the direction of LA systems development if combined with pedagogical requirements. Further work is needed to see how data protection provisions are handled by the LA developers community at large. It would also be interesting to see how ministries of education are planning to engage with the new field of LA and how they would use new legal requirements to influence the use of data-driven technologies in education. More work is needed to see how students, teachers and administrators could be involved in development of LA tools and systems to make the processes more transparent and understandable. It is implied in this paper that issues of data protection and privacy have potential to engage these stakeholders in LA design. From a technical architecture point of view, there is an immediate need to analyse whether current approaches involving learning record stores and data warehouses comply with the new data protection regulations; and, if so, identify what alternative architectures could be designed.

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Does the proximity-based network of MOOCs condition changes in universities? An agnostic approach to visualize the process of nominating and designing MOOCs

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Abstract: This paper serves to provide evidence of institutional patterns to nominate and design a MOOC. Using the concept of proximity, this paper applies economic principles centred on revealed comparative advantage to discern an institution's propensity to nominate courses of certain disciplines over others in the design of a given MOOC. The conditions to design a certain MOOC will lead to the design of MOOCs in a similar discipline, since the conditions are similar (expertise, familiarity, etc.). Prevailing trends in open education matched with unmet demand for higher education suggest that institutions will embrace online learning more and more. We predict this will lead to greater specialization, of which most universities have one or several. Data of all available MOOCs, harnessed from three distinct MOOC aggregators, is utilized in this paper.

Keywords: MOOCs, Concept of Proximity, Higher Education

1. Introduction

Might MOOCs (massive open online courses) push institutions towards greater specialization in course offerings displacing less popular courses and programs? Since their mainstream inception in 2012, MOOCs have spread rapidly and globally. There are now over 4,000 MOOCs found in cyberspace with trends showing greater growth and differentiation. Observers increasingly bemoan the lack of sustainability in MOOCs. Without legitimate credentialing, they argue, high levels of attrition will continue and ultimately lead to the demise of these courses. It is already common for MOOCs to be discontinued after being offered only once. New approaches, however, are gradually taking shape.

Over the next year, three separate organizations will offer credit-bearing MOOCs that will lead to institutional credentials. Arizona State University has launched its first freshman year program, offering an affordable alternative to its campus-based and some of its online programs. The Modern States initiative is another venture that will serve to offer self-paced online courses leading to degree bearing credentials. Finally, the OERu (Open Education Resource Universitas) will launch a full-year of courses that will lead to a first year of a bachelor in general studies. The OERu is distinct in that all courses are repurposed from pre-existing OER, and form to create new OER that can be utilized outside of its network for varying purposes, including commercial ones. Although each presents a divergent pathway, the conclusion is towards conferring legitimate credentials.

There is little doubt that Coursera and other major MOOC providers will watch these endeavours closely (edX, in fact provides the platforms for both First Year and Modern States). Coursera, in fact, is already offering fee-based programs in partnership with universities leading towards varying forms of credentials, such as certificates.

We believe that MOOCs are pushing greater sustainability and legitimacy for online learning and posit that there are early signs of patterns of MOOC development that will continue in future. An institutions subject specialization(s) is favored when selecting which courses to nominate and design as a MOOC. Over time, we predict that this will create a feedback loop whereby courses in the same or similar disciplines in a given university will follow suit. We draw lessons from revealed comparative advantage and in particular, the concept of proximity, to further this prediction.

2. Comparative Advantage and Proximity Concept

The concept of comparative advantage is central to development economics（Costinot,2009）. In the industrial age, a country's or region's ability to extract and distribute its natural resources was central to its ability to participate in the global economy and acquire greater material wealth. In the information age, a country's ability to support the creation of knowledge and innovation among its population has supplanted natural resources as the central determinant to participate in the global economy.

Higher education is central to the development of a knowledge economy. Elites, professionals, and other highly skilled workers generally pass through an institution of higher learning before making their mark on the world. OECD countries have participation rates in higher education in excess of 50 percent of the age cohort. An extension of creating a universal system of higher education is the creation of a lifelong learning society. Individuals are enrolling in continuing education programs to augment existing skills or to learn new ones.

Despite steady enrolment at multiple levels of higher education, there are growing concerns of budget shortfalls and unsustainable enrolment. Governments are receding from meeting the same levels of financial support for higher education that they have committed to in past. The most visible outcome has been a rise in tuition fees.

Amidst other financial pressures, many universities have become more differentiated and more entrepreneurial. Creating greater online programs and links with industry have proven successful. At the same time, some universities have ended programs of low enrolment. Some institutions have closed altogether. With pressures on some programs, universities have partnered to offer joint programs, giving some semblance of sustainability for smaller departments.

Most universities have particular areas of study for which they specialize. The Massachusetts Institute of Technology specializes in engineering and technology. Beijing Normal University specializes in education. These universities, like thousands of others, are also comprehensive universities offering a broad range of programs. Otherwise referred to as the multiversity (Hayhoe, 1995）they service a broad student body.

The ubiquity of technology is shifting the manner in which universities operate. The idea of comparative advantage has surfaced in policy documents on higher education（Sahni&Shankar, 2005. A major concern is if universities specializes in certain areas, then why differentiate to accommodate learners outside of these areas? Proponents of consolidation argue that learners would be better served in institutions that specialize in the subject area of their choice.

Opposition would surface from faculty unions and current and prospective students. Some may be out of a job or uprooted to work or study elsewhere. Counterarguments would suggest that interdisciplinary is an intellectual strength and worth preserving.

In returning to an understanding of comparative advantage relative to natural resources, the advantage a country yields includes its ability to extract the resource, refine it where relevant, and get it to market. Drawing an analogy to higher education, it is important to consider other elements of an institution's infrastructure the support its comparative advantage.

A lens into understanding how universities may operate in future is through the direction of using massive open online courses (MOOCs). MOOCs need little introduction. They appeared in the mainstream in 2012 after Stanford University offered a few of their courses online for anyone to participate. MOOC providers such as Coursera and Edx followed, and operate as the major players in the organization and delivery of MOOCs. They have partners from around the world and continue to experiment with varying forms of delivery, credentialing and revenue generation.

The number of MOOCs that exist in cyberspace hovers around 3,000. Hundreds of universities are involved, and many are lined up to join Coursera or Edx. Some venture out on their own. The longevity of MOOCs is uncertain. For one, no sustainable business model has taken shape. Both Coursera and Edx are propped up by wealthy institutions or venture capital. Considering poor completion rates and lack of legitimate credentialing, the longevity of these and other MOOC providers, along with innumerable independent providers, is suspect. Yet, some 20 million learners are enrolled in these courses from around the world.

These demographic patterns underscore larger issues in higher education. Outside of the industrialized world, higher education is in dismal shape. Among myriad issues, is quality, which is highly uneven. China, for example, is home to the world's largest higher education population, yet only several dozen universities are deemed world class. The aggregated enrolment of these elite institutions measures at several hundred thousand, a miniscule number out of a total higher education enrolment of nearly 40 million （Vol.40, 2005）.

Outside of quality is capacity. UNESCO predicts that an additional 70 million individuals will be seeking enrolment opportunities over the next 10 years. That is approximately 30% above current global enrolment. Adding one-third student numbers to a given institution around the world is seemingly impossible, as is the construction of thousands of new institutions. Construction costs, land, and the individuals to run and teach in these institutions are unfathomable. MOOCs may not be the answer, but they are a reasonable response to the growing demands on higher education that are occurring and will persist in the coming decade and onwards.

If online learning, and MOOCs by association, become integral to widening access to higher learning, might there be a way to predict how effective the delivery of MOOCs may be?

Applying the concept of comparative advantage to the global higher education context, and MOOCs as a predictor of future, it is important to look outside of the course specialization and consider the broader infrastructure and acumen in designing and delivering a MOOC.

According to a report by Southwest Jiaotong University, higher education institutions tend to choose existing courses to offer as a MOOC based on the following criteria:

First, courses are selected from those that won the national top level course award for excellence. Second, is to choose a course from the leading subjects of the school in order to highlight its ability and brand. Third is to choose from foundation courses that either are taught in English or get good evaluation from students for their resilient and innovative pedagogy.

Within the context of revealed comparative advantage, is the concept of proximity. According to Hidalgo, the concept of proximity posits that, "a country's ability to produce a product depends on its ability to produce other ones." Underlying the concept is compatibility of products. If a country produces apples, for example, there is a favorable infrastructure to produce pears. The climate, soil properties, and methods of packaging are all similar. Further, it is highly probably that the knowledge required to grow apples is transferrable to acquire the knowledge to grow pears.

Mapping the concept of proximity to an institution's propensity to nominate and design MOOCs based on preferred courses is the central objective in this investigation.

3. Methods

This investigation aims to take inventory of all available MOOCs, including paced and self-paced MOOCs as found on three MOOC aggregators: MOOC list, Class Central and Guokr (China). Preference for selection will be given to institutions of higher education, thereby excluding foundations or other educational agencies. The rationale for exclusion is to include institutions only that offer a range of courses taught on campus or online to students who have gained admission to a particular institution since the premise of the paper is to predict what other institutional courses may be transferrable to a MOOC.

3.1 The Concept of Proximity: Devising an Equation for MOOCs

We modify an equation devised by Hidalgo （Hidalgo, 2007） to ascertain proximity. Formally, the proximity f between courses A and B is the minimum of the pairwise conditional probabilities of a university offering a MOOC in a particular discipline given that it offers another MOOC in another discipline.

$F = \min\{P(A \mid B), P(B \mid A)\}$

With these figures a complex network will be constructed. In this network, a node represents a given course and the line that connects two nodes represents the proximity.

4. Results

We anticipate that the results will yield data that shows high probability that an institution offering two or more MOOCs will belong to the same or a similar discipline. Based on this assumption, we started using a web crawler tool—bazhuyu---to grab online MOOCs data. So far we have got all course data from Guokr, the total course number is 4367, and the categories are course name, school, time, platform, and basic introduction. Because Guokr doesn't provide discipline information, at this initial level we may not be able to inspect our hypothesis. The following are just some preliminary results from descriptive statistics.

4.1 Descriptive statistics

4.1.1 The number of Published courses showing an increasing trend

According to picture 1, the number of launched courses has been bigger since 2012 and reached its peak at the year 2015, which is the last year we can get course data of the whole year. Although there is a dropping trend during the next three year, we can obvious know that those are incomplete data, cannot reveal real situation. That means so far as we know, the number of published courses are showing an increasing trend. If studying the fitting curve more thoroughly, we can find that the yearly growth rate also increases. All of these tell us MOOCs have been rapidly developing during the last 4 four years , it has clearly been an educational hit recently.

4.1.2 The Self-paced courses account for a certain proportion

Another conclusion we can draw from picture 1 is that self-paced courses account for a certain proportion. As we can see, the number of self-paced courses take up almost 30% . One of the great advantages of online course is its ability to free students from time and space restriction, yet a lot of MOOCs are just like traditional offline education, with specific start time, and one will not be able to join in his fond course if he missed the time. The rather amount of self-paced course can fairly avoid this problem and provide learners the possibility to enjoy the merit of online education.

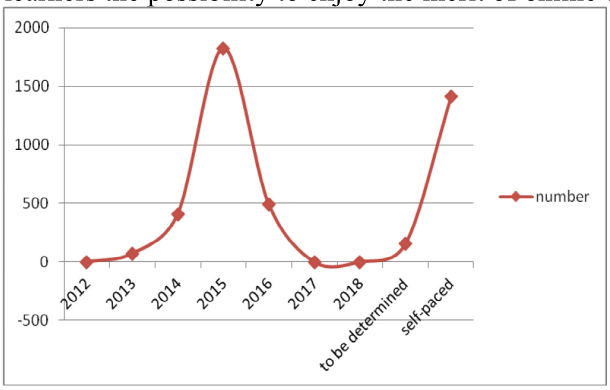

Figure 1. Time distribution of Guokr MOOCs

4.1.3 80% school have launched less than 10 courses during 2012-2018

The essence of our methodology is the concept of proximity, which will use the conditional probability to calculate. In line with the equation, the number of courses school have launched and the number of courses with similar name are indispensable data. Picture 2 is the distribution of course number a school published, over 200 school only published one course, 80% school have launched less than 10 courses the top 3 of course number a school published is 167(MIT),147(Tsinghua) and 93(Harvard).

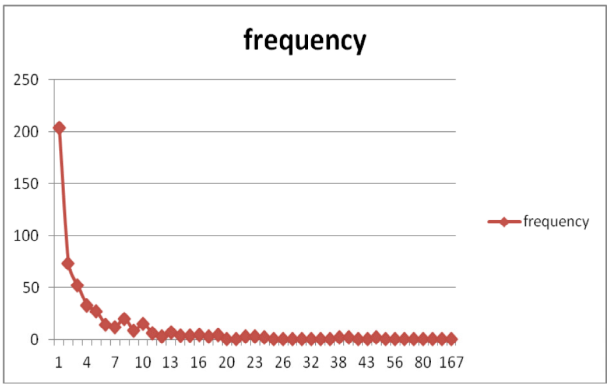

Figure 2 the distribution of course number a school published

4.1.4 Over 90% courses are with a different name

Another descriptive statistics we have done is about the course name, we want to have a general picture of how many courses are with the same name, which can show us if there are two school launched same course. Unfortunately, if we choose same course name as the indicator of connection between two separate school, we may not be capable of obtaining expected result, as 90% courses have different name.(table 1)

Table 1: the frequency of course name.

Course name	Number
1	4304
2	57
3	5
4	1

4.2 *What we planning to do next*

On account of the intial descriptive analysis, using same course name has clearly become an inferior choice, so we decide to find a way to better cluster two courses, since we have the basic introduction information of the course, text clustering is an option. Also, those data are just from Guokr, apparently there are a large amount of courses still missing, so we will keep on digging course informatin from other platform for further analysis.

5. Discussion and Conclusions

The study aims to provide evidence of institutional preference towards designing MOOCs. The hypothesis was that institutional preferences to nominate and design a MOOC will increase the likelihood of a course of the same or similar discipline to subsequently be nominated and designed as a MOOC. In a broader context, this idea was advanced using the concept of proximity located within the area of economics referred to as revealed comparative advantage. A country's propensity to extract and distribute a given resource provides conditions to extract and distribute another given resource that is similar in nature. Mapping this idea to higher education, and the prediction of greater reliance on specializations, we predicted that growth in MOOCs will reflect a similar result. A computer course that is nominated and designed as a MOOC will lead an institution to nominate and design a course in the same or similar discipline (e.g.,. mathematics), instead of nominating and designing a course from the humanities. The prediction is that this may lead to greater institutional focus towards subject specializations for which an institution has a known comparative advantage to other institutions. The long-term result is that lesser established specializations in a given institution will be pushed to the margins, an outcome that is increasing in regularity.

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The learning behavior difference between supervised online learning and unsupervised online learning for K-12 education

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Abstract: Supervised online learning is defined as the online learning under the requirement, supervision and guidance by the teacher, just as in the traditional classroom education. Unsupervised online learning is defined as the online learning without the supervision and guidance by the teacher. I analyze the multiple-dimensional data gathered from one web-based interactive mathematics learning platform "Lexue 100 (Happy Learning for 100 Points)" using SQL command scripts, SPSS statistics and WEKA. The findings include that the supervised online learners from one school spent much more time on participating in more quizzing activities than the unsupervised ones, though the time spent on every quiz by the supervised ones is less than that by the supervised ones, and their mean exercise score is almost the same as the unsupervised ones due to the system's drilling mechanism. This study suggests that the school teacher plays one important role to facilitate the sustainability and speed of pupils' online learning, and the pure online learning by the pupils themselves without the support and requirement from their teachers cannot guarantee the sustainability of the online learning.

Keywords: supervised online learning, unsupervised online learning, learning behavior, quiz

1. Introduction

The online learning with interactive web-based systems has become popular from K-12 to higher education worldwide. For example, Khan Academy is one famous website with lecture videos, interactive drills and other forms of learning materials (https://www.khanacademy.org). In China, the long-history tradition of valuing education drives the parents to look for more education chances like extracurricular activities besides the regular school education system for their children. The popularity of Internet, personal computers, smart phones and other information and communication technology enable the students to use all kinds of web-based learning materials and platforms to make up for deficiencies from the regular classroom education, such as lack of instant communication, feedback and comments from the teachers, as well as individualized learning demand. To meet such demands, a lot of educational institutes and companies have developed numerous web-based learning and teaching systems for K-12 and higher education. Due to the vast student population, some companies claimed to have gained a great amount of student users. However, the following question has not been thoroughly studied but very interesting both to the online learning providers and consumers: How long and how frequently can the users learn with the online environment?

Besides free usage by pupils, those online learning systems are also used by some schools and teachers as the complement to traditional classroom education. Thus the second question of this study is: what is the learning behavior difference of supervised learning and unsupervised learning using the interactive web-based systems?

The two research questions are important not only for research community but also for the learning system provider.

2. Learning Platform

2.1 System Functions

"Lexue 100" (http://www.lexue100.com) is a web-based interactive learning system for school mathematics. A large number of corresponding quizzes are designed for the different versions of mathematics textbooks that are used in different provinces and metropolis. Each quiz is composed of a series of gap-filling or single-choice questions. So the question's standard answer is predefined and can be compared with the user's trial answer. Thus the positive or negative feedback can be instantly given to the user, as soon as he or she submits the trial answers. Answering quizzes is the main learning behavior in this system.

Based on behaviorism and other learning theories, three learning strategies are adopted by this system: Individualized Adaptation, Incremental Mastery and Interactive Discovery. According to the system's website, they are defined as the following: "Individualized adaptation means that every student can select the quizzes according to his or her own demand. Incremental mastery means that in every quiz, the students should correctly answer every composing question in the sequence, otherwise he or she cannot go on to answer next question. Interactive discovery means that the student can ask for help from the online teaching assistant by answering difficult questions."

To interest the students, the system also delivers scores and credits to students, after they completed one quiz. The amount of score and credits is proportional to the question amount, the time spent on completing the quiz, and the proportion of the questions that are correctly answered by the first trial. Any user can be registered to the system for free of charge, take part in quizzes, and get corresponding credits and amount of virtual currency. For three years this learning system has been used by free users. Some middle schools and primary schools are also invited by the company to use the system for free. In the junior middle school C located in south-west China, one mathematics teacher Y has been invited to use this system to facilitate his teaching and the students' learning for free since September 2015. Because he taught two classes in Grade one of this junior middle school, he selected the corresponding quizzes for the textbook, and required the students from one class as the experiment class to do some quizzes before the lecture and after the lecture using their personal computers or tablet computers at home for every week. He checked the students' online learning activities almost every day. Therefore the online learning of the experiment students from the school C is supervised learning, which can be defined as the online learning under the requirement, supervision and guidance by the teacher, just as in the traditional classroom education. On the contrary, unsupervised online learning is defined as the online learning without the supervision and guidance by the school teacher. The other users of this system, who learn by themselves and without the supervision from their school teachers, are unsupervised students. In order to investigate the two questions regarding to web-based learning systems, I analyze the data from the Lexue100 system as an example.

2.2 User Data

In Lexue100 system, all users' learning activities are tracked and stored in the server database with 281 relational tables. The tables are interleaved with each other. To answer the research questions, I first scrutinized the structures of all tables in details, as well as the complicated relations among them. Then I analyzed the data from those tables dated from January 15, 2013 to May 5, 2016. Among those tables, only those related with users' information and quiz activities are investigated, because doing quizzes is the main learning behavior supported by this system. The records of those tables count from thousands to millions. The biggest table recording all users' quiz activity has more than 33 million records.

In our previous work on MOOC (Massive Open Online Course) and the MOOC users' learning behavior (Jia, Miao & Wang, 2014; Jia & Wang. 2015), we summarized the learning behavior of every MOOC user with a newly designed meta table. In this table, the term "duration" is proposed to describe one user's online time span, and is defined as the time difference between the last login time and the first login time. Similarly, in this paper I summarize the learning behavior of every user with a newly designed table "student_description". The composing fields and their meanings are listed in Table 1. Its field values are set by executing SQL commands script to calculate other existing tables.

Table 1: The composing fields and their mearnings in the table "student_description"

Field name	Field meaning
id	The user's identification number
first_time	The first time to do the quizzes
last_time	The last time to do the quizzes
duration	The time span between the last time and first time = last_time - first_time
quizzes	The number of doing the quizzes
scores_sum	The sum of scores the user received
scores_mean	The average score = scores_sum/counts
credits_sum	The sum of credits the user received
credits_mean	The average credit = credits_sum/counts
usetime_sum	The sum of time of the user's doing quizzes
usetime_mean	The average time of the user's doing the quizzes= usetime_sum/counts
correctness_mean	The mean of the rate the user correctly answer the questions in the quiz
time_bias_mean	The mean of time bias the user do the quizzes. Time bias is the allowed time period for one quiz minus the time spent on writing one quiz. If the result is positive, the user completed the quiz ahead of the allowed time, otherwise negative, after the allowed time. So this field indicates the speed the user completes one quiz compared with the allowed time.

Based on this student description table, the learning behavior of a specific users' group can be further analyzed, for example, the supervised learners and unsupervised learners. The experiment students from School C are regarded as supervised learners, while the others are regarded as unsupervised learners. The group's mean and standard deviation can be calculated by executing SQL commands script. The correlation among indicators in a group can be calculated with SPSS statistics. The clustering of the learners in a group can be calculated with WEKA or other data mining software. In the following sections, I present the statistical description, correlation and clustering result.

3. Statistical description

The learning behaviors of the two groups are described by their mean and standard deviation, as listed in Table 2. The first column is the learner behavior indicators. The second column is the value of unsupervised learners, and the third column is the value of the supervised learners. The fourth column is the times of the third column's value compared with the second column's value.

Table 2 shows that the supervised learners on average get more scores, credits and a higher correctness rate for every quiz than the unsupervised learners, though the advantage is too small to be noted. This finding can be explained by the drilling mechanism of this system, i.e. Incremental Mastery. Every user has to complete the questions in a quiz correctly in order to go to the next quiz, no matter how many times trials are done and how much time is spent on the questions. The same credit and same score are given to the user after he or she completed the quiz. Those three indicators can be classified as precision indicators.

Furthermore, Table 2 shows the surprising difference between supervised learners and unsupervised learners among the sustainability indicators including duration, quizzes number, time, score and credit. The first one is duration. Although the supervised learners just began their learning with the system on September 15, 2015, and the unsupervised learners began on January 5, 2013, the average duration of the supervised learning is 2.6 times much of the unsupervised learning. The second is the quiz number. The supervised learners did 6.2 times quizzes as the unsupervised ones. It is more noticeable that the supervised learners did almost 2 quizzes every day within the learning duration, while the unsupervised ones did less than one quiz every day. The third, fourth and fifth are quiz score, credit, and time, respectively. Because for every quiz the almost same score and credit were given, the total score, credit and time are proportional to the quiz number.

Table 2 also shows the speed difference for every quiz. The supervised learners spent less time on every quiz than unsupervised learners, i.e. 7 minutes versus almost 10 minutes. The time bias per quiz of the supervised learners is also significantly more than unsupervised ones. Those two indicators demonstrate that supervised learners completed the quiz much faster than the unsupervised ones.

Table 2: The comparison of unsupervised learners with supervised learners

Field name		Unsupervised learners	Supervised learners	Times of the third column's value compared with the second column's value
Users' number		84676	49	-
duration per user	Mean	7449370.2 Seconds = 86.22 Days = 2.87 Months	19450505.1 Seconds = 225.12 Days = 7.5 Months	2.6
	Std. dev.	12044822 Seconds =139.41 Days =4.65 Months	2546789 Seconds =29.48 Days =0.98 Months	0.21
quizzes per user	Mean	62.4	389.4	6.2
	Std. dev.	138.8	123.2	0.89
quizzes per user per day within the duration	Mean	0.72	1.73	2.4
	Std. dev.	4.0	0.5	0.12
scores sum per user	Mean	5980.7	37496.7	6.3
	Std. dev.	15926.5	12395.1	0.78
scores per user per quiz	Mean	93.6	95.3	1.0
	Std. dev.	38.6	4.87	0.13
credits sum per user	Mean	273.0	2018.4	7.4
	Std. dev.	1654.1	740.9	0.45
credits per user per quiz	Mean	4.5	4.6	1.0
	Std. dev.	7.7	1.1	0.14
quiz time sum per user	Mean	29129.5 Seconds = 8.09 Hours	162938.4 Seconds = 45.26 Hours	5.6
	Std. dev.	59752.9 Seconds = 16.60 Hours	68085.2 Seconds =18.91 Hours	1.14
quiz time per user per quiz	Mean	579.2 Seconds = 9.65 Minutes	419.9 Seconds = 7.0 Minutes	0.7
	Std. dev.	437.3 Seconds = 7.29 Minutes	123.3 Seconds = 2.05 Minutes	0.28
correctness rate per user per quiz	Mean	89.3%	90.6%	1.0
	Std. dev.	7.2%	4.1%	0.57
time bias per user per quiz	Mean	35.4 Seconds	283.4 Seconds =4.7 Minutes	8.0
	Std. dev.	883.6 Seconds =14.73 Minutes	165.5 Seconds =2.76 Minutes	0.19

After scrutinizing the users, I find 10993 users with duration=0, who did the quiz for only one time but not anymore, and may be classified as trial users. If those 10993 trial users are excluded from the other really unsupervised learners doing more than one quiz, the comparison of really unsupervised learners with supervised learners is shown in Table 3. The data in Table 3 show that all precision, sustainability and speed indicators of really unsupervised learners are improved, but the improvement is still too trial compared with the supervised learners. In other words, the more than 10 thousand trial users' single probe of this system did not have great impact on other unsupervised users' cumulative performance.

Table 3: The comparison of really unsupervised learners with supervised learners

Field name		Unsupervised learners doing more than one quiz	Supervised learners	Times of the third column's value compared with the second column's value
Users' number		73683	49	-
duration per user	Mean	8560765 Seconds = 99.08 Days = 3.3 Months	19450505.1 Seconds = 225.12 Days = 7.5 Months	2.3
	Std. dev.	12538259 Seconds =145.12 Days =4.84 Months	2546789 Seconds =29.48 Days =0.98 Months	0.21
quizzes per user	Mean	71.5	389.4	5.4
	Std. dev.	146.58	123.2	0.89
quizzes per user per day within the duration	Mean	0.72	1.73	2.4
	Std. dev.	4.3	0.5	0.12
scores sum per user	Mean	6859.4	37496.7	5.5
	Std. dev.	16898.2	12395.1	0.78
scores per user per quiz	Mean	94.0	95.3	1.0
	Std. dev.	41.03	4.87	0.13
credits sum per user	Mean	313.0	2018.4	6.4
	Std. dev.	1769.73	740.9	0.44
credits per user per quiz	Mean	4.5	4.6	
	Std. dev.	8.21	1.1	0.14
quiz time sum per user	Mean	33350.2 Seconds = 9.26 Hours	162938.4 Seconds = 45.26 Hours	4.9
	Std. dev.	62974.50 Second = 17.49 Hours	68085.2 Seconds =18.91 Hours	1.14
quiz time per user per quiz	Mean	540.3 Seconds = 9.00 Minutes	419.9 Seconds = 7.0 Minutes	0.8
	Std. dev.	346.85 Seconds =5.78 Minutes	123.3 Seconds = 2.05 Minutes	0.28
correctness rate per user per quiz	Mean	89.0%	90.6%	1.0
	Std. dev.	6.92%	4.1%	0.57
time bias per user per quiz	Mean	51.9 Seconds	283.4 Seconds =4.7 Minutes	5.5
	Std. dev.	934.39 Seconds = 15 Minutes	165.5 Seconds =2.76 Minutes	0.19

Besides collective performance expressed by the group mean, both Table 2 and 3 show the standard deviation's difference between the two groups. The unsupervised group is much larger than the supervised group, and the standard deviation of all indicators except quiz time sum per user of the former group is much greater than the deviation of the latter group.

4. Correlation

Correlation

[redacted]		duration	quizzes	scores_sum	scores_mean	credits_sum	credits_mean	usetime_sum	usetime_mean	correctness_mean	time_bias_mean
duration	Pearson Correlation	1	.543**	.530**	.140	.494**	.228	.343*	-.150	.122	.388**
	significance		.000	.000	.339	.000	.116	.016	.302	.404	.006
	N	49	49	49	49	49	49	49	49	49	49
counts	Pearson Correlation	.543**	1	.990**	.353*	.852**	.238	.749**	-.052	.348*	.600**
	significance	.000		.000	.013	.000	.099	.000	.724	.014	.000
	N	49	49	49	49	49	49	49	49	49	49
scores_sum	Pearson Correlation	.530**	.990**	1	.472**	.897**	.325*	.685**	-.131	.451**	.667**
	significance	.000	.000		.001	.000	.023	.000	.368	.001	.000
	N	49	49	49	49	49	49	49	49	49	49
scores_mean	Pearson Correlation	.140	.353*	.472**	1	.662**	.779**	-.111	-.620**	.918**	.707**
	significance	.339	.013	.001		.000	.000	.448	.000	.000	.000
	N	49	49	49	49	49	49	49	49	49	49
credits_sum	Pearson Correlation	.494**	.852**	.897**	.662**	1	.676**	.471**	-.275	.616**	.832**
	significance	.000	.000	.000	.000		.000	.001	.055	.000	.000
	N	49	49	49	49	49	49	49	49	49	49
credits_mean	Pearson Correlation	.228	.238	.325*	.779**	.676**	1	-.109	-.457**	.767**	.680**
	significance	.116	.099	.023	.000	.000		.454	.001	.000	.000
	N	49	49	49	49	49	49	49	49	49	49
usetime_sum	Pearson Correlation	.343*	.749**	.685**	-.111	.471**	-.109	1	.572**	.012	.124
	significance	.016	.000	.000	.448	.001	.454		.000	.936	.395
	N	49	49	49	49	49	49	49	49	49	49
usetime_mean	Pearson Correlation	-.150	-.052	-.131	-.620**	-.275	-.457**	.572**	1	-.396**	-.542**
	significance	.302	.724	.368	.000	.055	.001	.000		.005	.000
	N	49	49	49	49	49	49	49	49	49	49
correctness_mean	Pearson Correlation	.122	.348*	.451**	.918**	.616**	.767**	.012	-.396**	1	.529**
	significance	.404	.014	.001	.000	.000	.000	.936	.005		.000
	N	49	49	49	49	49	49	49	49	49	49
time_bias_mean	Pearson Correlation	.388**	.600**	.667**	.707**	.832**	.680**	.124	-.542**	.529**	1
	significance	.006	.000	.000	.000	.000	.000	.395	.000	.000	
	N	49	49	49	49	49	49	49	49	49	49

**. significant at .01 level (two tailors)

*. significant at .05 level (two tailors)

Figure 1. The bi-variance correlation for supervised learners

Correlation

[redacted]		duration	counts	scores_sum	scores_mean	credits_sum	credits_mean	usetime_sum	usetime_mean	correctness_mean	time_bias_mean
duration	Pearson correlation	1	.619**	.519**	.012**	.226**	-.011**	.676**	-.068**	-.261**	.013**
	Significance		.000	.000	.000	.000	.001	.000	.000	.000	.000
	N	84676	84676	84676	84676	84676	84676	84676	84676	84676	84676
counts	Pearson correlation	.619**	1	.873**	.027**	.330**	-.009**	.833**	-.115**	-.243**	.029**
	Significance	.000		.000	.000	.000	.007	.000	.000	.000	.000
	N	84676	84676	84676	84676	84676	84676	84676	84676	84676	84676
scores_sum	Pearson correlation	.519**	.873**	1	.493**	.736**	.459**	.696**	-.106**	-.193**	.027**
	Significance	.000	.000		.000	.000	.000	.000	.000	.000	.000
	N	84676	84676	84676	84676	84676	84676	84676	84676	84676	84676
scores_mean	Pearson correlation	.012**	.027**	.493**	1	.911**	.977**	-.001	-.135**	.105**	.036**
	Significance	.000	.000	.000		.000	.000	.773	.000	.000	.000
	N	84676	84676	84676	84676	84676	84676	84676	84676	84676	84676
credits_sum	Pearson correlation	.226**	.330**	.736**	.911**	1	.900**	.274**	-.048**	-.070**	.014**
	Significance	.000	.000	.000	.000		.000	.000	.000	.000	.000
	N	84676	84676	84676	84676	84676	84676	84676	84676	84676	84676
credits_mean	Pearson correlation	-.011**	-.009**	.459**	.977**	.900**	1	-.020**	-.048**	.107**	.019**
	Significance	.001	.007	.000	.000	.000		.000	.000	.000	.000
	N	84676	84676	84676	84676	84676	84676	84676	84676	84676	84676
usetime_sum	Pearson correlation	.676**	.833**	.696**	-.001	.274**	-.020**	1	.006	-.286**	.003
	Significance	.000	.000	.000	.773	.000	.000		.103	.000	.442
	N	84676	84676	84676	84676	84676	84676	84676	84676	84676	84676
usetime_mean	Pearson correlation	-.068**	-.115**	-.106**	-.135**	-.048**	-.048**	.006	1	-.151**	-.182**
	Significance	.000	.000	.000	.000	.000	.000	.103		.000	.000
	N	84676	84676	84676	84676	84676	84676	84676	84676	84676	84676
correctness_mean	Pearson correlation	-.261**	-.243**	-.193**	.105**	-.070**	.107**	-.286**	-.151**	1	.039**
	Significance	.000	.000	.000	.000	.000	.000	.000	.000		.000
	N	84676	84676	84676	84676	84676	84676	84676	84676	84676	84676
time_bias_mean	Pearson correlation	.013**	.029**	.027**	.036**	.014**	.019**	.003	-.182**	.039**	1
	Significance	.000	.000	.000	.000	.000	.000	.442	.000	.000	
	N	84676	84676	84676	84676	84676	84676	84676	84676	84676	84676

**. Signficant at .01 level (two tailors).

Figure 2. The bi-variance correlation for unsupervised learners

Correlation

[redacted]		duration	quizzes	scores_sum	scores_mean	credits_sum	credits_mean	usetime_sum	usetime_mean	correctness_mean	time_bias_mean
duration	Pearson Correlation	1	.604**	.505**	.005	.218**	-.005	.662**	-.017**	-.272**	.001
	Signigicance		.000	.000	.141	.000	.157	.000	.000	.000	.694
	N	73683	73683	73683	73683	73683	73683	73683	73683	73683	73683
counts	Pearson Correlation	.604**	1	.871**	.023**	.325**	-.005	.828**	-.104**	-.255**	.021**
	Signigicance	.000		.000	.000	.000	.181	.000	.000	.000	.000
	N	73683	73683	73683	73683	73683	73683	73683	73683	73683	73683
scores_sum	Pearson Correlation	.505**	.871**	1	.498**	.736**	.472**	.688**	-.100**	-.201**	.021**
	Signigicance	.000	.000		.000	.000	.000	.000	.000	.000	.000
	N	73683	73683	73683	73683	73683	73683	73683	73683	73683	73683
scores_mean	Pearson Correlation	.005	.023**	.498**	1	.917**	.983**	-.006	-.113**	.077**	.022**
	Signigicance	.141	.000	.000		.000	.000	.096	.000	.000	.000
	N	73683	73683	73683	73683	73683	73683	73683	73683	73683	73683
credits_sum	Pearson Correlation	.218**	.325**	.736**	.917**	1	.912**	.267**	-.046**	-.072**	.011**
	Signigicance	.000	.000	.000	.000		.000	.000	.000	.000	.002
	N	73683	73683	73683	73683	73683	73683	73683	73683	73683	73683
credits_mean	Pearson Correlation	-.005	-.005	.472**	.983**	.912**	1	-.015**	-.028**	.074**	.011**
	Signigicance	.157	.181	.000	.000	.000		.000	.000	.000	.004
	N	73683	73683	73683	73683	73683	73683	73683	73683	73683	73683
usetime_sum	Pearson Correlation	.662**	.828**	.688**	-.006	.267**	-.015**	1	.062**	-.302**	-.006
	Signigicance	.000	.000	.000	.096	.000	.000		.000	.000	.113
	N	73683	73683	73683	73683	73683	73683	73683	73683	73683	73683
usetime_mean	Pearson Correlation	-.017**	-.104**	-.100**	-.113**	-.046**	-.028**	.062**	1	-.132**	-.130**
	Signigicance	.000	.000	.000	.000	.000	.000	.000		.000	.000
	N	73683	73683	73683	73683	73683	73683	73683	73683	73683	73683
correctness_mean	Pearson Correlation	-.272**	-.255**	-.201**	.077**	-.072**	.074**	-.302**	-.132**	1	.030**
	Signigicance	.000	.000	.000	.000	.000	.000	.000	.000		.000
	N	73683	73683	73683	73683	73683	73683	73683	73683	73683	73683
time_bias_mean	Pearson Correlation	.001	.021**	.021**	.022**	.011**	.011**	-.006	-.130**	.030**	1
	Signigicance	.694	.000	.000	.000	.002	.004	.113	.000	.000	
	N	73683	73683	73683	73683	73683	73683	73683	73683	73683	73683

**. Significant at .01 level (two tailors)

Figure 3. The bi-variance correlation for unsupervised learners doing more than one quiz

I use SPSS Statistics (V20) to analyze the correlation between any two indicators. The correlation result for supervised learners, unsupervised learners and unsupervised learners doing more than one quiz is shown in Figure 1, 2 and 3, respectively. Those figures show that in the three groups, the positive correlation between any two indicators of duration, quizzes, quiz score sum, quiz time sum and time bias mean is significant at 0.01 or 0.05 level. The credits mean is significantly positively correlated with correctness mean and time bias mean at 0.01 level, but negatively correlated with use time mean at 0.01 level. The score sum is significantly positively correlated with duration, quizzes, credits sum and mean, use time sum, correctness mean and time bias mean at 0.01 level. Those correlations can be explained by the specification mechanism for scores and credits by the system.

5. Clustering

I use the Weka (V3.8.0) from the University of Waikato, New Zealand (http://www.cs.waikato.ac.nz/ml/index.html), a data mining software, to cluster the users descriptive data. The clustering algorithm is Simple KMeans with the default parameters.

weka.clusterers.SimpleKMeans -init 0 -max-candidates 100 -periodic-pruning 10000 -min-density 2.0 -t1 -1.25 -t2 -1.0 -N 2 -A "weka.core.EuclideanDistance -R first-last" -I 500 -num-slots 1 -S 10

The clustering result for supervised learners (N=49) is two clusters. The first cluster contains 13 (27%) learners, while the second one with 36 (73%) learners. All the performance indicators of the instances in second cluster are better or much better than those in first cluster. For example, Figure 4 shows the duration in X axis and quizzes in Y axis, and the blue and red instances are the instances in cluster 1 and 2, respectively. The blue ones are located mostly in the lower-left corner and indicate smaller duration and quiz number value, while the red ones are located mostly higher-right and indicate larger duration and quiz number value.

The clustering result for unsupervised learners (N=84676) is two clusters. The first cluster contains 69105 (82%) learners, while the second one with 15571 (18%) learners. All the performance indicators of the instances in first cluster are worse or much worse than those in second cluster. For example, Figure 5 shows the duration in X axis and quizzes in Y axis, and the blue and red instances are the instances in cluster 1 and 2, respectively. The blue ones are located mostly in the lower-left corner and indicate smaller duration and quiz number value, while the red ones are located mostly higher-right and indicate larger duration and quiz number value.

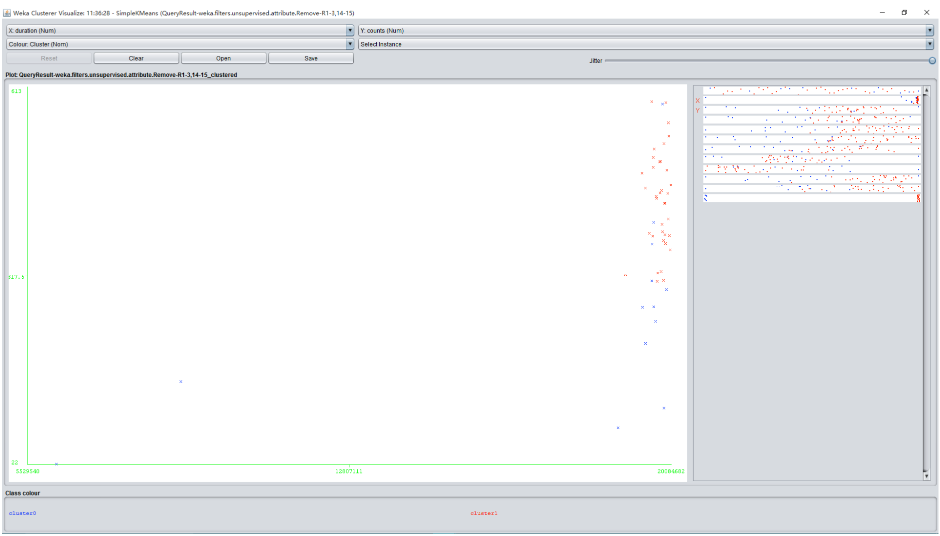

Figure 4. The visualization of clustering result for supervised learners

The clustering result for unsupervised learners doing more than one quiz (N=73683) is two clusters. The first cluster contains 59040 (80%) learners, while the second one with 14643 (20%) learners. All the performance indicators of the instances in first cluster are worse or much worse than those in second cluster. The clustering result diagram is similar to Figure 2.

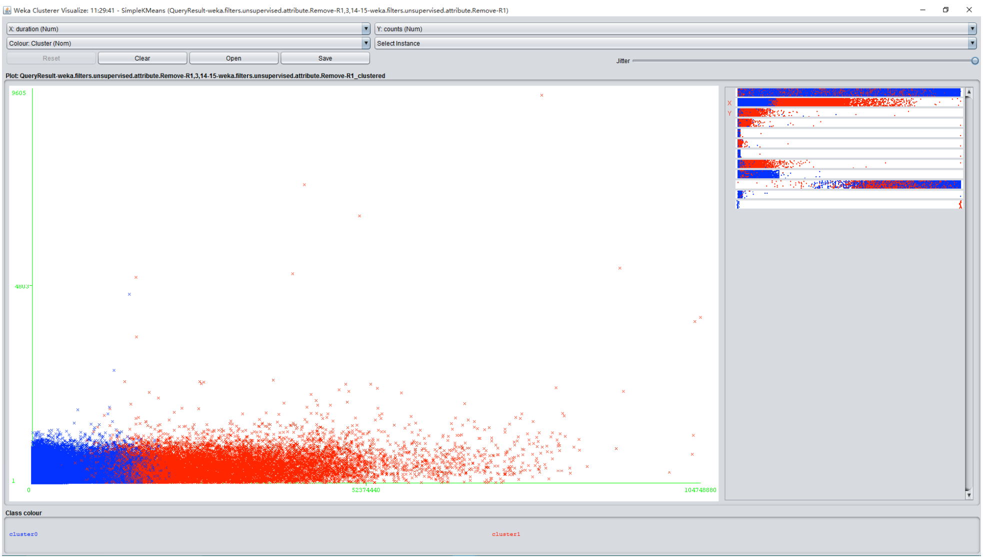

Figure 5. The visualization of clustering result for unsupervised learners

6. Conclusion and Discussion

Through analyzing the data from Lexue100 system with SQL scripts, SPSS statistics and Weka, I find the supervised online learners from one school spent much more time on participating in more quizzing activities than the unsupervised ones, though the time spent on every quiz of the supervised ones is less than that of the supervised ones, and their mean exercise score is almost the same as the unsupervised ones due to the system's drilling mechanism. The sustainability and speed of the supervised learning are better than that of the unsupervised learning. The reason to explain such findings may be that the school teacher plays one important role to facilitate the sustainability and speed of students' online learning, and the pure online learning by the pupils themselves without the support and requirement from their teachers cannot guarantee the sustainability of the online learning.

Due to time and literature resource limitation, I have not compared the findings from this specific research with previous related works. Moreover, the learning behavior concerned in this study is only mathematic quizzes for the textbooks. Thus it would be questionable to apply the findings from this study to other web-based online learning platforms. Besides quiz and other learner behavior, interoperability and other important issues should also be considered in learning analytics (Hoel & Chen, 2014).

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Assessing Processes and Products for LEarning (APPLE) of Collaborative Argumentation

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Abstract: In the realm of CSCL research, collaborative argumentation is regarded as a key type of knowledge construction process that should be mastered by students to enable knowledge advancement. We designed an automated assessment system to support students' collaborative argumentation in Science learning. This paper describes the conceptual framework, the pedagogical and technological design of the system.

Keywords: collaborative argumentation; assessment for learning; automated assessment

1. Introduction

There is an ever-increasing need to provide students with learning experiences that reflect the challenges and opportunities they will experience in the workforce of the 21st century. The key classes of workforce skills relate to critical and inventive thinking and information and communication skills that can be developed through participating in collaborative argumentation. For both individuals and groups, the ability to evaluate and reflect on arguments and counter-arguments in relation to specific issues is critical as it enables sound reasoning, decision making, and task performance (Nussbaum, 2008). Argumentation is also an effective approach to learning as it promotes conceptual understanding and deeper learning of content (Nussbaum, 2008) and enhances knowledge creation (Erduran, Simon, & Osborne, 2003). There have been increasing practices engaging argumentation to teach various subjects (e.g., science: Driver, Newton, & Osborne, 2000; mathematics: Lampert, Rittenhouse, & Crumbaugh, 1996; social studies: de La Paz, 2005), all producing positive results.

Understanding the significance of both "learning to argue" and "arguing to learn" (Scheuer, et al., 2010) to the development of 21st century skills (particularly critical and inventive thinking) and domain knowledge in students, researchers have developed a good number of computer-based systems to support argumentation in the collaborative fashion, to facilitate communication and argumentation between multiple participants (Scheuer, et al., 2010). With the recognition that there is little consensus on assessment practices, the present project aims to develop an assessment-oriented collaborative argumentation system called "AppleTree" for measuring collaboration and argumentation in real classrooms. Apples are fruits of wisdom. Inspired by the "three apples" (Apples in Eden, Apple fallen on Newton's head, and Steve Job's Apple) that have changed human life so dramatically, we hope our AppleTree, an innovative work that is built on existing systems for collaborative argumentation and automated assessment of collaborative learning, can make a difference to existing school practices after iterative cycles of validation in Singapore educational context.

2. Design Rationale

The assessment we proposed for AppleTree is the assessment *for* learning instead of assessment *of* learning. Assessment *for* learning is using multiple forms of information about students' learning as feedback to modify the learning activities they are engaged in, and assessment *of* learning is establishing what students have learnt in a summative way (Shepard, 2000). As indicated in previous research, the roles of assessment in scaffolding learning are well known (Bransford et al., 1999; Shepard, 2000) and computer-based assessment tools that can provide semi-automatic or automatic analyses and diagnosis of online discussions to better scaffold learning are increasingly developed.

White and Fredericksen (1998) tried to make scientific inquiry accessible towards learners through embedding assessment in the design and development of ThinkerTools. ThinkerTools includes a set of assessment criteria to help participants to reflect on their inquiry discourse and communication. In such kind of "reflective assessment", students constantly evaluate their own and other's work. In some studies on knowledge building, researchers employed electronic portfolio notes in Knowledge Forum for formative assessment, and their findings show that portfolio scores can make a significant contribution to conceptual understanding scores (Lee, Chan, & van Aalst, 2006; van Aalst & Chan, 2007). Enlightened and encouraged by these work, we believe via incorporating mechanisms for supporting formative (diagnostic) and automated assessment of the on-going collaborative argumentation process, AppleTree can empower the regulation of collaboration, that is taking actions "on the fly" (immediate adaptations) when unexpected events occur based on a quick appraisal of the current learning status and its compatibility with the desired, to foster productive learning (Jermann & Dillengourg, 2008). During this process, student collaborative argumentation is enhanced and teacher instruction is optimized.

We are attempting to develop automated assessment components that can assess both the cognitive and the social aspects of collaborative argumentation. Cognitive aspect of collaborative argumentation is the ability to construct, evaluate and reflect on arguments and counter-arguments is critical as it enables sound reasoning, decision making and task performance (Nussbaum, 2008). In this study the cognitive aspect of collaborative argumentation is about the construction of sound and syntactically valid arguments which can be measured by the structure and content validity of the represented argument. Social aspect of collaborative argumentation in informed by Wenger's theory (1998) which has been widely acknowledged that participation in collaborative learning in a CSCL learning environment can enhance participants' learning (Prinsen, Volman, & Terwel, 2007; Sorensen, Takle, & Moser, 2006). However, knowledge on how participation in online environment contributes to learning is lacking. With the assessment components proposed, we can understand this issue by identifying collaborative patterns that can bring about improvement in argumentation via iterative cycles of use. In this study, social aspect of collaborative argumentation is about students' participation and online-based communication for constructing the represented argumentation. The behavioral indicators of these 2 aspects of assessment will be discussed in section below with detailed instrumentation described. The key elements of AppleTree assessment are:

1) It supports assessment ***for*** learning rather than assessment ***of*** learning.
2) It assesses argumentation and collaboration at ***individual*** and ***group*** level respectively.
3) It is not only an ***assessment*** tool, but also a tool for visually ***representing*** learning processes unfolding in classrooms.
4) It not only assesses the learning ***outcomes*** but also helps tracking and monitoring the ***process*** of collaboration and argumentation.
5) It involves both ***self-assessment*** and ***peer assessment*** by the students.
6) It is a ***real-time*** assessment tool which provides immediate feedback to teachers and students with which they can adjust or improvise teaching and/or learning, as well as 'feed forward' into future work.

3. System Design

AppleTree is envisaged as a multiuser tool for developing scientific argumentation skills and collaboration skills in secondary school students. Like most collaborative argumentation systems, its user interface provides students with a shared and synchronized working space for collaborative construction of arguments and a chatting tool for communication and coordinating group work (Figure 1). Collaboration scripts are embedded in the system design to empower effective teaching and learning. Real-time visualizations and evaluations of students' social participation and argument construction at different learning stages are displayed to scaffold the argumentation processes and to inspire reflections on both individual and group work.

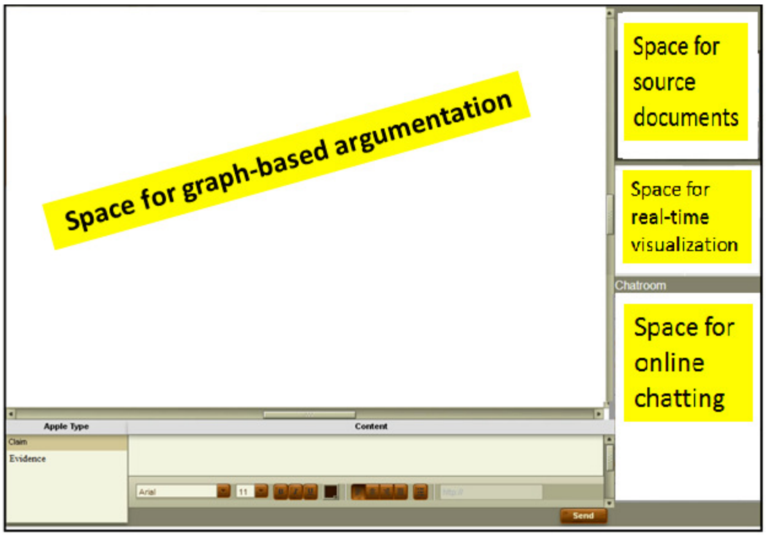


Figure 1. AppleTree user interface

3.1 Argument pattern and representation

For argumentation systems, providing an external representation to enable the creation, reviewing and modification of arguments by users is an important goal (Scheuer, et al., 2010). Compared to linear texts, graphic representation has been shown as being able to induce better learning outcomes (Suthers, et al., 2001) as it expresses the argument structure explicitly and is an intuitive form to model knowledge. AppleTree uses graphic representations. The specific types of argument elements designed are in accordance with Toulmin's Argumentation Pattern (TAP) (1958). In AppleTree, three argument elements, namely claim, support (including data, warrant, or backing) and rebuttal are identified as the essential components of an ideal argument. On an AppleTree implementation, these three elements are indicated by: 1) the type of Node: Claim vs Evidence and/or 2) the type of directed Link: For vs Against (Table 1). Following this, a claim is represented by a "***Claim***" node without any link; a "***Support***" is represented by an "Evidence" node with a "For" link; and a "***Rebuttal***" is represented by an "Evidence" node with an "Against" link. In constructing an argument, a student first chooses the type of argument element and then inputs the content. In the following, the student connects the element crafted to the shared argumentation graph.

Table 1. Argument elements and examples

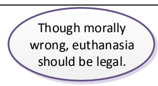
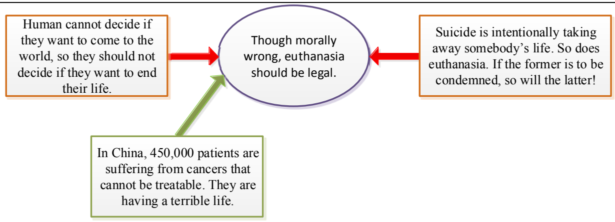
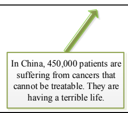
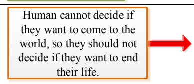
<table>
<tr><th>Argument Element</th><th>Textual representation</th><th>Graphic Representation</th><th>Example of an Argument</th></tr>
<tr><td>Claim</td><td>Claim</td><td>
</td><td rowspan="3">
</td></tr>
<tr><td>Support</td><td>Evidence
+For</td><td>
</td></tr>
<tr><td>Rebuttal</td><td>Evidence
+Against</td><td>
</td></tr>
</table>

Figure 2 presents an example of argument representation on AppleTree (simulated data concerning whether euthanasia should be legalized was used).

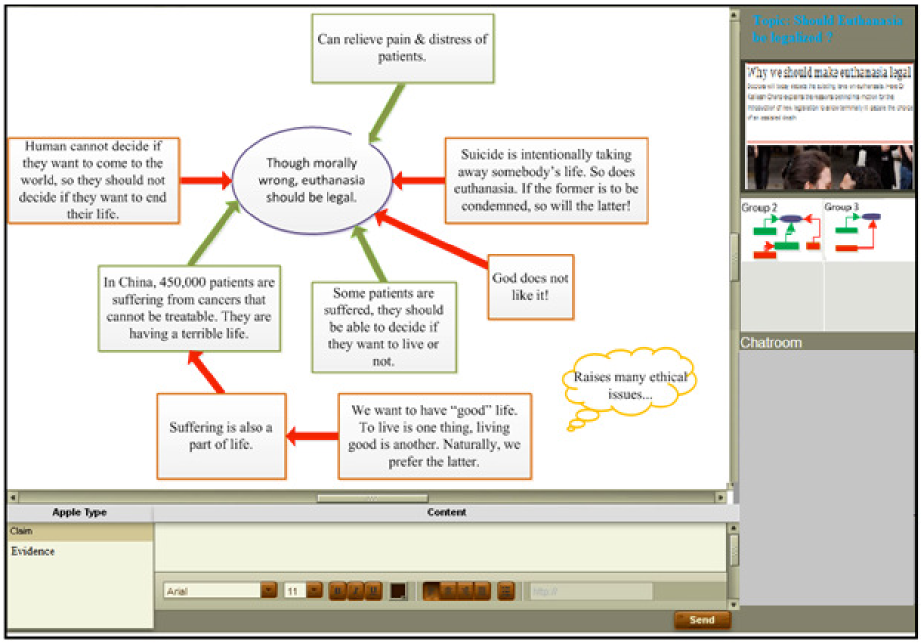


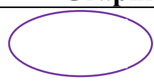
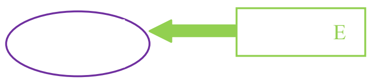
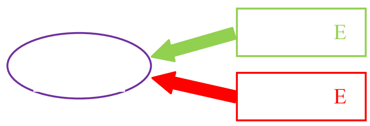
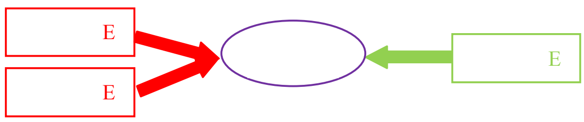
Figure 2. Argument representation on AppleTree (using simulated data)

3.2 AppleTree-supported automated assessment

3.2.1 Cognitive aspect of assessment

AppleTree supports on-going and automated analysis and evaluation of the quality of argumentation unfolding in collaborative work. As reflected in literature, the arguments constructed by effective arguers are of both structural completeness and valid content. Thus, in AppleTree, the assessment of group argumentation quality is measured by structural completeness which refers to constructing arguments with a complete structure, i.e. with all the essential argument components (e.g. claim and evidence) that are critical to effective argumentation. In this project, an argument that is complete in structural is composed of a claim, supporting evidence and rebuttal. Table 2 presents the coding scheme developed for assessing argument structural completeness.

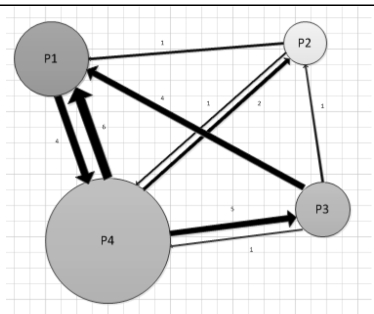
Table 2.Coding scheme for argument structural completeness

Level	Description	Graphic representation (examples)
1	An argument that only contains a claim.	
2	An argument that contains a claim and support (s).	
3	An argument that contains a claim, support (s) and one rebuttal.	
4	An argument that contains a claim, support (s), and more than one rebuttal.	

3.2.2 Social aspect of assessment

Social network analysis (SNA) is a well-known approach to investigate online social participation and is embedded in AppleTree. SNA can help identifying patterns of relationship between participants and visualizing the "flow" of information/knowledge and/or other resources that are exchanged among participations (de Laat, et. al., 2007; Haythornthwaite, 2002). In AppleTree, the analysis of the social network established focuses on "***centrality***" and "***density***".

The "***density***" of a network is defined as the number of links in a network divided by the maximum number of all possible links (Scott, 1991). It varies between 0 and 100%. For example, in a network of a class of 40 participants, the maximum number of all possible links (connections) is 780 (40x39/2). "***Centrality***" is also an important indicator for social participation in as it informs the extent to which an individual interacts with other members in the network (Wasserman & Faust, 1997). Using this measure, we can uncover who is the dominant participant in the group or which group interacts most frequently with other groups.



Legend:
- Node (vertex) size refers to the in-degree centrality of each users (bigger node have higher out-degree centrality);
- Node (vertex) color refers to the out-degree centrality (the darker have a higher in-degree value);
- Link width refers to the frequency of reply.
- Link direct refers to "build on" or "reply to"

Figure 3. An example of social network representation

4. Conclusion

In summary, the main benefits of AppleTree include:

1) Providing a generic collaborative argumentation tool that can be used across classrooms, grades, curricula and subject areas.
2) Visualizing continuously the collaborative argumentation process unfolding or happening in classrooms.
3) Defining specific metrics for measuring collaborative argumentation progress.
4) Minimizing the use of classroom instructional time for doing explicit assessment.
5) Supporting teacher professional development by providing a common language to discuss teaching and assessment practices and articulating the mechanism and parameters for assessment of collaborative argumentation.
6) Inspiring and enabling reflection on teaching practices with regard to how it helps equipping students with 21st-century skills.

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Data, the Story, the Storyteller

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Abstract: This short position paper is focused on questions that arise from the entire data lifecycle, from data specification and gathering, to visualisation and interpretation, to data storytelling. We argue that storytelling and human sense-making are critical considerations in how we might determine the validity of learning analytics and highlight data literacy as a critical competency in the emerging era where data has increasing value. We use data collected by the Government of India to illustrate our argument in which two issues arise: lack of protocols and adequate structure supporting learning analytics methods based on sound educational research.

Keywords: data, data literacy, data visualisation, data storytelling, learning analytics

1. Introduction

Schools and universities around the world collect student data routinely. Making use of such data, however, can be a challenging task for teachers and educators – it is not always straightforward how to use the collected information effectively in order to optimise student learning outcomes. Moreover, higher education "has traditionally been inefficient in its data use, often operating with substantial delays in analysing readily evident data and feedback" (Siemens & Long, 2011, p. 32).

Educational technologies are fast converging to fill this gap through the new field of Learning Analytics. Using big data to predict behaviour and through tracking learning activities of students who may come from different backgrounds, places and differing abilities aims to address this need while offering new insights that extend teaching and learning, exploring frontiers not previously accessible. The ongoing revolution instigated by innovation in digital technology continues to excite and enable new practices in education; it is ushering in, however, a new world of challenges associated with data.

2. Position

We situate our position on learning analytics within a broader context that connects with the discourse on *21st century skills* and competencies. In particular, we are concerned with determining the scope of what *data literacy* is or might need to be. With the rapid development and deployment of analytics tools in recent years, in which data visualisation occupies a prominent place, we find that:

- As a term, data *is* as much as data *are* – and academic pedantry will not change that;
- Data is not (necessarily) neutral;
- Data can be misused and misunderstood;
- Cultural and ethical dimensions need to be considered as aspects of data literacy;
- The emerging era of *data-driven everything* presents new challenges for human sense-making;
- The (data) story and the storyteller are contextually bound and should not be separated; and,
- Asking key questions of the data is an art and science.

3. Data Literacy

For us, data literacy implies capabilities of gathering, processing, analysing and presenting data as information to support decision making. But what is data, how is it created, and how do we need to retrieve and interpret information from it? We are often 'data rich and information poor' within an expanding data environment of spreadsheets, reports, books, surveys, Facebook likes, pictures, twitter streams, newspapers, 24-hour TV news cycles and numerous other sources all aiming to inform us with data. How can we know whether our learning is rightly directed, ethical or even correct? Is there something in the data or excluded from it that the storyteller hasn't told? How can we become data literate and develop skills that assist in asking key questions? How do we devise ways to make sense of data that can inform how we might improve our practices? The discourse on *21st century skills* opens one pathway, although such an umbrella term is itself problematic. Responding effectively will likely require new tools, expertise, dogged curiosity as well as willingness to act on what we find. Challenges of cognitive bias and whether data visualizations might be conveying emotional content are just a few.

In determining the scope of data literacy Gummer and Mandinach (2015) propose a useful framework that considers data functions during teaching and learning giving emphasis to the inquiry cycle. Elsewhere, we support this approach but raise further questions about the semantics and scope of literacy and numeracy in the emerging age of data-driven everything (Mason, Khan, & Smith, 2016).

4. Indian Case-Studies

In reporting 2011 census data on religion, Indian newspapers used the same data with different headlines and stories: e.g., in *The Times of India*, "Hindu population declined, Muslims increased"; while for *The Hindu*, "Muslim population growth slows". Such difference is striking but is actually commonplace – if we look for it. As educators, what do we make of such reporting? We suggest that *data literacy* needs to imply access to validation tools that relate to data as well as the storyteller.

In a 2013-2014 survey implemented by the Government of India analysis of results estimated that the total enrolment in higher education was 32.3 million of which around 17.5 million (54 %) were boys and 14.8 million (46%) were girls. Distance enrolments represented 11.7 % of total enrolment (Government of India, 2015). The shear enormity of this young population seeking formal education makes a compelling argument for utilising learning analytics to shape and improve the delivery of formal education. In 2015 some Indian venture capital firms assessing the potential and business model raised $40m to fund educational technologies while others placed funds elsewhere because they see the sector as 'too hyped' (Yourstory, 2015). Simple arithmetic tells us that if costs are as low as $1 per month per student this would equate to approximately a $400 million/year market. Perhaps it is caution playing out that deployment of learning analytics is not yet being scaled up. Perhaps this is wise.

Due to the lack of mature protocols and established processes questions that need to be addressed prior to implementing learning analytics include topics such as privacy, safety, assessment, management, ethical use, and determining what data can legitimately be collected (from both structured and unstructured sources) to avoid misuse and misinterpretation. In reviewing available documentation, we find that these issues are not yet sufficiently addressed if the full scope of data literacy is considered.

5. Conclusion

As data determines more and more what we do it is imperative that the digital technologies being used to render data into information as well as knowledge and information into data are designed in ways that enable us to check the veracity of the data, the story and the storyteller. What we don't want is indiscriminate rendering of raw data into compelling visualizations and even actionable knowledge for teachers and learners to manipulate without any validation let alone informed consent.

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Towards an Open and Extensible Learning Analytics Systems

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Abstract: The power of learning analytics systems comes from the ability to support diverse analytics needs that arise from a variety of learning environments at various scale. As an effective integration framework for learning analytics, the system should be versatile enough to seamlessly incorporate various analytics methods and tools as needed. Based on our previous design and implementation of a reference model for learning analytics, we describe the progress made towards an open and extensible learning analytics system to support various analytics tools and processes by explicit specification of analytics tools and flexible management of the analytics processes.

Keywords: Learning Analytics System, Open and Extensible System, Plug and Play

1. Introduction

The drastic advancement of information and communication technologies (ICTs) and learning management systems (LMS) is making learning analytics and consequential personalized learning more feasible and practical than ever before. Learning analytics, however, is still an emerging field in which sophisticated and various analytic tools need to be integrated as a unified framework to improve learning and education.

The power of learning analytics systems comes from the ability to support diverse analytics needs that arise from a variety of learning environments at various scale. As an effective integration framework for learning analytics, the system should be versatile enough to seamlessly incorporate various analytics methods and tools as needed. Based on our previous design and implementation of a reference model for learning analytics (Choi, Cho & Lee, 2014; Bae, Cho & Lee, 2015), we describe the progress made towards an open and extensible learning analytics system to support various analytics tools and processes by explicit specification of analytics tools and flexible management of the analytics processes. The reference model is built to meet the identified requirements for the learning systems to be open, extensible, distributed, interoperable, reusable, configurable, real-time, predictable, usable, secure, and traceable as shown in **Error! Reference source not found.**.

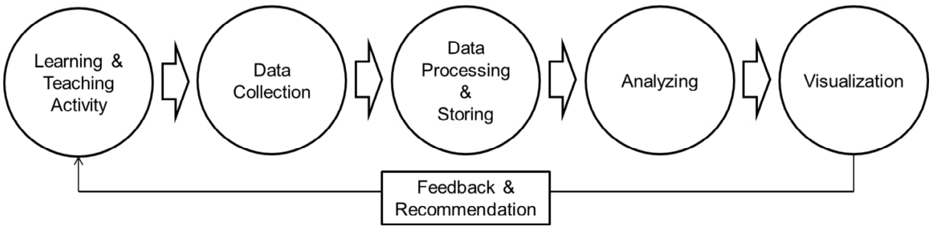

Figure 1. Workflow of Learning Analytics

The workflow shown in **Error! Reference source not found.** is adopted in the reference model of the ISO/IEC JTC1 SC36 WG8 *Information technology for learning, education, and training — Learning analytics interoperability (*ISO/IEC JTC1 SC36 WG8, 2016). The reference model describes the constituent steps as follows;

- **Learning and Teaching Activity**: the process of data modeling sources of learning activities in order to decide upon learning activity data that could be used for analytics, and the release of learning activity data for Data Collection

- **Data Collection**: the process of gathering and measuring information on variables of interest in the learning and teaching activities
- **Data Processing and Storing**: the process of preparing and storing data from diverse and heterogeneous data sources for interoperable data analysis by utilizing the standardized data model and representation.
- **Analyzing**: the process of systematic investigation of learning data by inspecting, and modeling the learning data with the goal of producing descriptive and possibly predictive knowledge
- **Visualization**: the process of creating representations of abstract data including text and schematic representations such as social diagrams and maps to allow stakeholders to see, explore, interact, and understand large amounts of information in analyzing and reasoning about data and evidence
- **Feedback and Recommendation**: the process for serving the results of a cycle of learning analysis back to the learners and their contexts so that corrective actions can be taken

Although the aforementioned requirements are applicable to the entire steps of the workflow, in this paper we focus on the requirement to be open and extensible especially for the design of analyzing step since it is the indispensable step that involves diverse and dissimilar analytics tools. In the rest of this paper, we describe our approach to explicit specification of analytics tools and flexible management of the analytics processes towards an open and extensible learning analytics system.

2. Analyzing for Learning Analytics

Analyzing is the process of systematic investigation of learning data by inspecting, and modeling the learning data with the goal of producing descriptive and possibly predictive knowledge as illustrated in **Error! Reference source not found.** *(*ISO/IEC JTC1 SC36 WG8, 2016).

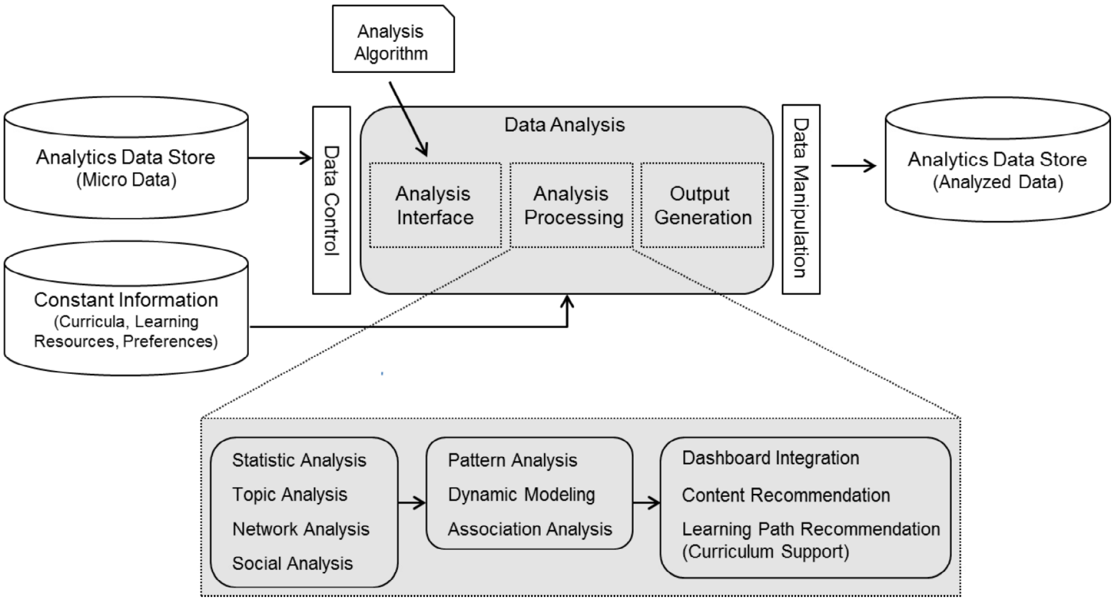

Figure 2. Analyzing for Learning Analytics

In this figure, the greyed area depicts the data analysis process for which our work to make open and extensible. Our aim is to make the analysis interfaces and tools to be interchangeably used in the learning analytics systems to allow to implement continuous learning processes in diverse learning contexts and provide on-demand adoption of the tools.

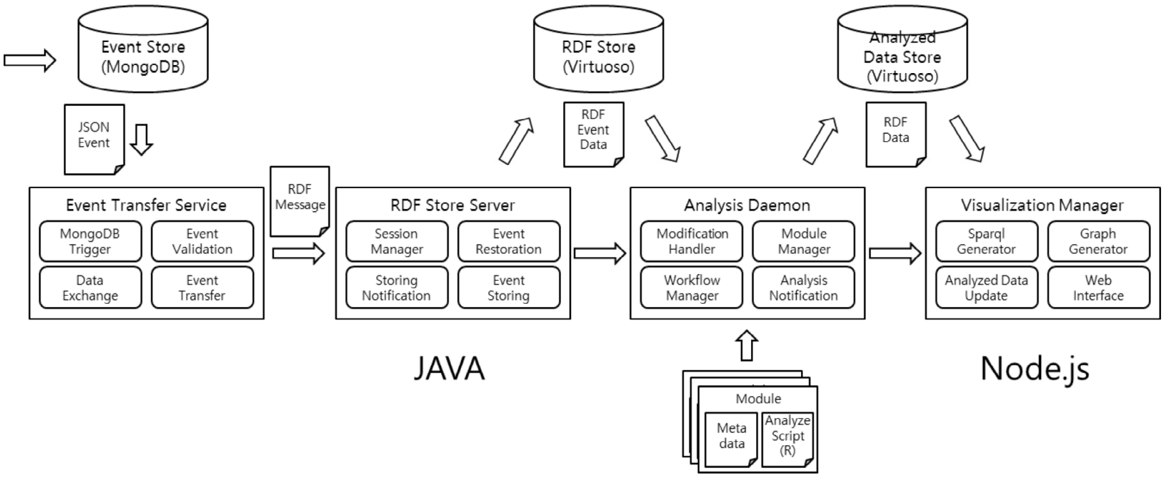

Figure 3. Overall Implementation View

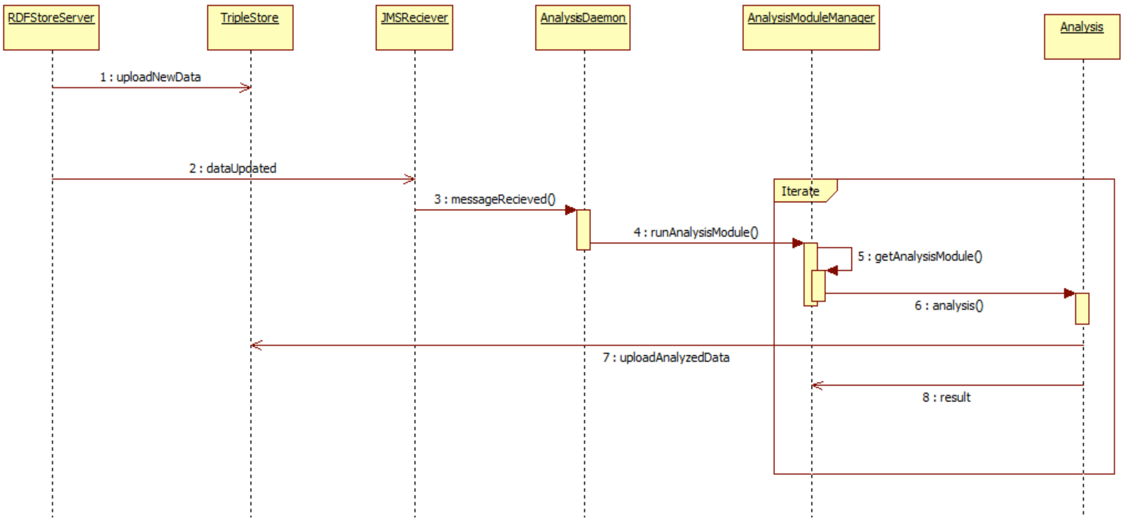

Figure 4. Sequence Diagram for the Learning Analytics System

Error! Reference source not found. shows the overall implementation view of the workflow for the learning analytics system and **Error! Reference source not found.** illustrates the sequential interactions of the components of the workflow. The following descriptions are based on this implementation view and the sequence diagram.

2.1 Analysis Interface

Analysis Interface provides a common interface to various external analysis algorithms such as predictive analytics, adaptive analytics, discourse analytics, and other assessment tools. These analysis modules firstly need to be explicitly specified for the learning analytic system to handle uniformly. We use the following minimal set of metadata as shown in **Error! Reference source not found.**.

Table 1. Metadata for Analysis Tools

Properties	Description
Developer	Description of the developer of analysis module
Location	The path to the analysis module
RequiredData	The list of data required for the analysis module
RequiredType	The associated list of types of the required data
ResultData	The list of data produced by the analysis module

ResultType	The associated list of types of the produced data
Version	The version of the module

The metadata basically describes the input and output of analysis modules and used for the module manager in the Analysis Daemon in **Error! Reference source not found.** to control the analysis module. The metadata is also utilized to search and locate appropriate analysis modules as needed.

2.2 Analysis Processing

While Analysis Interface provides a common interface to various external analysis modules, Analysis Processing manages sequencing and execution of analysis modules accordingly to the metadata of the analysis modules as shown in **Error! Reference source not found.**. Analysis Processing may start with statistical analysis, topic analysis, network analysis, social analysis and more. The results of low-level analysis then may feed into pattern learning, dynamic modeling, and association analysis before they are used by dashboard integration, content recommendation, and learning path recommendation.

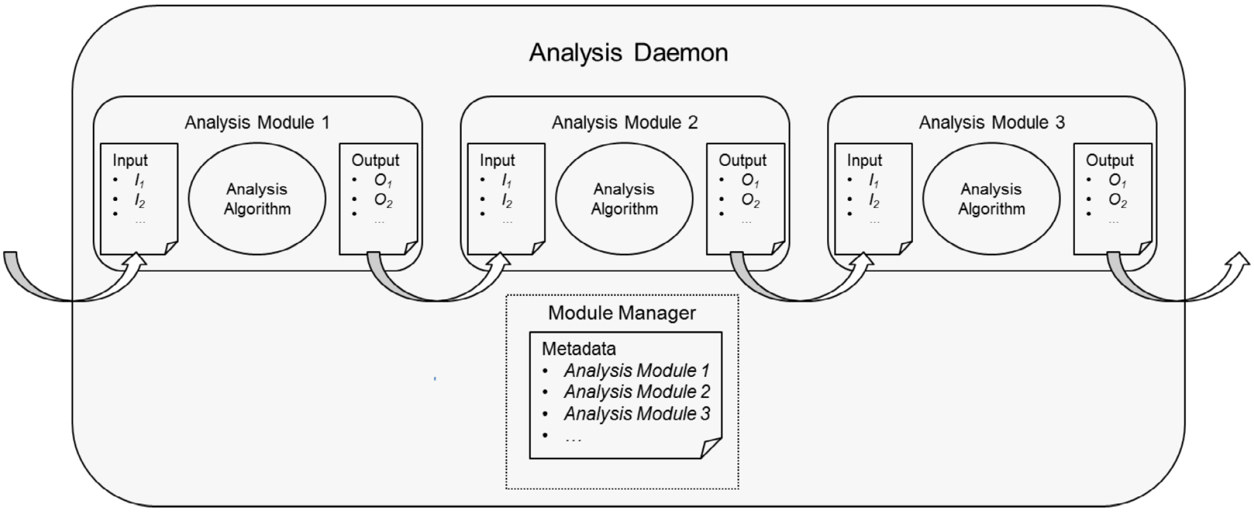

Figure 5. Analysis Processing

Metadata for the analysis modules are crucial for the Module Manager to relay data from the output of one module to the input of subsequent analysis module sequence. The activation of analysis module is spontaneously triggered by creation or changes of the corresponding data specified in the module description. Instead of statically specifying the sequence of analyzing, asynchronous and data-driven invocation of necessary modules is the key feature enabling open and extensible analyzing processes. Additionally such a data-flow feature allows parallel execution of independent analysis modules automatically.

3. Discussion and Future Work

In this paper, we presented our approach towards an open and extensible learning analytics system that is developed based on a standard reference model of ISO/IEC JTC 1 SC 36. Learning analytics systems are required to support diverse analytics necessities generated from a variety of learning environments at various scale. Our approach is to explicitly specify the metadata for analysis modules and to adopt data-driven and asynchronous invocation model analysis processing. We believe that our approach is effective in building an open and extensible integration framework for learning analytics by providing a versatile way to seamlessly incorporate various analytics methods and tools as needed. Currently, we are looking into a way to apply our approach to the whole workflow of learning analytics by leveraging our experience.

Acknowledgements

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Tracking and Visualization from in-class Moodle Page Views Using TSCS Monitor

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Abstract: This paper describes the development and trial performance of Time Series Cross Section (TSCS) Monitor, an interactive student monitoring and tracking system that uses an Excel macro to extract tracking data from Moodle page views. TSCS Monitor generates pivot tables using a Time Series Cross Section framework that can be used by the course instructor. TSCS Monitor and the tables it provides allow comprehensive visualizations that give an overview of the entire class, rather than solely tracking the activity of individual students or focusing on a particular resource. Instructors can perform an analysis of the entire class and produce a clear picture of when learners have opened the material, either in-class or previously. The numerical data provided by the TSCS tables can be used to identify learners who access the materials without properly following instructions as well as those who delay accessing the materials.

Keywords: time series, cross-section, engagement, page views, educational data mining, student tracking

1. Introduction

Educational Data Mining has developed as an application of data mining in the education field. Its object is to produce information that will improve the quality of education for teachers and learners. Recent Course Management Systems (CMSs) and Learning Management Systems (LMSs) such as Moodle keep track of learning histories for system developers as well as teachers and learners, and have the potential to generate valuable information (Baker & Yacef, 2009). Records of the learning histories of learners are being collected on an increasingly large scale. Using these learning histories to improve the quality of teaching and learning shows great promise. Many kinds of data mining methods have already been proposed in the education field (Romero & Ventura, 2013).

The success of learning in the classroom is ultimately due to the interaction of teachers and learners. This interaction, especially during class time, has a direct effect on teaching evaluation. In a blended face-to-face learning environment using a CMS, the teacher provides learners with a description of course materials and instructions for how to use them; the response of the learners is recorded in logs showing their learning histories. As one of the more common learning management systems, Moodle enables the automatic accumulation of data such as a student's history of access to pages of the course materials. The information obtained from the Moodle system, however, is insufficient for direct use as a basis for enhancing teaching quality and judging how a teacher should proceed with the class.

What is needed is a data mining method for use with a CMS that would analyze learning histories in real time and report the status of the learners in a timely manner. Classroom teaching can be expected to improve if educators are provided with a means of early detection of student status without having to leave their desks—a method by which they can readily assess student progress and facilitate thorough instruction for learners. The challenge is to provide appropriate data to both educators and learners. A favorable strategy would be to supply teachers with the results of appropriately conducted analyses in a timely manner so that the analytical insights gained can be used to advance teaching effectiveness. A tool that could be employed frequently in-class for such a purpose would be highly desirable.

This paper discusses a method that was developed for viewing student access to course materials during class and visualizing student engagement with the materials as change numerical values. It also describes the development of an Excel macro system called TSCS Monitor that automatically generates Time Series Cross Section (TSCS) tables from Moodle page views. The system monitors learners' in-class page views and provides information that can be used as a reference for reinforcing classroom instruction and keeping track of student engagement. The TSCS Monitor macro can be accessed by any Moodle course administrator (Dobashi, 2015a, 2015b).

2. Related Research

Romero, Ventura, and Garcia (2008) classified the trends of data mining in education for specific areas, such as statistical analysis, visualization, and text mining. They also investigated the various data mining methods that have been attempted by researchers. They found that Moodle learning history data used to classify learners with features derived by mining are applicable to measures for improving the educational effects of data mining (Romero et al, 2008).

Moodle page views shows a record of when and how students access course materials, duration of access (initiation, time spent), IP addresses, users' full names, operations, and accessed items. This information is summarized in a time series list. However, the original Moodle logs provide only a rough picture of classroom situations and are therefore minimally useful. To address this issue, Dierenfeld and Merceron (2012) and Dobashi (2015a) show various kinds of learning analytics methods using Excel pivot tables. Konstantinidis (2013) has also developed Excel macros to process the Moodle logs in order to analyze page views and overall usage.

Attempts to track the behavior of online visitors by taking advantage of the system of access logs is increasingly common (Sen, 2006). For example, tracking the behavior of visitors to online shopping sites to improve advertising messaging is now widely practiced. Such efforts have led to the development of systems that aim to track the behavior of students during a lesson (Chen, 2003; Mostow etal, 2005; Mazza et al, 2012; Stephens, 2014).

In addition, Google Analytics provides a website analysis service that enables data analyses grounded in different perspectives (Google, 2016). Such service also helps educators improve course materials and lessons. Related Google Analytics offerings, such as the provision of data on aggregate visitors and frequency of website visits, number of users that access a website, and website content viewed, are available in real time. Google's services likewise allow for visually analyzing the behaviors of users who are executing any operation on a page.

Moodog reports that Zhang and Almeroth have developed an approach that incorporates an analysis function for logs in Moodle. Their system is able to analyze the course materials browsing rate, page views and viewing time of students. The analytical results are displayed on Moodle screens showing the interaction of the students and Moodle using graphs and the tables (Zhang & Almeroth, 2010).

Mazza and Dimitrova have developed a system called CourseVis (Mazza & Dimitrova, 2003, 2004, 2007) that tracks student behavior in an online class. Such behavior can be visualized graphically, along with the status of student access to content pages following the course schedule. GISMO (Mazza & Milani, 2004; Mazza & Botturi, 2007) uses Moodle access histories to produce a graph of student access of course and teaching materials in order to better understand student behavior. It has been integrated into the Moodle open source learning environment and is currently installed in many educational institutions involving actual users.

3. Tracking and TSCS Analysis

3.1 TSCS Analysis

Moodle offers an accumulated learning history for such elements as page views of course materials and quiz results. For this study, we created course materials on Moodle in order to collect page views and developed a method using Excel macros that apply TSCS analysis. The system continuously provides TSCS analysis of learner page views during the lesson. A TSCS table is automatically generated to apply the concept of TSCS analysis and panel data. TSCS data represent continuous observations of a single investigated unit and enables both time series and cross-sectional analysis (Fig. 1).

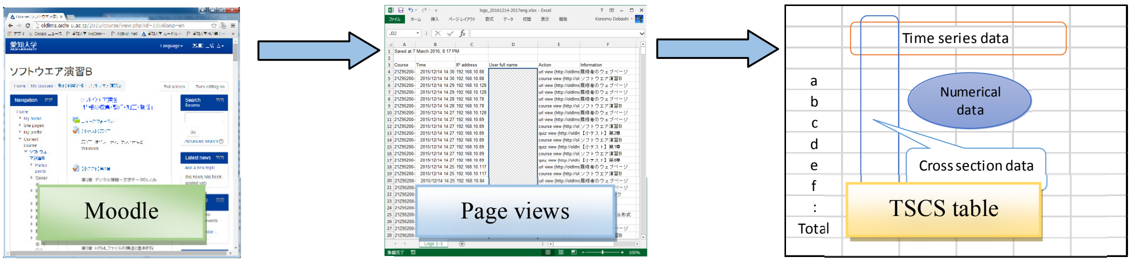

Figure 1. Flow of Processing a Time Series Cross Section table.

The work described here is based on the TSCS theory of Fisher (1973) and Beck (2008). Both TSCS and panel data-based analyses can handle quantitative data and quantify qualitative data. Quantification can be performed by, for instance, assigning a value of 1 to the selection of an item and a value of 0 to non-selection.

3.2 Overview of Course Materials and Page Views

Collecting data on page views necessitates preparing course materials on Moodle in advance. In Moodle, PDF, Word, Excel, and Text document users can employ various file formats, such as external referrers. This study primarily used PDF files that are viewable through a PDF viewer by clicking on a link in the table of contents created in the Moodle topics format, which is commonly used in Moodle-based courses.

Because topics can be easily entered into the Moodle system, we created a digital section that corresponds to the table of contents of paper textbooks by entering the heading that corresponds to a chapter section and minor material items. When students click on these topics and browse the course materials (corresponding to Moodle resources), the topic name (resource name) and course material browsed are recorded in a log and displayed in table form. This process retrieves page views.

Table 1: Example page views (Used material's page views) in-class of Excel format of Moodle logs.

Saved at:14 December 2015, 14:21 PM			Teacher's page views		
Course	Time	IP address	User full name	Action	Information
21Z95200-B	2015/12/14 13:02	192.168.10.73	Teacher	course view (http	0.1 Introduction to software
21Z95200-B	2015/12/14 13:03	192.168.10.73	Teacher	quiz view (http:/	0.2 Quiz Chapter 8
21Z95200-B	2015/12/14 13:14	192.168.10.73	Teacher	course view (http	0.1 Introduction to software
21Z95200-B	2015/12/14 13:15	192.168.10.73	Teacher	resource view (ht	9.2 Basic style sheet
21Z95200-B	2015/12/14 13:17	192.168.10.73	Teacher	resource view (ht	9.6 Pseudo-classes and color of link
21Z95200-B	2015/12/14 13:22	192.168.10.73	Teacher	course view (http	0.1 Introduction to software
21Z95200-B	2015/12/14 13:28	192.168.10.73	Teacher	resource view (ht	9.7 Display position of the image
21Z95200-B	2015/12/14 13:38	192.168.10.73	Teacher	resource view (ht	Sample sentences
21Z95200-B	2015/12/14 13:55	192.168.10.73	Teacher	resource view (ht	10.0 Overall layout
21Z95200-B	2015/12/14 13:56	192.168.10.73	Teacher	resource view (ht	10.1 Margin of the text
21Z95200-B	2015/12/14 14:04	192.168.10.73	Teacher	resource view (ht	10.2 Indent
21Z95200-B	2015/12/14 14:15	192.168.10.73	Teacher	resource view (ht	10.3 Layout of the background
21Z95200-B	2015/12/14 14:16	192.168.10.73	Teacher	url view (http://l	Students' web page

3.3 System Configuration and Data Processing

The steps of the algorithm used for TSCS table generation can be summarized as follows: (1) Download logs in Excel format from Moodle, with focus on the logs recorded on lesson day, (2) Retain data that contain lesson times and remove those without lesson times, (3) Extract the page views of the teacher, (4) Use the page views of the teacher to distinguish materials that are used and unused during a lesson, (5) Incorporate the time series data into the string at 1- to 5-minute intervals, (6) Generate a TSCS table of page views for course materials, (7) Produce a TSCS table of page views of students, (8) Generate a graph to visualize TSCS data.

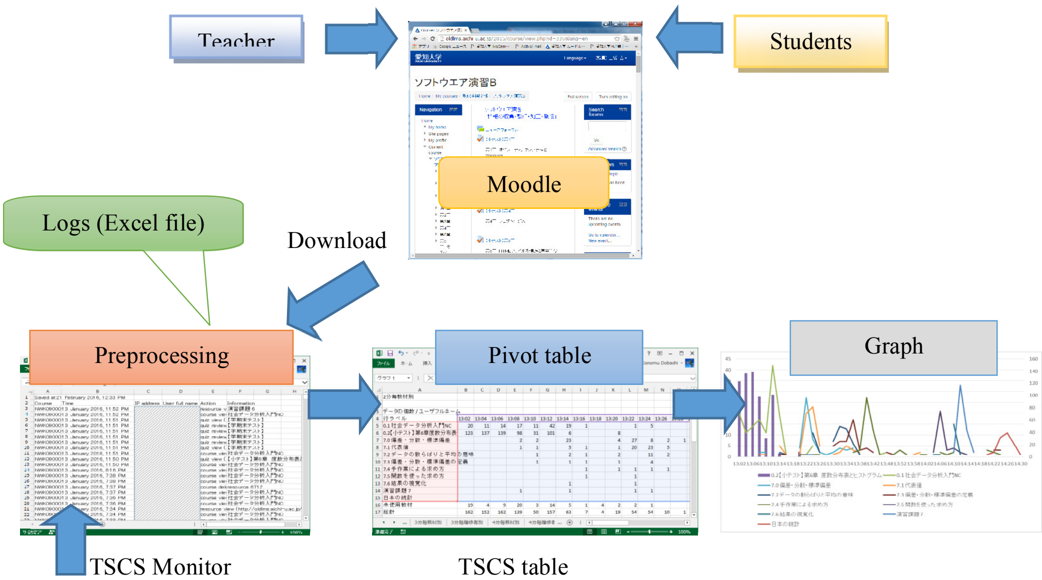

Figure 2. Flow of processing and TSCS table.

4. Experiment

Moodle’s capability for downloading and collecting data on page views was used in this study. As previously stated, we developed a system that analyzes logs and employed it to create course materials. The system was developed using an Excel macro to be used in actual classes. Permission was acquired from the Moodle administrator of the case university to create an account that provides the same privileges as those offered by a general student account. This account affords both teachers and students access to course materials during class. Additionally, the account was prepared as a course management account with which logs and course materials can be managed. The account course administrator was used primarily for functions such as downloading logs of a lesson and it was used on the notebook computer.

4.1 Overview of the Whole Class for a Comprehensive Perspective

To demonstrate how a TSCS table is generated, the macro that was developed was used in an “Introduction to Software” class offered at the case university. Table 2 is the TSCS table of page views for course materials. The course materials contain commentary concerning HTML and CSS, and students learn how to make and design web pages. On December 14, 2015, the teacher discussed the lesson for 90 minutes. The lesson was initiated at 13:00 and ended at 14:30. Table 2 and 3 illustrate the TSCS table generated at 1-minute intervals, downloaded at 14:21 from Moodle logs and aggregated.

Twenty students attended the lesson that day. First, a quiz was given in the classroom. The teacher then opened thirteen files (Table 1). Table 2 shows all the course items used in the lesson and displays the number of views in a time series. From such a table, it is possible to identify the more heavily engaged portions and the less heavily engaged portions of the lesson.

Table 2: Example of a TSCS table for used course items by minute of class time (Introduction to Software, Saved 14 December 2015, at 14:21 PM).

Saved at:14 December 2015, 14:21 PM																			
Number of data / User full	Column label																		
Row label	13:00	13:01	13:02	13:03	13:04	13:05	13:06	13:07	13:08	13:09	13:10	13:11	13:12	13:13	13:14	13:15	13:17	13:18	13:19
0.1 Introduction to softwar	3	8	2	2	4	1	2	2	1	2	5	12	5	9	6	1			
0.2 Quiz Chapter 8	5	48	33	32	55	24	10	14	12	1	10	58	14	11	3				
9.2 Basic style sheet																14			1
9.6 Pseudo-classes and color of link																	12	2	
9.7 Display position of the image																			
Sample sentences																			
10.0 Overall layout																			
10.1 Margin of the text																			
10.2 Indent																			
10.3 Layout of the background																			
Students' web page									1	1		1			1				
Unused materials		2			1			2	2	6				3	3				
Page views	8	58	35	34	60	25	12	18	16	10	15	71	19	23	13	15	12	2	1

See Table 5

Row label	13:20	13:22	13:25	13:28	13:29	13:30	13:31	13:32	13:33	13:37	13:38	13:39	13:40	13:41	13:44	13:45	13:46	13:48	13:54
0.1 Introduction to softwar		1		1															
0.2 Quiz Chapter 8																			
9.2 Basic style sheet							1												
9.6 Pseudo-classes and color of link	1	3	1				1			1									
9.7 Display position of the image				10	1	1	1	1	1	1	1			1		2	3	1	
Sample sentences											13	3	3		1				
10.0 Overall layout																			
10.1 Margin of the text																			
10.2 Indent																			
10.3 Layout of the background																			
Students' web page																			
Unused materials					3						1				1				1
Page views	1	4	1	11	4	1	3	1	1	2	15	3	3	1	2	2	3	1	1

Row label	13:55	13:56	13:57	13:58	13:59	14:02	14:03	14:04	14:05	14:06	14:10	14:15	14:16	14:17	14:18	14:19	14:20	Page views
0.1 Introduction to softwar					1								1		1			70
0.2 Quiz Chapter 8																		330
9.2 Basic style sheet																		16
9.6 Pseudo-classes and color of link																		21
9.7 Display position of the image		1				1												26
Sample sentences	1		1				1											23
10.0 Overall layout	5	2			1													8
10.1 Margin of the text		9	2	1	3													15
10.2 Indent								11	2	3								16
10.3 Layout of the background	1										1	3						5
Students' web page													13	1	3			21
Unused materials	1		2		2		4									4	1	39
Page views	8	12	5	1	7	1	5	11	2	3	1	3	14	1	4	4	1	590

See Table 4

See Table 5

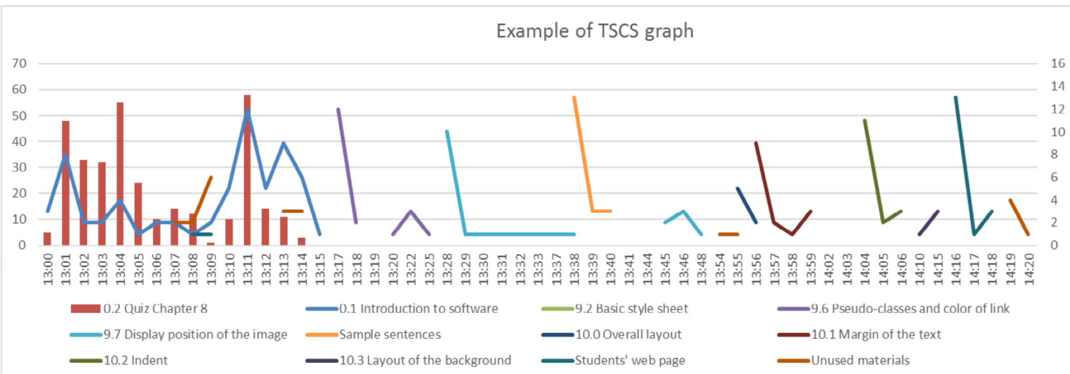

Figure 3. Example of a TSCS graph for used course items by minute of class time (Introduction to Software, saved 14 December 2015, at 14:21 PM, Twenty students attended).

The graph in Figure 3 was created from Table 2. In total, five quizzes were given in this class during the term. We have created a complex graph because the viewing times of the quiz are relatively larger than the viewing times of course materials. The left side of the bar graph in Figure 3 shows the number of views of the quiz; the scale is at the left. The line graphs show the number of views of course materials; the scale is at the right. The higher mountain portions of the graph indicate that there were many page views; the lower mountain portions indicate fewer page views.

Table 3: Example TSCS table for the entire list of students in the class (Introduction to Software, Saved 14 December 2015, at 14:21 PM).

Saved at:14 December 2015, 14:21 PM																					
Number of c	Column label																				
Row label	13:00	13:01	13:02	13:03	13:04	13:05	13:06	13:07	13:08	13:09	13:10	13:11	13:12	13:13	13:14	13:15	13:17	13:18	13:19	13:20	13:22	13:25
Student01				4	4	5							2						1		1	
Student02		4	1	1	5							7	1	2		1	1			More data cut here		
Student03	1	6	3		1	2	2		2	8		2	2	3	2	1						
Student04	2	2	1	1	2		1	5	8			1	8	3		2						
Student05					5	1	1	4				7	2				1					
Student06	1	3	1	1	8						1			1	1	1	1					
Student07		3	2	2	1	4					1	2		1	1							
Student08		4	2	1	3	4						5		1		1					1	
Student09		3	2	2	4				1			6	1	8		1	1					
Student10		3	1	2	2	3	1					7				1	1					
Student11		4	3	3	6					2		3			3	1	1					
Student12		5	3	3								10				1	1				1	1
Student13		4	1	3	3						1	4						2				
Student14		4	2	2	3							2			1	1	1					
Student15		5	2	1	3						1	1		3	3							
Student16		4	2	1	1	3	1				1	1				1						
Student17			4	1	3	1	3	6			10											
Student18				4	1	2		3	5			8	2	1		1	1					
Student19	4	1	2	1	3							4	1				1					
Student20		3	2		2		3					1			1	1	1					
Teacher			1	1											1	1	1				1	
Page views	8	58	35	34	60	25	12	18	16	10	15	71	19	23	13	15	12	2	1	1	4	1
Students	4	16	17	17	19	9	7	4	4	2	6	17	8	9	7	13	11	1	1	1	3	1

Table 3 is a TSCS table for the entire list of students who attended the lesson. In Table 2, we can see the student viewing times and page views. Used when conducting a lesson, such a table can identify students whose views of a course item are delayed or indicate whether a particular student is viewing course items according to the instructions of the teacher.

In Table 2 and Table 3, some portions of the time data are not displayed; such portions have no page views. For example, the time of 13:21 does not appear in the table, indicating that no students were viewing the course material at that time.

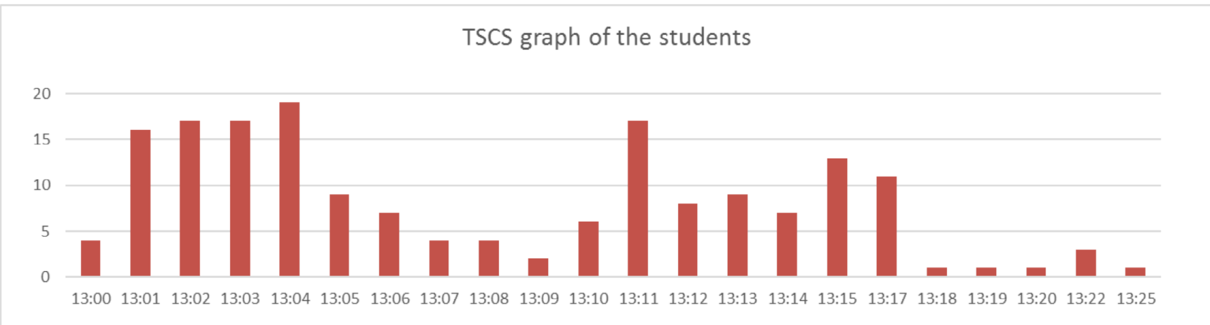

Figure 4. Example of a TSCS graph for the entire list of students in the class (Introduction to Software, Saved 14 December 2015, at 14:21 PM)

The graph in Figure 4 was created from Table 3 using the time data and the corresponding number of students. It shows, minute-by-minute, the number of students who opened the course materials.

As mentioned above, twenty students attended the lesson. However, there was no time interval during which all of the students opened the course material. Students who did not open the course materials on their own computer may have been looking at the teacher's projector. Although the quiz continued until 13:10, it can be seen that more than half of the students had completed it by 13:04.

4.2 *Overview for a Particular Resource*

Table 4 is a TSCS table of page views for a particular course item (here, “10.1 Margin of the text,” as shown in the fourth row from the bottom in Table 1) in the lesson. It displays page views of the targeted item by individual students during each minute of class time. In Table 4, the row showing the teacher’s page views indicates that at 13:56 the teacher instructed the students to open the course item. Six students exhibited a delay in accessing the materials at 13:57, 13:58, and 13:59. As shown on the right side of the table, there is no value for total page views for six students in the class. However, this table does not track cases in which a student may have viewed or downloaded the item previously.

<u>Table 4: Example TSCS table for particular course item in the class (Introduction to Software, Saved 14 December 2015, at 14:21 PM).</u>

10.1 The margin of the text																	
Number of	Column label																Page
Row label	13:00	13:54	13:55	13:56	13:57	13:58	13:59	14:02	14:03	14:04	14:05	14:06	14:10	14:15	14:16	14:17	views
Student01						1											1
Student02	Left side no data			1											Right side no data		1
Student03							1										1
Student04							1										1
Student05				1													1
Student06				1													1
Student07																	
Student08				1													1
Student09				1													1
Student10				1													1
Student11					1												1
Student12				1													1
Student13																	
Student14																	
Student15																	
Student16																	
Student17							1										1
Student18				1													1
Student19																	
Student20					1												1
Teacher				1													1
Page view				9	2	1	3										15
Students	0	0	0	8	2	1	3	0	0	0	0	0	0	0	0	0	14

5. Using Pivot Table Functions

We developed TSCS Monitor to automatically generate useful pivot tables in Excel. Thus, in the table discussed above, it is possible to utilize the functions of an Excel pivot table to produce a more detailed data analysis. For example, Table 2 is a TSCS table for the course materials used in-class that shows the opening of course materials by the class as a whole. By utilizing a function of the pivot table, it is possible to view the situation in more detail.

To illustrate, if we double-click on the course material cell on Table 2, we can display student names, IP addresses, and so on. Table 5 shows an example in which we have added individual student page views for the “Indent” course materials highlighted in Table 2 (and shown as "10.2 Indent" in the third row from the bottom in Table 1). Since the teacher’s name is at the bottom of the list of names, we can be see when the teacher gave the instructions to the students, making it possible to identify students who delayed opening the materials.

Table 5: Example of a TSCS table and pivot table function (Introduction to Software, Saved 14 December 2015, at 14:21 PM)

3	Number of data / User full name															
4	Row label	13:58	13:59	14:02	14:03	14:04	14:05	14:06	14:10	14:15	14:16	14:17	14:18	14:19	14:20	Total
5	0.1 Introduction to software		1								1		1			70
6	0.2 Quiz Chapter 8															330
7	9.2 Basic style sheet															16
8	9.6 Pseudo-classes and color of l															21
9	9.7 Display position of the image			1												26
10	Sample sentences				1											23
11	10.0 Overall layout		1													8
12	10.1 Margin of the text	1	3													15
13	10.2 Indent					11	2	3								16
14								1								1
15							1									1
16								1								1
17							1									1
18								1								1
19						1										1
20						1										1
21						1										1
22						1										1
23						2										2
24						1										1
25						1										1
26						1										1
27						1										1
28						1										1
29	10.3 Layout of the background								1	3						5
30	Students' web page										13	1	3			21
31	Unused materials		2		4									4	1	39
32	Page views	1	7	1	5	11	2	3	1	3	14	1	4	4	1	590

Course items

Total page views

Delay

Students

Teacher

6. Discussion and Conclusion

If one were to attempt to manually produce information similar to that provided in the TSCS tables, it would take approximately one hour or more. By contrast, using the macro described here requires only a few seconds. To achieve maximum effect, a teacher should be able to quickly incorporate data such as the number of student page views and the material content being viewed into their assessment of their classroom effectiveness.

If the data reveal a low level of student browsing of class materials, this may well indicate that the instructions and descriptions that the teacher is providing to students may be insufficient. This issue prompted us to develop an independent means for determining whether teacher explanations or instructions are, in fact, effective. Accordingly, lectures were documented by using a voice or video recorder—a countermeasure that can be easily implemented to assess effectiveness at a later time.

TSCS tables have undeniable possibility of looking at student activity in downloading materials. Clearly, after a teacher provides directions for opening an item, students will spend several minutes accessing the resource. This lag should be considered before teachers advance to the next part of the lesson.

In this paper, we described how Moodle logs and TSCS Monitor can be used to efficiently generate TSCS tables that track in-class course material page views by teachers and students. With these tables, one has a minute-by-minute, bird's-eye view of the page views and viewing times for all the various course items. The generated tables make it possible to look at changes in page views for individual students throughout the class period and can provide the means to assess the reactions of students to the teacher's instructions. Additionally, they can identify students who fail to open some of the course items, are delayed in opening some items, or are viewing course items not used in the lesson. Such features can be extremely valuable as a guide to teaching and learning improvement.

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Time Well Spent: A Data Warehouse Solution for Temporal Analyses of Educational Data

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Abstract: Education is an important area for data analytics; recent buzz words are Learning Analytics and Educational Data Mining. This paper present the work accomplished in the context of the Lea's Box project. Two main work strands are presented; first a technical solution for an educational data mining and learning analytics data warehousing concept that completely rests on open source software will be presented, together with its future development plans to make it accessible as a service for various data input points via xAPI. After a reflection on the obstacles faced by research that collects data from real-live educational environments, together with lessons learned by the project and possible solutions for future projects, temporal analyses of single tasks carried out by students in US middle school are presented.

Keywords: data warehouse; learning analytics; visualization; xAPI; MySQL; interconnectivity

1. Introduction

Lea's Box 1 (www.leas-box.eu) is a European research and innovation project that brings together two industry partners from Turkey and the Czech Republic with the University of Birmingham, UK and the Technical University of Graz. It is, in part, a continuation of the successful work of the Next Generation Teaching, Education and Learning for Life (NEXT-TELL) project that ran from 2011 until 2014. Lea's Box was designed to undertake research and development of tools that serve practitioners both in formal as well as informal sectors in the educational world in real-live, i.e. technology sparse, environments with little or non-existing knowledge of software handling. In the focus of the project is using educationally relevant data to optimize teaching by providing teachers with deeper insights into the learning processes of individual students. In contrast to typical (data rich) Learning Analytics scenarios (e.g., in eLearning courses), the project is focusing on the (data lean) settings of typical school education. Thus, the project envisions developing simple tools that allow teachers to bring all the available bits of data from various sources together, to analyze and visualize them in a suitable way. One key part, which is presented here, is having a broad data model in place that allows working with incomplete and extremely diverse data and, perhaps more importantly, that is able to cover all the various needs of teachers – independent of school type, age level, proficiency, or school system.

In this paper we present a data analysis warehouse solution and a complex data model that is to be understood in this context of need for stable, simple and meaningful software solutions. Its main purpose is to serve as a central hub of diverse sources of information that needs to be transformed into insight about learners, used by themselves as by teachers or administrators. In this way it is comparable, in nature, to the integrated designs (Masud and Huang, 2012; Rayon, Guenaga, and Nuñez, 2012) . Moreover, as the xAPI (https://github.com/adlnet/xAPI-Spec/blob/master/xAPI.md OR http://experienceapi.com/) is used as the connection to data sources, it holds the capacity for future tools to put data into and obtain it from the database, as needs arise. From a psychological/educational viewpoint, it serves as a transmission belt to generate a sound and high-speed basis for formative assessment about competencies, tasks and learning assignments, carried out by individual as well as groups of students. It should, in the near future, broaden the capability of tools like *myClass*[3], the Open Learner Model (Bull et al., 2016) and other existing educational software. Additionally, it can enhance the availability of visualization services such as.

[3] Accessible at www.leas-box.eu

Regarding the focus of the analysis of this paper, temporality in quantitative measures of student's actions, a perspective on the individual on a micro level (referring to the diagnosis within the fine facets of behaviors in learning objects, exercises, test items, etc.) seems to be missing in the current literature. Although there have been attempts to remedy the situation and increase the awareness for the benefit and necessity of a conceptual inclusion of a timely perspective that informs about order and the arising narrative (cf. Reimann, 2009) or a proof of concept in a qualitative empirical way, the common analysis takes the form of a longitudinal analysis on the meso (i.e., learning objects level) or macro (i.e., course) level. Such grand-scale analysis (Jo, Kim, and Yoon, 2014) is undoubtedly with merits, but more informative for administrators or fit for large scale courses as in universities or vocational schools in China. The insights to be gained by such a micro level analysis and the usage of them in classroom situations or for individual learner's advance of their study is thus presented in the final section of this paper.

2. Database

2.1 Concept

The database described in this paper was designed and deployed as part of the multi-partner international research and development project Learning Analytics Toolbox (referred to from here on as Lea's Box). The project:

"[...] aims at a competence-centered, multi-source learning analytics methodology based on the foundations of sound psycho-pedagogical models, intelligent model-based reasoning services, innovative visualization techniques, tailored to the very concrete demands and requirements of teachers and learners" (unpublished description of work for the project), see also (Kickmeier-Rust, Bull, and Albert, 2016). Fig. 1 displays the overall concept of the project. The database of this paper is located in the lower right, to provide central data filtering, data aggregation and data storage capability.

The design had three focal points: (1) simplicity at first, with simple and basal data flow destination points within the database architecture, (2) high capacity for different sources, that would create a diverse and sometimes unforeseeable influx of data, (3) transferability, since the project needs to publish all code as open source after the wrap-up, so the ease of putting the database to work somewhere else was deemed of high importance.

As MySQL was used at other parts of the project, it was deemed sufficient for the task at hand. This may be unconventional, since other database management systems were specifically designed to match the requisites of a data warehouse/data mining task, as MonetDB (Idreos et al., 2012), MongoDB (Rayon, Guenaga, and Nuñez, 2012) or cloud architectures (e.g., Sonwalkar, 2013).

Nonetheless, MySQL has the huge advantage of a widespread use, low threshold due to non-existent costs accompanied by an exhaustive documentation and quick transferability to other database management systems.

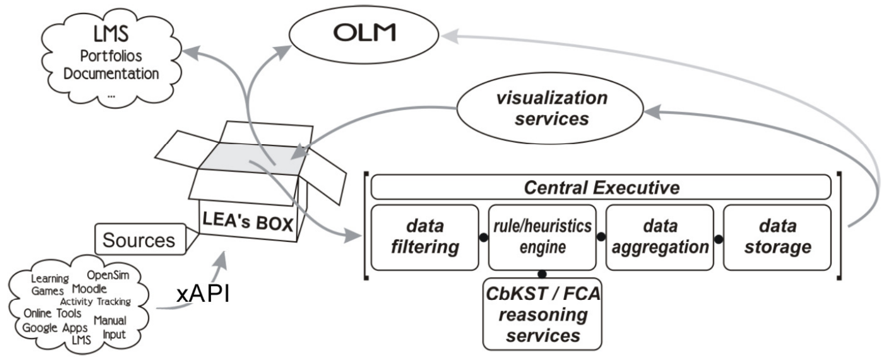

Fig. 1. Extended architecture of the Lea's Box system.

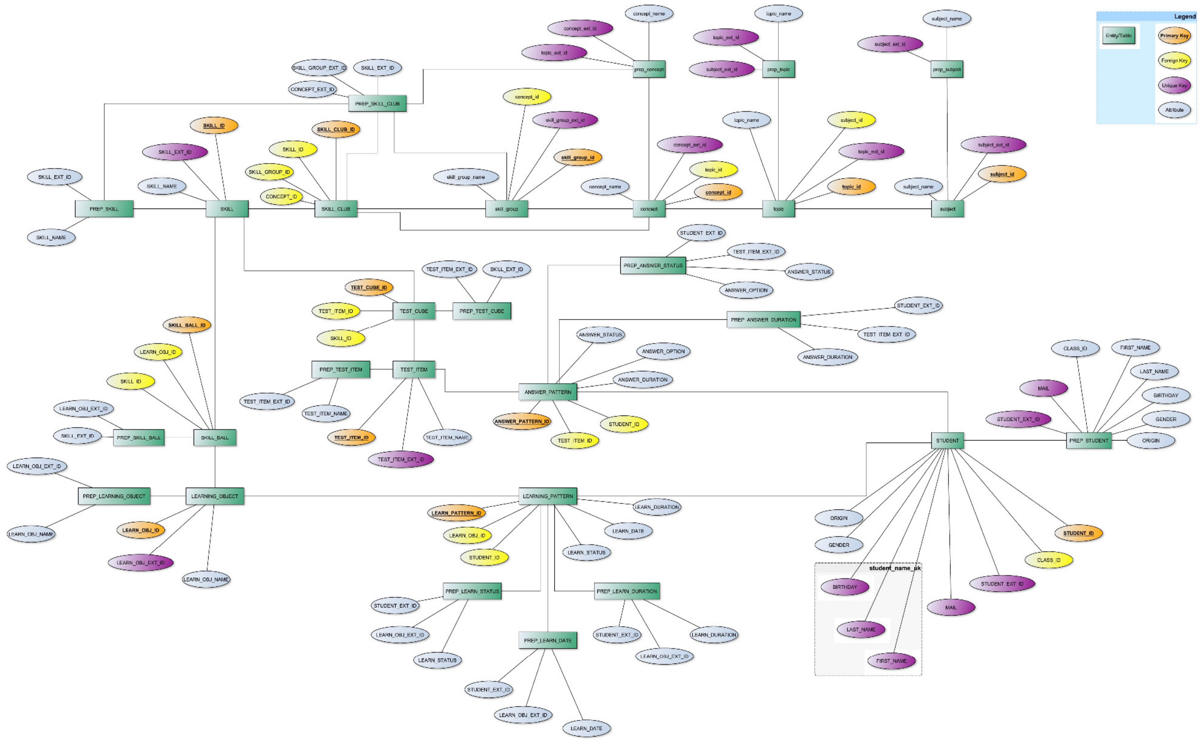

Fig. 2. Lea's Box data model.

Since other successful implementations of a data warehouse exist with MySQL, as shown by business practitioners (Anguanti, 2011; Sennhauser, 2016) educational institutions (Ingham, 2000), or have been integrated into big data solutions [18], the value of such solutions has been demonstrated. In addition, for a small project as Lea's Box, quick development, deployment and plug-in capacity are of utmost importance.

Within the database, a hybrid architecture with third normal form and a dimensional presentational area as suggested by Thusoo et al. (2010) are currently developed. The third normal form has been realized already. The hybrid approach was chosen to better fit the presently existing databases in the project. To make the database capable of high-speed data communication, a dimensional area with as few joins necessary as possible for queries, is in planning for the final phase of the project, to start with this summer. This will have to be weighed against the question of easier data integration from out-of-the-project sources like Moodle or inside-the-project sources like the Open Learner Model of the University of Birmingham (Bull et al., 2013) a partner in the project.

The final issue that was kept clearly in mind regarding the concept of the database was the potential barrier that a sophisticated extract, transform, loading (ETL) system could have posed for integration of data and for the budget of the project, both in time and financial resources. For this reason, a staging area (preparatory, or PREP, area) within the database was realized, that enabled it to write data into the database that possesses many NULL values and transform it within the database, without the need to lay another level of software between an outside source, the API and the services of the database.

2.2. Design

The overall design of the database is visible in Fig. 2. A snowflake structure design was deemed most appropriate. Differing from a design by the textbook, the database was built to have a four-fold center, which coincides with the possible angles of analyses. These are:

1. skills/competencies
2. test items/answers
3. content/learning accomplishments
4. personal data

Skills/competencies are central to the Lea's Box psycho-pedagogical structure that is competence focused, with a pronounced depth of skill hierarchies that can be more than 10 levels deep and might also be configured as tridimensional maps of complex relationships. The model should fit this layout. Personal data so far has been captured mainly to identify groups and control variables for analyses, but should be thought of as a slowly changing dimension that might lead to new insights once longitudinal data is put in. The difference between test items and learning accomplishments is that the former are defined by answer options that yield a (more) correct/incorrect outcome at some point, whereas the latter are characterized by a structure that differentiates between participation statuses alone.

The presentational area so far is work in progress. Although impressive access to information is possible even now, as can be seen from the section about temporal analysis in this paper, the presentation to an audience that is less technological savvy is still open. Several approaches are pursued, either by integration into established systems like the OLM or Moodle (in future, via the xAPI[4]) or by new solutions from the project, such as landscape visualization. For this part of the database that should have the capacity to act as a standalone service, processing data transferred via the xAPI, a dimensional model will be developed during the final months of the project in late 2016. This will make the queries faster and present a cube like data structure, being geared to the standards of Business Intelligence applications. This area will make the slicing and dicing of educational data available to administrators and practitioners alike.

The xAPI was selected as the connection most appropriate for the database, as it has demonstrated tremendous capacity for interoperability (Kitto et al., 2015), providing an easy, quick and secure transfer of educational data (Judrups, 2015).

2.3. Obtaining data

Between the preparedness of the structure and the results in a live school environment, there are huge obstacles that manifested in the quest of obtaining data. First of all, schools in Europe are, generally speaking, technology sparse organizational systems. This leaves much to be desired in the realm of data capture. And apart from what influential glossy technological magazines might fantasize about (Anderson, 2008), the age of data storage in the petabyte dimension still needs models, especially where hypotheses are central to not only making a process visible but making it understandable and in this way changeable. Barbera Gros, and Kirschner (2015) were dead-on when they stated that: "This perception of more time spent and higher workload [as a consequence of technology implementation]

[4] https://www.adlnet.gov/adl-research/performance-tracking-analysis/experience-api/

has been found to be related to a lack of knowledge of and abilities with respect to ICT for teachers and administrators." It will not do to hope for the rise of a "digital native", tech-savvy cohort, finding their place in educational organizations.

The question remains open of how to get schools to work together with researchers when the resources perceived to be scarcest by the practitioners are attention and time. Nor do school children leave a digital footprint that is easily accessible to scientists, nor should it be. Lessons learned from the project were that a tight-knit interpersonal relationship is necessary, which takes time to build up and that cooperation base firstly on persons and not organizations. One result of this is that, especially schools that are advancing in technological implementations, are feeling beleaguered by requests to dedicate more time of their professionals and students to undertakings that have no calculable return on investment or clear sustained future, being based on project-to-project funding.

Additional obstacles faced by the authors were strict and sensible rules and guidelines on data privacy and tracking. Higher education systems like universities or academies for professional have the ungrudgingly existent advantage of their students being of age or even customers that are in a contractual relationship. This results in a documentation that is both rich and deep in nature, if the institutions have the necessary funding. It is an answer to be found how these high standards of data privacy, clear-cut reduction to only the indispensable intrusion into the stream of information produced by students or teachers and advancements of epistemological meaningful results can be married.

To test the usefulness of structures and also to overcome the question of what is in for the schools targeted for study, data simulation might be of great use. Typically, after gaining confidence of a single teacher, implementation and wider spread of usage is mostly word-of-mouth propaganda within the organization, which, without belittling the importance of that to gain insights into school procedures in the field, is of limited use in the short time frame of most scientific projects. But with insights presented to the administration that are generated from the projected path of a few hundred students over the next few years, and are based on scientifically sound assumptions and axiomatic verifiable models, the path of entrance into educational data might be smoothed. However, so far there seems to be a lack of models to soundly compute individual student's data, especially in the area presented in the next section.

3. Temporal Measures as Distinct Features

As Barbera, Gros, and Kirschner's (2015) systematic literature analysis shows, time is both central and peripheral to educational research.

Its central status derives from the fact that ICT modifications of existing learning practices, usually desired to be an improvement or at least an amendment, are time-focused: They are constrained by the fact that they are "time-consuming" for students and teachers alike while they are heavily relying on the timely delivery of their content. Their advantages are also quite often of a temporal nature, as they promise an asynchronous availability of feedback, support or content as a benefit; additionally, a more speedy delivery through channels formerly not used for education promises a more focused and uninterrupted learning process, as in the case of flipped-classrooms via learning management systems or mobile applications.

Peripheral is time in educational research with the meaning of that it is seldom assessed as an end in itself. Most of the time, temporal measurements are used as control variables for other measures, e.g. retained knowledge, delivered content or degree of competency acquired. The educational community wants for research designs that focus on the usage of time, as proposed by a longitudinal research design which is event-centered, that [9] advocates.

Arising from the nature of the data processed so far, a longitudinal examination was not possible. However, the database can considerably facilitate a combined variable-event-approach by providing both information on temporal factors and of the choices, events and order of tasks or activities that were undertaken. This brings the goal to exhaustively use the temporal data of students closer into reach of researchers, practitioners and organizational specialists.

Apart from the availability of an otherwise neglected resource, data about time is crucial for pedagogical success in other ways, too. As an example for the deployment of temporal resources, of which there are way too less studies for a thorough model, Langa (2013) found that teachers in tertiary education generally lacked instructions for their students about how much time they should allocate to self-study time, with sometimes quite negative results. Although there is not a clear relationship between time dedicated to self-study and educational success, spending more time on individual assignments lead to higher achievements in this study. This finding is corroborated by the extensive study of Morris, Finnegan, and Wu (2005), which tracked students for 1.5 years in their online coursework. A clear distinction arose between the three groups of (successful) completers and the non-completers of the courses, most heavily correlating with the amount of time spent on discussion pages and the amount of content/discussion pages read.

These findings point to the close connection between engagement, resource-allocation and achievement. However, as remarked above, without a more fine-grained analysis that takes into account order of activity and also more acute measures, the predictive value and the feedback to the author/teacher of a course remains foggy at best. One should not assume that "data speaks for itself", but remain aware of the close limitations that raw and coarse-grained data entails (Long and Siemens, 2011).

When considering middle or high school children who are a fair bit more dependent on exact and stepwise instructions, one cannot stress enough that temporal measures of tasks handed out for self-study are important, as results of homework are generally graded or given feedback upon after a relatively long time has passed, sometimes weeks.

3.1. Data analysis

The data that was analyzed for the purpose of this paper, as a proof of concept, stemmed from an extra-curricular activity in middle school biology, focusing on evolution. Thus, the activity is under more intense scrutiny for its benefit by both teachers and students as it lacks the authority of the official textbook for the course. The provider of the course, however, only gives feedback on "traditional" measures: content viewed/(non-)completed, (un-)successful answer to test items, aggregable by group only. To complement the great content with further use for the learners and teachers, the logged data was examined completely with regard to creating additional value for further implementations.

The temporal analysis was deemed most useful, since it a) is directly available after the completion of a segment of the course, is b) easily comparable across students and groups and teachers and c) provides information that is not obtainable for classroom or homework activities unless huge efforts are taken or costly technology is available.

The data set consists of the log-data of a total of 105 students that viewed three information sources (learning assignments) which were presented to them online. After the familiarization with the content, the students answered five test items which were logged as either "correct", "incorrect" or "not completed". The time of viewing per learning assignment and the time until an answer was given were also monitored for each individual student.

All student data was anonymized before it was sent to the database by the vendor of the online course. The only information disclosed were the grade of the students, a group membership on class level, as given by the teacher, and their location on state level. All students were in the 7th grade and were from Texas, USA. The whole set comprised 6 groups of Science classes. Even though the number of students per group was unevenly distributed, with rather low numbers per group, a group-wise analysis was conducted for purpose of demonstration.

Keeping in mind that the analysis should be something that is easily understandable without statistical background and should also be simple to visualize, (un-)completed assignments and a temporal analysis of completed assignments was conducted firstly. The limitation on completed assignments arose from the circumstance that, sadly, the vendor did not log temporal information on uncompleted assignments.

It can be discerned from Table I that even though the average time of completion of the learning assignments per group is evenly distributed, there is a considerable difference in the deviation from this mean. This would be valuable information for a teacher, pointing to difficulties and to different learning strategies, as well as time spent on homework assignment, an insight normally not available.

TABLE I. TEMPORAL ANALYSIS OF THE ASSIGNMENTS

Group	N[a] of students	Students' achievements		
		Sum of CA[b]	*Sum of UCA*[c]	*Average time of completed items (SD)*[d] *[s]*
Science 7, 2nd	15	45	0	519.31 (353.46)
Science 7, 4th	15	44	1	459.52 (285.28)
Science 7, 6th	23	62	7	497.69 (417.75)
Science 7, 7th	15	43	2	507.09 (469.79)
Science 7, 8th	16	48	0	513.90 (421.91)
Science 7, 9th	21	53	10	542.04 (579.89)

a. Number
b. Completed Assignments
c. Un-completed Assignments
d. Standard Deviation

In contrast to the learning assignments, for the test items presented in Table II, there exists temporal log-data for both correct as well as incorrect answers. Again, easily discernible are pronounced differences between the temporal patterns of the items. Items 2, 3 and 4 have low deviance regarding correct answers, which speaks for an established knowledge for these tasks. Contrasting that is the noticeable difference for test items 1 and 5. Although item 1 was the easiest, it had the biggest deviance for correct answers, on a level with item 5, which was the hardest. This contrasts with the intuitive assumption “easiest is quickest (for everyone)”.

TABLE II. TEMPORAL ANALYSIS OF THE ASSIGNMENTS

Test item	Sum of correct (incorrect) answers[a]	Students' achievements	
		Average time of correct items (SD)[b] *[s]*	*Average time of incorrect items (SD)*[b] *[s]*
1	98 (1)	19.85 (75.85)	137.00 (0.00)
2	96 (3)	17.60 (30.67)	11.33 (5.73)
3	94 (5)	13.80 (20.87)	7.00 (2.28)
4	91 (8)	18.36 (27.89)	43.00 (51.51)
5	88 (11)	60.55 (62.43)	50.00 (59.47)

a. Missing amount to 105 where non-reported values of six students, either due to technical issues or non-completion of the test item
b. Standard Deviation

Interestingly, a different pattern can be seen for the incorrect answers. Test items 2 and 3 are both quickly and evenly distributed answered incorrectly. However, both items 4 and 5 take considerably longer when they are answered incorrectly. This markedly contrasts for item 4, where incorrect answers took more than twice the time of correct answers.

4. Further Insights

The initial insights gained from the data underline the need for further inquiry into the temporal characteristics of pedagogical tasks. With scarcity of time constantly named as one of the top issues by teachers, students and parents, this irrecoverable, once spent, resource cannot be neglected when thinking about the advantages one could gain from an information-(en)rich(ed) classroom or learning system. Additional information about the time spent per task or content also gives rich feedback and substantiates discussions about learning patterns, styles and problems that arise from a forced (a) synchronicity of time spending in both formal and informal settings. For this, a research and monitoring approach that takes into consideration the importance placed on order, sequence and paths by Reimann (2009) can reap low-hanging fruits of data for increased relevance of evidence-based pedagogical efforts. To garner these rich data fields the overcoming of barriers, both in psychological/socio-cultural and technological /logistical areas seem a central obstacle. Time is intimate as it is unequivocally up to individual choices how it is spent. When and for which length tasks are undertaken speaks as much, sometimes even more, about consensus or dissent regarding educational matters than care, intensity and efforts shown in results. Therefore, as with all data, especially from minors, a careful balance has to be sought between increased empirical substance of decisions and the privacy and space for necessary mistakes or more vital tasks at hand for students.

5. Conclusions

Learning Analytics solutions that focus on less well-defined settings such as analyzing data of a specific e-learning system, where (a) all elements are designed tailored to this system and where (b) all activities occur in a digital environment, can easily work up the data and provide analyses to the educators. Learning Analytics solutions that aim at accommodating the various needs of different educational settings ranging from primary school to higher education up to workplace learning are confronted with much greater challenges. There are various, in parts incompatible, competence models, there are extremely diverse demands on a dynamic grouping of learners, there are diverse types of data life cycles, and there is an extremely broad range of data formats that are spilled into the system. Lea's Box is a project that is working in such complex scenario. The project's vision is to support teachers in their daily educational routines and provide them with means of using data and data analytics to optimize their teaching. In the typical school context, the data we can fall back on are thin, unfortunately. Usually, in school settings learning data are primarily generated by teachers' manual assessments and marking of students' works. Additionally, students use diverse learning apps, perhaps they accomplish an exercise in the computer lab every now and then, at best, homework is made in some electronic form. Such data basis is far from being coherent or complete. In far most cases they are not brought together as basis for educational decisions of a single teacher, even more seldom are scenarios where data 'owned' by multiple teachers are brought together. The reasons are quite clear: Most tools used in education do not provide a suitable data export and most Learning Analytics solutions cannot handle diverse and incomplete data. Lea's Box attempts to provide such solution. On the basis of open APIs and import features, we want to equip educators with a system that takes every bit of information that it can get and provides the best possible analytics for the teacher.

This, of course, is not trivial. In the past we saw a large number of attempts to develop educational standards and to achieve interoperability. Almost all failed in achieving a substantial uptake in education. Today, a good portion of tools used in school settings are not even primarily educational; teachers are using Google docs for homework, Dropbox for file sharing, or Minecraft for practicing. The way Lea's Box addresses the problem is to start from competence frameworks. We see competencies as the main entities in any educational setting; it's always about improving the knowledge, the skills, the aptitude of learners. We define competencies, we try to identify the relationships among them and we try to find a natural course of learning or development (Kickmeier-Rust, Bull, and Albert, 2016). Having such beacons, we provide an open system that allows linking all sorts of activities, all sorts of data as evidences for the competencies. By this means we can maximize the data sources that are contributing to learning analytics and support teachers in a competence-focused way in by providing open and transparent models of learners.

The essential foundation for such system is a data model that s capable of dealing with the described diversity and that is capable of analyzing the data in a high-speed and scalable way. In this paper we sketched the approach developed in the Lea's Box project. In ongoing user studies we are bringing the solution into practice and evaluate the effectiveness and adequacy of the approach. The studies run in various countries (i.e., Austria, Germany, the Czech Republic, Turkey, and the UK) and at various school levels. Our first experiences show that the described 'data analyses warehouse' meets these expectations and provides a strong and high-speed approach to 'ill-defined' learning analytics settings.

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Designing of LMS using in Flipped Classroom to Enhance Knowledge Transfer

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Abstract: Learning Management System (LMS) plays an important role in classroom. According to the increase of devices and connectivity, LMS becomes widely used in education institutes. The present study aims to purpose key elements and development process of the LMS usage in flipped classroom environment. System Development Life Cycle (SDLC) was used in the development phase while learning outcome was investigated in the evaluation phase. The target group of 22 students studied by using the LMS and flipped learning including 5 learning processes: 1) Knowledge acquisition; 2) Knowledge transfer; 3) Knowledge construction; 4) Knowledge reflection; and 5) Knowledge sharing. The results revealed that key elements of LMS composed of 5 elements: 1) Problem base and Learning task; 2) Knowledge Bank; 3) Scaffolding; 4) Collaboration; and 5) Coaching. The LMS was designed in Model-View-Controller (MVC) structure with Yii2 framework. It showed the relationship of retention and transfer test was positive (r = 0.569) and learning outcome of most students was constructivist learning (59.09%). However, no learning and rote learning were found among the students of 22.73% and 18.18% respectively. The guidelines for developer and the LMS can be used in the classroom are provided in this paper.

Keywords: Learning Management System, Flipped Classroom, Knowledge Transfer, Learning Outcome

1. Introduction

In this century, students are not only able to remember things but also able to transfer their knowledge to accomplish the tasks. Constructivist learning is a kind of learning outcome that students can both recall prior knowledge and transfer to appropriate problem (Mayer, 1996). From this perspective, retention and transfer skill are important. Flipped classroom is the pedagogy approach that focuses on learner-centered and widely used in the recent years. The concept of flipped classroom has been traditionally done during the class i.e. lecture is shifted to home activities such as homework and projects transferred to class activities (Sohrabi and Iraj, 2016). Therefore, knowledge transfer is essential to accomplish the learning objectives. Learning management system (LMS) is important to bridge this gap. It is not just resource repository but also to support learning process as well. There are advantages of web technologies such as geographically independent so that the student can study in their own time and place. It means they can control their learning process. This might encourage student learning motivation. When the class begins, they are ready to do activity more attentively. Specific purpose of LMS is needed to address this issue. This study aims to design the process of LMS using in flipped classroom to enhance knowledge transfer and investigate learning outcome among the students.

2. Literature review

Learning Management System (LMS)

Learning Management System (LMS) is the software for learning management. LMS is often used to deliver material, learning process management and support communication among learners and teachers (Bele, Mujkić, Bele and Mujačić, 2015). Student can search information or test. Nowadays, LMS is a form as web application and advantage of online learning. LMS can overcome geographically issue because student can learn at their own time and space. LMS consists of many technologies such as blog, wiki, discussion board or digital learning material. (Kaewkiriya, Utakrit and Tsuji, 2011; Partheeban and SankarRam, 2014). In previous study, Swart (2016) purposed the components of LMS into four sections: 1) Contents, 2) Assessment, 3) Communication and 4) Administration.

Flipped Classroom

Flipped Classroom is another kind of blended learning which has face-to-face (F2F) learning and online learning. Most activities in the traditional classes were inverted. Students perform knowledge acquisition (preparation) at home by watching video or another material and then perform activity in class. The term of flipped classroom originally came from teachers Jonathan Bergmann and Aaron Sams in 2007 (Sohrabi and Iraj, 2016). It was created to help absent students keep up with their classmate by using recorded video. By this method, mass learning group is accessible via using internet technology. Salman Khan invented Khan Academy and shared his thought at TED talk at the time he helped his cousin to understand the lesson by recorded videos. Nowadays, Khan Academy becomes global resources for people around the world (Khan, 2011). There is no official model for flipped learning. In this study, flipped learning is adapted from Kanjug's model (2014) and will describe in the next section.

Knowledge Transfer

Knowledge transfer is a form of knowledge acquired from one task or situation. It can be applied to different task (Nokes, 2009). Flipped learning students need to transfer knowledge outside the class into the class. We interest in the knowledge transfer mechanism purposed by Gentner, Holyoak and Kokinov, 2001; Nokes, 2009). It is "analogical transfer" which composed of three processes: 1) retrieve prior knowledge 2) creating a mapping with new context and 3) transfer to new context. We could use this concept to create learning task to support knowledge transfer.

Learning Outcome

There are two major goals of learning: remembering and understanding. Remembering is the ability to recognize the lesson learned which can be measured by retention test. Understanding is the ability to construct relevant knowledge to use in new situation which can be measured by transfer test. Learning outcome can be categorized into three groups: constructivist learning, rote learning and no learning. The difference of rote learning and constructivist learning depends on retention and transfer ability. Constructivist learners perform well at both of retention and transfer test whereas rote learner perform well at retention but poorly at transfer test. In addition, no learning means they fail in both at retention and transfer test. The concept learning outcome can be summarized in Table 1 (Mayer, 2001).

Table 1: Learning outcome.

Learning Outcome	Retention Test	Transfer Test
Constructivist learning	Passed	Passed
Rote learning	Passed	Failed
No learning	Failed	Failed

3. Method

System Development Life Cycle (SDLC) was used in development phase. The LMS was used with target group of 22 students in high school. The context was computer classroom with computer program subject. Learning outcome were derived from transfer and retention test. Correlation between transfer and retention test were investigated by using Pearson's correlation. In the following section, the details about development process will be described.

Preliminary Investigation

We purposed the framework design as shown in Figure 1. It consisted with 5 stages of learning outside the classroom activity and during class learning activity. From these learning processes, we form the elements of LMS which are essential to use in each process; 1) Problem base and learning task; 2) Knowledge bank; 3) Scaffolding 4) Collaboration and 5) Coaching. The description of each key element is shown in Table 2.

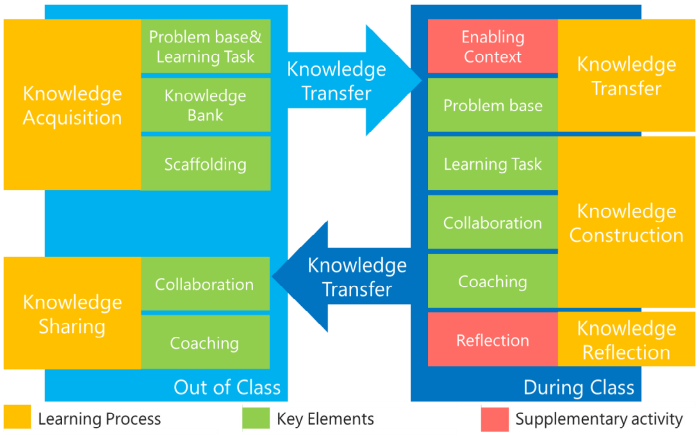

Figure 1. Framework Design.

Figure 1 illustrates framework design. There are 5 stages of learning process which are separated into 2 stages outside classroom activity and 3 stages during class activity. Students begin to perform knowledge acquisition by studying problem base and learning task. Knowledge bank and Scaffolding are provided to support students. After finishing individual preparations, they share their knowledge by using collaboration tool (in this study we use web board). Teacher provides feedback and facilitates students by observing learning activity. At the same time, other students learn from multiple perspectives from their classmates. During the class, students transfer their knowledge to perform activity. Outside classroom task and during class activity was shared common knowledge. This leads students to transfer their prior knowledge into new situation or problem solving. Enabling context and reflection are supplement activities when students are lack of attention or confuse with the lesson they learned.

Table 2: The key elements and descriptions of purpose LMS.

Key Elements	Description
Problem base & Learning Task	Authentic problems with meaningful tasks
Knowledge Bank	Knowledge repository for student to accomplish their goals
Scaffolding	Scaffolding composes of 4 types: conceptual scaffolding, metacognitive scaffolding, strategic scaffolding and procedural scaffolding
Collaboration	Place for collaborative learning and sharing.
Coaching	Teacher provide supports to help the student perform a task

System Analysis

We collected user requirement and then described as the use case diagram. The LMS has 2 types of user (actor) refer to Student and *Teacher*. Their functions to the system are shown in Figure 2.

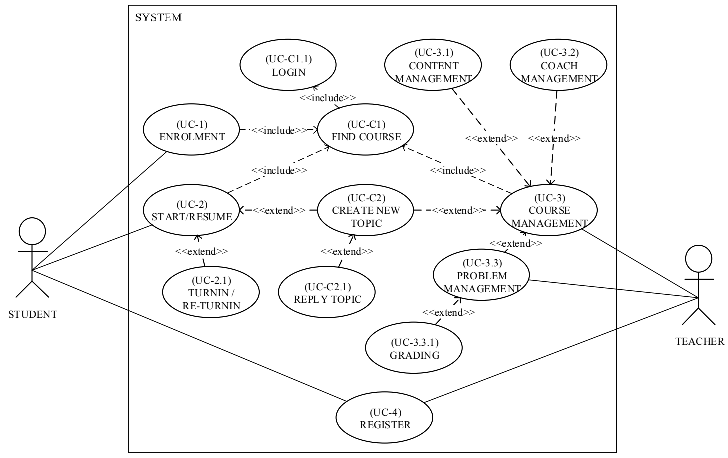

Figure 2. Use case diagram.

Teacher: The main function, teacher is responsible to create, update or delete the course. All information of the course such as course descriptions, problems of the tasks, scaffoldings, and coach information can be modified. Assignment can be added after the course has created. The LMS enable teacher to assign course work and due date as well as evaluation of student assignment.

Student: Student is responsible to enroll the course. After enrolling the course, students search for information provided and perform the learning task. Students submit the assignment. When the assignment is evaluated, student can get feedbacks and scores. They can choose to submit the assignment again and the submission history will be recorded.

The teacher and students can share problems or ideas by user registration or web board.

System Design

Yii2 framework was used to develop LMS. Yii2 framework is well known for developer. MVC (Model-View-Controller) structure is an application developed by Yii2 framework. The other advantage of Yii2 framework is the tool for coding generation; Gii. Developer do not need to code for CURD (Create, Read, Update, Delete) operation from the beginning, so Gii can reduces development time. The detail of MVC, data modeling and process are described as following.

Model-View-Controller Application Structure

The LMS was designed in MVC structure which separates the whole system into three sub-modules: Model, View and Controller.

Model is responsible to manage. It is lower module that closes to database. The important role of *Model* is to validate data and perform CRUD operation of database as well as manage relation between tables in database.

View is responsible to generate all the information in the web page (User Interface). Generally, the system renders information to the web browser bases on HTML (Hypertext Markup Language), JavaScript and CSS (Cascading Style Sheet).

Controller is responsible to perform logical part of system such as calculation, data filtering and selecting, route control etc.

Process and Data Flow of the LMS

The LMS data model and process by using data flow diagram as shown in Figure 3. In brief detail, we explore each process as follow. All registered users are managed by *User Management* which handles task of signing up. The data of new users will be stored in *User* table. Similarity with function of user is described by case diagram. Teacher has ability to create the course and update appropriate activity course information. This task is performed by *Course Management* which directly updates data in *Course* table. After course has created, students can enroll the course handled *Enrolment System*. All of enrolment transactions are recorded in *Enrolment* table. Student can submit their assignment via *Course Work Management* and teacher can evaluate student submission via *Grading System*. During learning activity, student and teacher can post or reply about the topic on web board. This task is handled by *Web Board Management.*

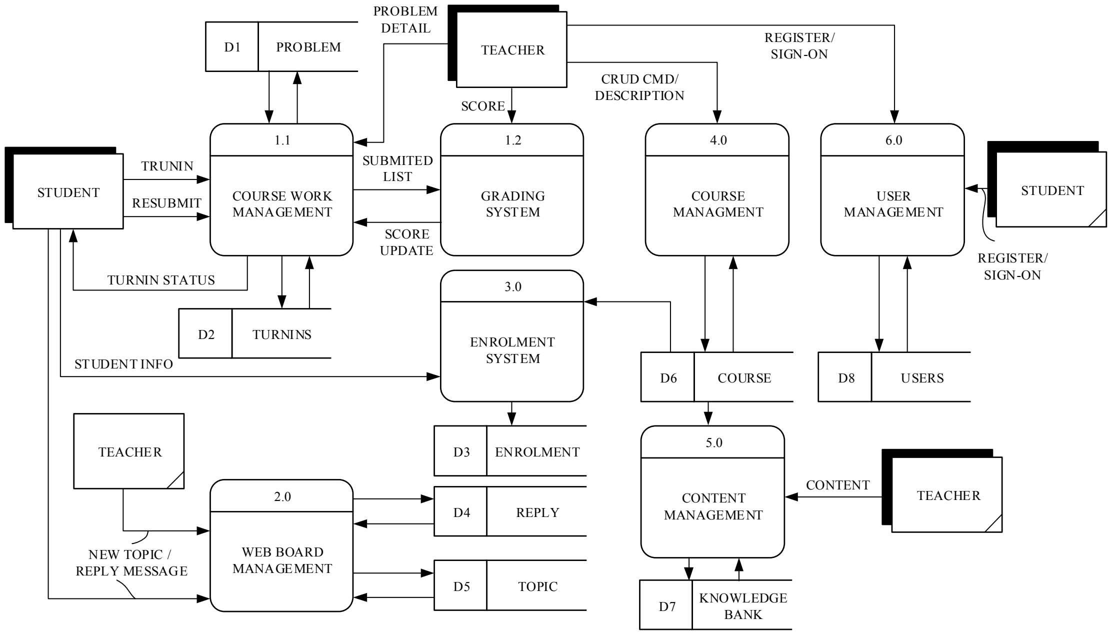

Figure 3. Illustration of data flow diagram.

System Development

The LMS was implemented by using Yii2 framework. Basically, Yii2 framework is PHP framework provided for developer to build systematic of MVC structure application. Developer requires the knowledge of object-oriented programming and the knowledge of web technology such as HTML, CSS and JavaScript. We found that Yii2 framework reduced the development time because of the MVC architecture of Yii2 framework is suitable for web application development. Another advantage of using Yii2 framework is the tool for auto-generated code called Gii for CRUD operation of data in database. Developer does not need to code everything from scratch because this tool provides the automation of code generation. Some of user interfaces are shown in Figure 4 – 8.

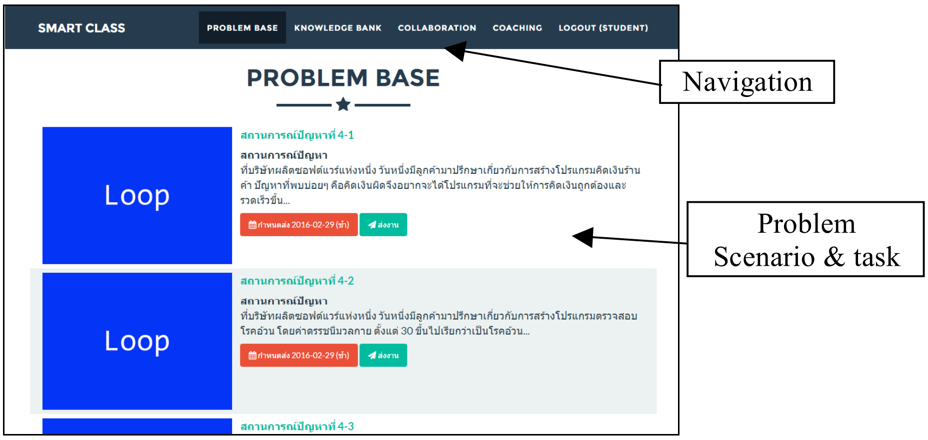

Figure 4. an illustration of class main page.

Figure 4 displays the class main page. There is navigation bar at the top which is the key element of the LMS: Problem base, Knowledge Bank, Collaboration and Coaching. Problem base consists of problem scenario and task.

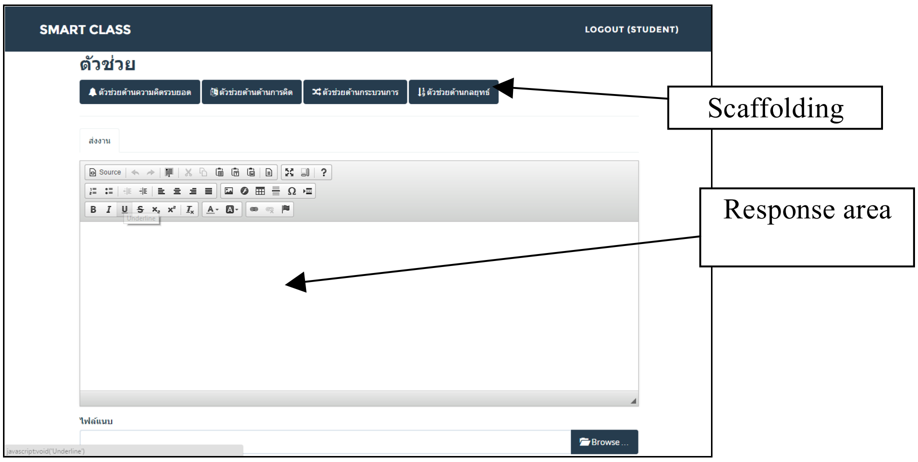

Figure 5. An illustration of assignment submission page.

Figure 5 illustrates assignment submission page. Students are provided scaffolding included conceptual scaffolding, strategic scaffolding, procedural scaffolding and metacognitive scaffolding. Texts, images and file can be added in the submission area. Students can submit several times. Each submission will be recorded by the system. The latest submission will be displayed first in the teacher's evaluation page. However, students and teacher can view submission history.

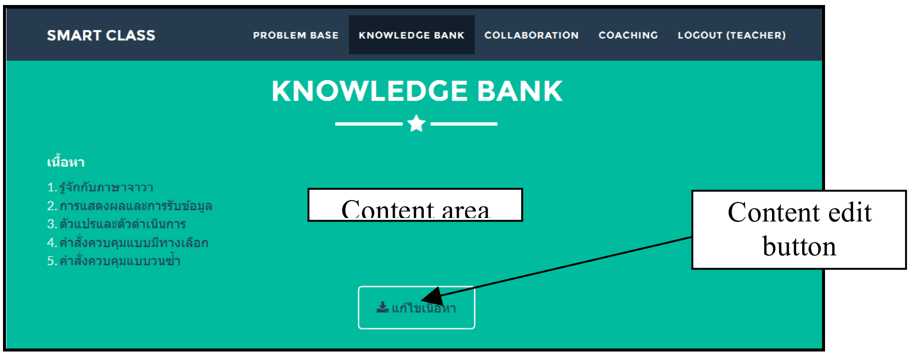

Figure 6. An illustration of knowledge bank

Figure 6 shows the knowledge bank page. Knowledge bank contains essential need for problem solving in the task. Contents include texts, images and video which are added by teacher.

Figure 7. An illustration of collaboration (web board)

Figure 7 demonstrates collaboration page. Web board is used to post any topics or share the information among students. Teacher can observe learning activity from web board and give student feedback.

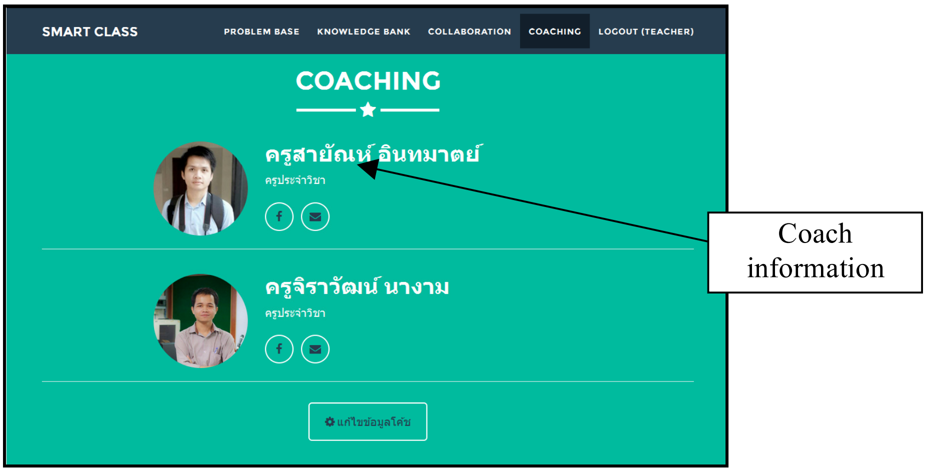

Figure 8. An illustration of coaching

Figure 8 explains coaching page. Coaching contains the information such as Facebook and e-mail of teacher or expert in the field. In this page, teacher can modify the course after it has created.

System Implementation

The LMS was installed in shared-host environment as shown in Figure 9. The system requirement of the host must meet Yii2 requirement. In this study, we installed in the system on the host with specification in Table 3.

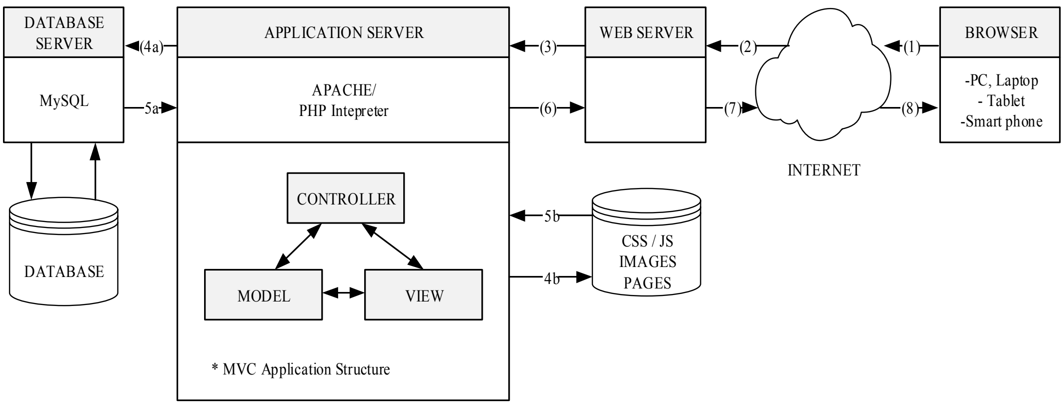

Figure 9. System environment.

Table 3: Testing environment.

Software	Description
Operating system	Windows 10 Education
Web server software	Apache 2.4.9
PHP version	5.5.12
Database management system	MySQL 5.6.17

4. Results and Discussions

The LMS was evaluated by experts and piloted with 22 students; 18 years olds in average. The study field was Pathumthep Wittayakarn School. Secondary school located at Nong Khai province, Northeastern part of Thailand. The study held during second semester, academic year 2015 (February – March, 2016) in context of computer classroom. Learning objectives were to help students know basic concept of computer programming such as input statement, output statement, data types and variable, decision making and loop in JAVA language. Lesson plans were designed based on flipped learning process (Kanjug, 2014). Learning tasks were designed to support knowledge transfer (Gentner et al., 2001). Experimental period was 6 weeks by using flipped learning. Achievement test and transfer examination were tested in the week 6, retention test was 2 weeks later. The result of the test was shown in Table 4.

Table 4: Test score of target group.

	Achievement Test, M (S.D.)	Retention Test, M (S.D.)	Transfer Test, M (S.D.)
Target Group	6.82 (1.18)	5.09 (1.41)	10.64 (3.19)

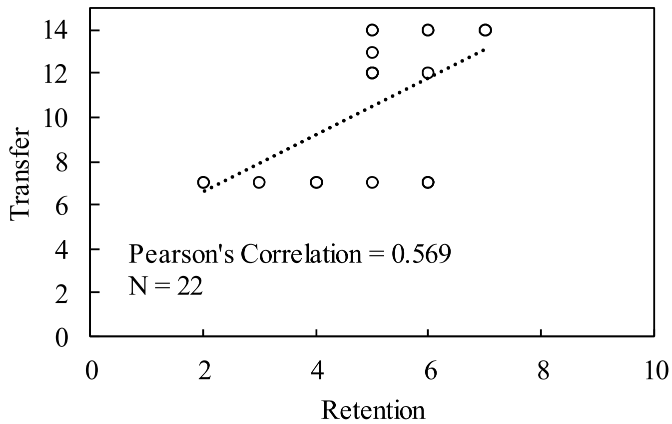

Figure 10. Correlation between Retention and Transfer Test.

In Table 4, Achievment test score of target group was 6.82 (SD = 1.18) and retention test score was 5.09 (SD = 1.41), roughly reduced 25% after achievment test 2 weeks. Transfer test score was 10.64 (SD = 3.19). The standard deviation was quite high means. There was different transfer ability among the target group. In Figure 10, we found the correlation between transfer test and retention test was positive (r = 0.569), transfer score propotionally increased when retention score increased and vice versa. By using criteria half of maximum score, we could get student who passed the test. Learning outcome is demonstrated in Table 5.

Table 5: Learning outcome of target group.

	Frequency	Percentage
Constructivist learning	13	59.09
Rote learning	4	18.18
No learning	5	22.73
Total	22	100.00

Learning outcome of students is shown in Table 5. We found more than half of learning outcome of students was constructivist learning at 59.09% whereas no learning at 22.73% and rote learning at 18.18%. The result revealed the efficiency of learning by using flipped classroom with purposed LMS could enhance students to perform constructivist learning more than half of class. Constructivist learners could transfer their learning into relevant situation. They performed well at retention and transfer test. However, there were several students at rote learning and no learning point. For those rote learning students, they failed transfer test. For no learning students, they failed neither retention test nor transfer test. The continuity of learning may affect testing result due to the target group were grade 12 students who were busy and worried about admission to university in the following year as shown in Figure 11. There were many tasks to concern and manage, this may also affect to the learning outcome.

(a) (b)

Figure 11. (a) and (b) Illustration of target group was using the LMS

5. Conclusion

In this paper, we purposed the key elements of LMS to use in Flipped Classroom as well as development process. Yii2 framework was used to build MVC application. The advantage of using Yii2 framework was the reduction of development time and effort. The value of this study, LMS was approved by experts and constructivist learning was made most among the target group. For future study, we plan to improve the LMS functionality and develop mobile application.

Acknowledgements

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Geometry-via-Gestures: Design of a Gesture based Application to Teach 3D Geometry

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Abstract: Geometry holds a special place in Mathematics. Learning of Geometry requires understanding and integrating a wide range of topics such as coordinates, shapes, theorems, proofs, properties and formulae, to name a few. In 3D geometry, students find difficult the manipulation of 3D objects and interpreting their structure and properties, such as volume and surface area. Research shows that students mainly focus on the formulae and the numerical operations to calculate the volume or the surface area of a 3D object, and not on visualizing the 3D objects. Various media such as images, animation, simulations and 3D geometric software have been used to help learners visualize 3D shapes. However, the affordances provided by these media do not fully support the construction and manipulation of 3D objects. Based on an embodied interaction approach, we have designed a gesture-based application for high school students to learn the properties of 3D objects. In this paper, we describe the design of the application, "Geometry-via-Gestures" (GvG), which enables learners to construct a right circular cylinder using gestures and derive its volume. We present the results of the first prototype pilot and the proposed redesign.

Keywords: 3D geometry, gestures, embodied cognition, 3D property

1. Introduction

Geometry has always been an essential part of the mathematics curriculum. Concepts in geometry are used across various domains such as computer graphics, medical imaging, image processing, robotics etc. Bloom (Bloom, 1998) stresses the importance of geometry "not only in its role in day-to-day activities but also as a vehicle to promote visualization in mathematics and many of the sciences". Practice in many science disciplines require building three-dimensional geometrical models, which are visualized and manipulated. Howe and Yasu (Howe and Yasu, 1989) state that "most basic science concepts are related in some way to a three-dimensional object or model whose understanding requires an act of imagination in the formation of a mental image."

Since the learning of 3D geometry involves visualizing and manipulating various 3D structures, and visualizing such 3D structures is difficult, teaching and learning of 3D geometry is a challenge faced by many. A common lament by teachers of geometry is that learners merely memorize formulas of various properties of 3D structures, like volume and surface area, without understanding how they have been derived. Research findings also show that students mainly focus on the formulae and the numerical operations required in calculating the volume or the surface area of a solid, and completely ignore the structure of the unit measures (Pittalis and Constantinos, 2010).

For learners to conceptually understand the idea of volume or surface area, they need to form connections between the formula and the structure of the solid. Marios Pittalis et al, (Pittalis and Constantinos, 2010) in their work on geometrical thinking, express the importance of constructing 3D objects from constituent 2D primitives. According to their observation, understanding the properties of a solid is equivalent to understanding the characteristic parts of 3D shapes. They claim that 3D geometry thinking is closely connected to students' ability to calculate properties of 3D objects, such as volume and surface area. To enable learners to understand various properties of 3D structures, it is important to help them understand how 3D structures are generated from their constituent 2D primitives. Traditionally, physical models and computer applications have been used to teach 3D geometry. However, physical models do not lend themselves to manipulations such as breaking open, changing shape and 2D - 3D translation, to name a few. Although the learner is able to interact with the physical model, the learner cannot construct intermediate structures while translating from 2D to 3D. Animations and simulations do provide a certain degree of interaction. However, they are restricted by the affordances provided by the keyboard and the mouse. Gestures offer a more natural form of human and computer interaction. The idea that knowledge is embodied and expressed through bodies (Goldin-Meadow and Beilock, 2010) suggest gestures could be a natural form of interaction for learning 3d geometry. With the advancement of technology, it is now possible to use gestures for intuitive and natural user interactions. In this paper, we describe the initial design of our application "Geometry-via-Gestures" (GvG). GvG, along with orchestration of activities, enables learners to visualize and manipulate 3D structures using gestures. This paper reports evidence of improvement in the learning process while using the application. We also identify additional features which could strengthen the pedagogical design of GvG, based on learner interaction with the application and interviews. We conclude with a proposed redesign and recommendations.

2. Theoretical Underpinnings

"Embodiment is the property of being manifest in and as a part of the world" (Dourish, 2004). Philosophers and psychologists have taken the position that the body plays a significant role in cognition. There have been different views of the role of body in cognition, starting from individualistic aspect such as reasoning (O'Donovan-Anderson et al., 2000), to a larger sociocultural world (Hutchins, 2014). Cognition, as per these theorists, derives from, and repurposes, action. Such theories seek unification of body, action and mind. Embodiment theories treat cognition as participation. The bodily participation then becomes a part of the conceptual structure.

Technology offers different levels of embodiment. The desktop technology is very much static, whereas new media offers a more dynamic medium (Victor, 2014). New media offers multi-touch, sensor and tangible interfaces that can be utilized to exploit more bodily interactions. The new media interfaces are not limited to interactions, but can be extended to experiences as well (Farr et al., 2012). There are two general ways in which the embodiment literature is related to technology. The first is where current interaction technology is considered wanting, and embodiment is considered as a way of developing new interaction technology. This stance of embodied interaction aims at creating new media, which creates new representations and interactions, which can become new thinking tools. In this theme, education technology (ET) researchers focus on creating new conceptual structures for education. The lack of educational theory to inform or analyze such learning through new media limits development of such systems (Abrahamson and Sánchez-García, 2016).

In the second way in which embodiment is related to technology, specific design decisions are supported by appealing to embodiment as a design principle. With the recent advancement in technologies, embodiment is now considered as an interaction feature. Natural User Interfaces (NUI) allow computer interactions through user's body movements. Some examples of NUI comes from gaming environments where controllers such as Nintendo Wii Remote, Wii fit, Microsoft Kinect etc. allow gamers to engage directly with virtual environments through their body. In ET, this design approach could include an appeal to the compatibility between the embodied nature of the concept/skill (say mental rotation) and the embodied technology to teach it (say actual rotation of complex structures). Learning gains have been reported using this stance of embodiment (Hung et al., 2014). A related theme could be an appeal to embodiment as a user-friendly feature in general, which could make concept-learning interesting or motivating. This paper takes the above stance, as learning 3D geometry is inherently an embodied process, as teachers and learners talk about 3D objects through gestures.

When the process of action is included in perception and memory making the self is associated with these processes, and this leads to better cognition (Hung et al., 2014). Actions such as physical manipulation and imagined manipulation can lead to enhanced comprehension (Alibali et al., 1999). There is empirical evidence that the actions performed by a learner in the "field of experience" positively influences internal representations (Novak et al., 2014). Gestures are special kind of actions that people produce when talking (McNeill, 2012). They are representational modes that convey spatial, relational and embodied concepts (Chue, 2015). Gestures contain information that supplements speech, or they can be independent (Goldin-Meadow, 2006). Gestures are particularly good at expressing spatial and motor information (Alibali, 2005). For example, while giving directions such as “Turn right/ turn left” we also tend to move our hands in the corresponding direction. This movement conveys the spatial information as well as the mental image present in the speaker’s mind. Information about the problem solving process and problem representation is available in gestures (Hung et al., 2014). Gestures have been used as a problem solving strategy in mathematics with higher learning gains (Cook and Goldin-Meadow, 2006). Additionally, Cook and Goldin-Meadow (Cook and Goldin-Meadow, 2006), claim that adding gestures to instruction promotes learning. In the teaching of astronomy to school students gestures have been found to be an appropriate pedagogy, making concrete models dynamic (Padalkar and Ramadas, 2011).

Gestures are classified into deictic, metaphoric, beat and iconic (McNeill, 1992). Deictic, metaphoric and iconic are categorized under representational form as they convey semantics, whereas beat gesture is used more for emphasis and does not convey any meaning. We speculate that in our application Metaphoric gestures will be used by the learner, but analysing the learner’s gestures for the type is beyond the scope of this paper.

3. Pedagogical Design of GvG

3D geometry understanding includes spatial structuring, conceptualization of mathematical properties, and conceptualization of measurement. Spatial structuring of object involves identifying spatial components, combining them into spatial composites, establishing interrelations among components and composites. Literature emphasizes the need to conceptually link 2D and 3D objects and also derive the properties of 3D objects. Representing 3D objects by 2D figures is a 3D geometry ability (Pittalis and Constantinos, 2010). The geometry knowledge of 3D structures is built on prior geometry knowledge of 2D primitives. The traces that form during the process of building 3D structure from 2D structure are attention anchors that aid students to relate 2D primitives with 3D structure formation (Abrahamson and Sánchez-García, 2016). The process of construction of a 3D object from its constituent 2D shapes will help learners derive the properties of the solid they make. Understanding properties of solid means (Pittalis and Constantinos, 2010):

- understanding characteristic parts of 3D shapes, comparative relations between same or different structural parts, how elements of a solid are interrelated
- conceptualization of numerical operations and links of formulas with structure of solid
- understanding visualization of internal structure of solid which contributes to understanding of how volume is calculated

One of the modes of learning 3D geometry by experience is to use physical models. In a traditional setup, the teacher brings a 3D artefact to the class and draws the different views on the board. Students do not interact with the 3D objects. For the development of the abstract and concrete aspects of geometry, emphasis has been on experience, rather than theory, which is found lacking in the traditional setup (Hansen et al., 1998).

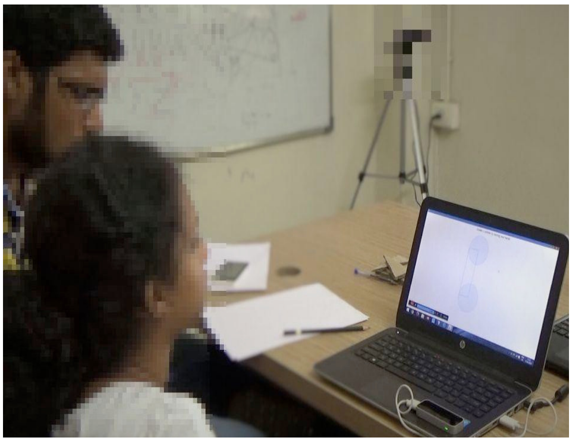
We have designed three learner tasks with the application based on the embodied cognition, gesture and 3D geometry literature for the three learning objectives. Each activity maps to a specific learning objective and the learner interacts with the application to achieve the objective. Table 1 contains the mapping of the learning objectives, application features and literature support. The researcher/mediator is with the learner during the task, prodding, guiding, hinting and collating learner insights during the interaction.

Table 1: Mapping Learning Objective, Features of application and Theory.

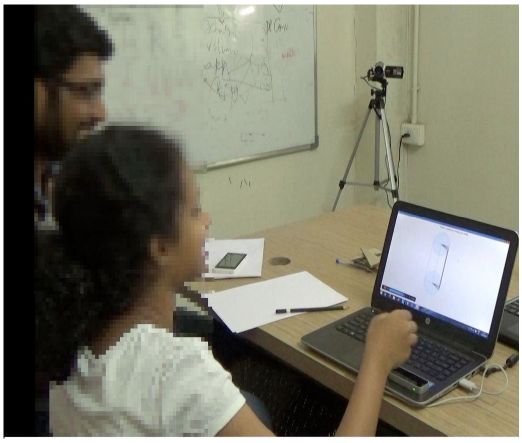
Sno	Learning Objective	Feature	Theoretical Backing
1	Learner should be able to use gestures to move on screen 3D object in various orientations.	Task 1	Run-in Period (Hung et al.,2014)
2	Learner should be able to explain the formation of a 3D object (right circular cylinder) from a known	Task 2	Representing 3D objects by 2D figures (Battista, 2007; Pittalis and Constantinos, 2010)

Sno	Learning Objective	Feature	Theoretical Backing
	basic 2D structures (rectangle, circle)		
3	Learner should be able to conceptually derive the volume of a 3D object (right circular cylinder)	Task 3	Conceptualizing links of formulae with structure of solid (Battista, 2007; Pittalis and Constantinos, 2010)

In the application, the task of formation of a right circular cylinder (task 2) is done using gestures. The student will see a rectangle with two circles - one at the top and one at the bottom. The two sides of the rectangle forms the radius of the two circles (see Figure 1a.). The student uses the sliding gesture in front of the leap motion controller. When the sliding gesture is sensed by the controller, it will be verified by the application code if the gesture has been associated with any action with the current model on-screen. If specific action is associated, as in this case, then the rectangles can be made to move like a 3D cycle wheel (see Figure 1b). This will enable the student to associate the 2D rectangle primitive with the 3D right circular cylinder. Figure 1a-b shows students interacting with the application for this particular task.



a.



b

Figure 1. Student participants interacting with GvG for creating a right circular cylinder using gestures.

4. Study Design

The broad research questions guiding the study were:

1. How do learners use GvG to learn 3D geometry?
2. What features are required to strengthen the pedagogical design of GVG?

Participants: Geometry as a subject is taught in India over several grades, beginning from primary (4th grade) school, making it difficult to pinpoint the optimum age group. Hence we conducted the study on learners in the 6th, 9th and 10th grade. The learners for the GvG application were students residing around the research centre.

Procedure: The study was conducted in an experiment room, by an interviewer, and two observers. A laptop with the GvG application loaded on it was placed before the learner, along with the leap motion controller. Sufficient writing material was also placed close to the student for use if necessary. The whole study was recorded using two video cameras and an audio recorder. The learners were interviewed individually, and the study was spread over two days.

Gestures are the application input interface in GvG. As the learners use gestures to interact, questions were posed by the facilitator. The facilitator had three sets of pre-determined questions to pose before, during and after the activity. The questions posed before the activity aimed at eliciting prior knowledge and identifying misconceptions. During the activity the facilitator asked questions to extract the student's thought process and knowledge construction. The answers by the learners formed the intermediate outcomes. The goal of the post-activity questions was to evaluate knowledge transfer.

Intermediate Evaluation: Questions posed by the facilitator during the activity was expected to make students reflect on what action they did, why they did that particular action/gesture, what happened to the object on screen, what insight did the student gain from this activity, and finally, whether the student could conceptually describe the volume property of the 3D object in terms of the 2D objects. The student answers were evaluated based on a rubric. Two Rubrics with three levels (Expected, Intermediate and Poor) was developed to evaluate responses for questions posed for Task 2 and Task 3. The first rubric was meant to rate the response to the question on the students' observation of transformation to onscreen object, on successful manipulation using gestures. This was applicable for both Task 2 and Task 3 as in both these tasks the students constructed a 3D shape (right circular cylinder) using rectangle (task 1) and using circles (task 2). The second rubric was to rate the response to the question on derivation of volume of the resultant 3D object displayed on screen. This was applicable for Task 3 as the students could explain volume of the right circular cylinder as area of circle multiplied by the height of the circles.

Post-test: In the Post-test a rectangular sheet of cardboard was given to students and they were asked questions on the number of ways in which a right circular cylinder could be formed, using the sheet. A triangular cut-out in a cardboard was provided to students and they were asked to generate 3 dimensional objects using the triangular cut-out. The expected outcome is a triangular prism structure obtained such triangular cut-outs are stacked. Also expected is the conceptual understanding of volume of such a structure. An interview after the Post-test was conducted to understand the role of gesture in the 3D structure formation, usefulness of the tool and additional features they would have preferred. Figure 2 depicts the study steps and the outcome from each of the steps. From the outcomes available the focus of the paper is only on "Learning Processes" and "Application Features".

5. Results

We conducted the pilot with two 6th grade learners, and one each from the 9th and 10th grade. To answer the research questions posed in this paper, we focus on the video recordings and interview transcripts of the 9th (X) and 10th (Y) grader.

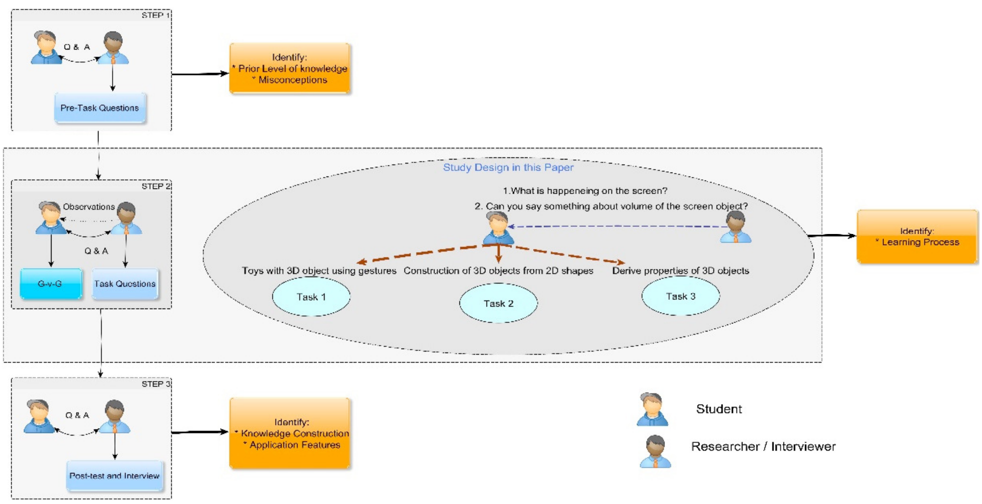


Figure 2. Pilot Study Steps

Clinical Interview - Student X

Student X used gestures spontaneously while describing abstract concepts. X used gestures to show a solid object in space while explaining about the concept of volume. To explain area, X used gestures to indicate flatness. This indicates the naturalness of gestures in describing geometrical concepts. X showed signs of giving up during tasks 2 and 3 when the required gesture could not be identified. The facilitator showed the gesture and X performed the same. Confidence started building up when the gesture used by X started producing output on the screen. This observation gives us inputs for the features to be incorporated in our design, namely scaffolds and reflection prompts.

While interacting with the object on screen using gestures, in the rotation of rectangle to form cylinder activity, X accidently discovered the gesture. This caused the rectangles to replicate. Seeing the output, X was excited and tried the gesture more confidently. In task 2, X understood that the rectangle has to follow the circular path. Accordingly the gesture indicated the movement of the rectangle along with the trajectory it has to take. But X was not able to visualize which side of the rectangle is fixed and which side is moving. So learning using this task seems complicated. This seems to indicate the need for scaffolding in the form of pointers and reflective questions.

Before the intervention, x calculated the concepts of area and volume based on the formula. But using the intervention, X could figure out that 3D shapes are composed of 2D shapes. The intervention helped in the learner deriving the formula of the volume from the area and helped in connecting disparate concepts of area and volume. In the post-test, X is able to transfer the learning that volume is the product of area and height, to a new 3D object - Triangular prism.

Clinical Interview - Student Y

Y used natural gestures extensively even in his general conversations, mostly to emphasize his point. He also used analogies and artefacts during explanations or while conveying ideas. Y would use any available artefact to put forth his idea. Y was positive about technology and could use the leap motion controller in a comfortable manner.

In task 2 Y got the gesture right and successfully understood the concept. Y went a step further and came up with an innovative analogy for the activity -- that of a compass movement. The implication seems to be that the activity helps the student understand the concept of 3D as a composite of 2D shapes. In task 3 Y used gestures which were a variation of the vertical movement. This seems to indicate a desire to move the 2D disk in the vertical direction to form a cylinder, thereby suggesting the intuitiveness of the designated gesture.

Y had a strong misconception regarding area and volume. This prevented him from obtaining the right formula in spite of deducing the volume of cylinder conceptually. This points towards the need for scaffolding, in the form of reflective questions and hints. Y derived the volume of cylinder as 'Area of individual unit x n divisions'. There was no clarity between 'n' and height. This suggests misconceptions overshadow any learning gained by the activity. Due to the misconceptions the volume derivation process could not be extracted from Y.

Student Learning

In this section we present the answer to the first research question that we posed in the start of section 6. The next section, section 8 answers the second research question in detail. Based on the analysis of student interactions with GvG and interviews, we have come up with the following insights:

1. Participants use gestures intuitively to explain geometric concepts: We noticed several instances where the participants used their hands and gestures to explain various geometrical concepts. When asked the definition of volume, Student X used fingers to indicate the volume is the space enclosed by an object. Student Y used hands to explain x, y and z coordinates, by placing hands perpendicular to each other. These instances further support our claim that gestures are indeed a natural way to learn and describe geometry concepts.
2. After using GvG, learners are able to derive a 3D shape from its constituent 2D shapes: Prior to interacting with GvG, Student X differentiated 2D and 3D structures by mentioning the "lack of depth". Student Y differentiated 2D and 3D structures by mentioning that there is a "difference in

dimensions". After interacting with GvG, students stated that a cylinder is formed by "layers of circles" and "infinite 2D circles placed line by line". One of the participants, when asked about difference between circle and cylinder in task 2, responded: "There are more layers of it. Circle fits to the base, and adding more and more of the same thing". This shows that GvG enabled students to visualize the 3D shape from its 2D primitives.

3. After using GvG, participants are able to derive the volume of a 3D shape using properties of the constituent 2D shapes - Participants were able to use the above information and derive the volume of the cylinder conceptually. Student X was able to conceptually link the concepts of area and volume. Although Student Y had a misconception about the structure of the cylinder, Y was able to determine that length, breadth and height are required to derive the volume of the cylinder and some property of the circle is also needed.

Based on the above insights we conclude that learners are able to derive the properties of 3D shapes such as volume using GvG. These properties can be derived by first construction of the 3D shape from a known 2D shape. The construction of the 3D shape in this application is aided by gestures. The learners are already aware of the 2D shape properties such as area. This knowledge is connected to the activity performed to derive the volume of 3D shapes. During the construction of 3D shapes appropriate traces are visible, which shows the construction happening. These visualizations along with the activity using gesture helps them to connect prior knowledge to derive the formula of volume.

6. Re-Design

Limitations of GvG

Based on interviews and observations of students using our application, we have identified the following limitations:

- In its present form, the application cannot help override misconceptions. Student Y's misconception of the concepts of volume, area and surface area, proved unsurmountable using the tool in its present form. Reflection questions could help overcome misconceptions.
- Student X's inability to find the appropriate gesture could have easily lead to frustration but for the presence of the facilitator. Scaffolds are therefore needed to prevent loss of interest due to frustration.
- Self-learning mode requires a number of additional scaffolds. In the present form, the facilitator asked several thought-provoking questions to accompany the activity. If such reflection questions are absent, students may not gain sufficient insights into 3D geometry structure.
- If derivation of 3D objects are done from other 3D objects and not from 2D objects as intended, then the link between 2D and 3D geometric structures would not be properly established.

To overcome the above limitations we propose the induction of features proposed from 8.2 – 8.6 in the GvG application.

Re -Design of Tasks

Geometric solids can be considered as whole, and according to its components. From our student observations, we noticed that students have vague and inconsistent prior knowledge of how solids are formed. Hence, in the redesign, we want to introduce activities from 1 dimension geometry, and gradually progress to 3 dimensional geometry. This would help our tasks prime students to think of a solid in higher dimension in terms of the constituent parts in the lower dimension. Specifically, the tool will have:

1. Task 1 - 1D to 2D transitions and back; may include: line to rectangle, line to circle, line to triangle
2. Task 2 - 2D to 2D transition and back; may include: triangle to square, triangle + square to pentagon, square + square to rectangle etc.

3. Task 3 - 2D to 3D transition and back; may include: rectangle + circle to cylinder, stack of circles to cylinder, stack of rectangles to cuboid, stack of squares to cube etc.
4. Task 4 - 3D to 3D transition and back; may include: stack of cubes to cuboid

Re-Design for Multiple Representations

Concepts of form, properties and transformations are embedded in the representation of shape. Hence geometrical figures, especially 3D figures, are "rich cognitive structures"(Freudenthal, 1991). Each property of the shape has a corresponding algebraic representation as well. For example, the volume of a cylinder can be visually represented as the space enclosed by the cylinder. The volume of the cylinder can be represented algebraically by the formula pi*r^2*h. Students should be able to understand the relationship between these two representations, and how changing the visualisation affects the algebraic representation and vice-versa. Hence, we intend to ask the student for the constituent algebraic representation for each visual representation at each dimension. Further visual changes in the solid will result in changes in the algebraic formula and vice-versa.

Scaffolding

Based on students' observation and to facilitate self-learning, we wish to show three levels of scaffolds:

- Level 1: Show right gesture only, in the form of an animated hand movement.
- Level 2: Show expected output only, in the form of a partly completed output.
- Level 3: Show gesture and expected output as animation simultaneously.

Having such scaffolding in each activity will help prevent the student from getting frustrated or losing interest. These levels could pop-up either on demand or after the user has tried out multiple types of gesture, or if the student has tried only one gesture and has not interacted with the system for more than 5 minutes. To equip the application to respond in terms of the latter two possibilities, some form of activity logging will be required, where the leap motion will be used to sense all types of user gestures and log them.

These scaffolds could address the issue of flagging interest, on not being able to identify the correct gesture and also not knowing what the correct outcome would look like. When the facilitator interacted with the student and asked what gesture they were trying to do, why they feel that the gesture is appropriate and what do they expect the outcome to look like, it was clear that the student's idea and thought process was in tune with what was designed. In the stacking of disk activity, the student rightly conjectured that the cylinder could be formed if the circle was lifted.

However, the student was trying the lifting gesture (vertical movement) with all fingers pinched together. The correct gesture was flat palm moved vertically. Conceptually the two gestures are close. However, due to small variation, i.e. the pinched fingers versus open palm, the response was not seen. Here, if the scaffold pops up with an animation of the gesture, the student could imitate it and still reap the benefit of the understanding via gestures.

Reflective Questions

During the task 3, the student X accidently stumbled upon the gesture (right to left swipe) and saw the output. The output subsequently disappeared when the leap motion controller detected the left to right swipe, which was coded to indicate clear or reset. Thereafter, her focus was completely on using the gesture to complete the task rather than on understanding the concept underlying it. This could adversely affect the efficacy of the intervention. To counter such scenarios, a second type of scaffolding involving reflection questions would be desirable. Ideally, a facilitator would elicit responses from the student by questioning her thought process behind the nature of gesture and the corresponding output. However, in a self-learning mode, a virtual agent with popup questions could play the role of a facilitator and put forth reflection questions that force the student to think along the lines of cause and effect of gesture to the output visualized onscreen. This will in turn help establish the link between 2D and 3D structures. These popup questions could be enabled after the student has interacted with the system for around three minutes.

7. Discussion and Conclusion

Using a gesture based technology, the GVG application has brought in more natural learner interactions with 3D shapes. However, the learner interaction needs to be channelled via meaningful activity. The natural interactions during meaningful activity, combined with the visualizations on screen, helps the learner connect the 2D shape's properties to the 3D shapes.

In this paper, we have tried to extract the process while interacting with the GvG application, beginning with the construction of a 3D shape from a known 2D shape via gestures. The use of the gestures and the visualizations shown during 3D shape construction enable learners to come up with strategies to derive the properties of 3D shapes such as volume. The learners can now extend this learning to other 3D objects and follow the process to derive the properties.

In our study, it is unclear whether gestures function as epistemic actions (Kirsh and Maglio, 1994) that contribute to learning of the concept. We observed that when students were asked to explain concepts like volume, surface area and explain different shapes, they naturally used their hands and gestures to articulate the concept. Hence gestures themselves act as an external representation, primarily to offload the concept. Gestures also act as a complement to language, since students find it more natural to use gestures to explain these concepts. We are not claiming that identification of gesture is contributing to learning. Rather it is the linking of the gesture with the output, and the reflection on what is exactly happening, that contributes to learning. However, this linking of the gesture with the output alone may not contribute to learning. For such a relation to be established, we would require a control experiment.

The visualisations offered by the tool themselves act as an external representation. They are persistent, and act as anchors, allowing students to build solids of higher dimensions by interacting with the tool. Hence while interacting with the tool, there is an interplay between the visualisation, the gesture, and the multiple forms of representation. Which representations predominantly contribute to learning is an open question.

The application of embodiment theory of cognition in the creation of interaction environments is termed "embodied design" by Abrahamson (Abrahamson, 2009). There exists three areas of challenges in embodied design: (i) activities, (ii) materials, (iii) facilitation (Abrahamson and Lindgren, 2014). Activities in embodied design should start from the simplest task which requires only prior knowledge to be utilized in the new environment. The orchestration of learning materials needs to be supported with feedback. Additionally, as the complexity of task increases the tools should support novel actions, which then leads to new conceptual structures being built. Just in time feedback and hints need to be incorporated with the design which will lead the learners to the objective. The redesign features for GvG 2.0 incorporate almost all of the recommendations of embodied design.

In GvG 2.0, with the additional features, the most interesting question will be to find out the individual contribution of gesture and visualization to the learning. Additionally a control group experiment would be able to measure the learning gain using GvG 2.0.

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Designing Framework of Augmented Reality Learning Environment to Promote Analytical Thinking for Grade 8 Student

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Abstract: Analytical thinking involves the process of gathering relevant information and identifying key issues related to this information. This type of thinking ability also requires you to compare sets of data from different sources; identify possible cause and effect patterns, and draw appropriate conclusions from these datasets in order to arrive at appropriate solutions. Moreover, the purpose of this research was to design of constructivist augment reality learning environment to promote analytical thinking. The expert reviews for assessment of the efficiency of constructivist augment reality learning environment were as follows: three content experts, two instructional designers, two augment reality learning designers, and one measurement and evaluation expert. The research design are used the document analysis and survey. The procedure were as following: 1) to examine and analyze the principles and theories regarding constructivist augment reality learning, constructivist and analytical thinking 2) to synthesize designing framework of augment reality learning environment to promote the analytical thinking 3) to design of augment reality learning environment to promote the analytical thinking, and 4) to evaluate the efficiency of the constructivist augment reality learning environment to promote the analytical thinking. The result revealed that: 1) The constructivist augment reality learning environment to promote the analytical thinking was comprised of six components are following: (1) Problem base and learning tasks to promote analytical thinking (2) Resources (3) The center of promote analytical thinking (4) Collaboration (5) Scaffolding and cognitive strategies for problem solving, and (6) Coaching center by experts. 2) The efficiency of the constructivist augment reality learning environment to promote analytical thinking are shown in following: learning content, instructional design and the augment reality learning design.

Keywords: Analytical thinking, Augmented Reality, Constructivist learning environment

1. Introduction

Learning in the 21st century, both of instructors and the learners can learn together. In the present, the roles of the teachers and students have been changed. The students can learn outside the classroom they can exchange and construct their knowledge by themselves around their environment and including they can bring technology use for their learning.

The analytical thinking is the person who has a letter of analytical thinking more they the others about the development of intelligence, the deeply of analytical thinking must to use the abilities of observe, searching and how to identify for the reasons. Also, when the person can link about the interpret to the understanding it's might be get a fact of the knowledge for solve the problems including the assessments and the decision for everything correctly (Chaijaroen, 2009).

Constructivism is basically theory based on observation and scientific study about how people learn. It says that people construct their own understanding and knowledge of the world, through experiencing things and reflecting on those experiences. When we encounter something new, we have to reconcile it with our previous ideas and experience, maybe changing what we believe, or maybe discarding the new information as irrelevant. In any case, we are active creators of our own knowledge. To do this, we must ask questions, explore, and assess what we know. In the classroom, the constructivist view of learning can point towards a number of different teaching practices. In the most general sense, it usually means encouraging students to use active techniques (experiments, real-world problem solving) to create more knowledge and then to reflect on and talk about what they are doing and how their understanding is changing. The teacher makes sure she understands the students' preexisting conceptions, and guides the activity to address them and then build on them.

Augmented Reality (or AR in short) is both a variation and the opposite of virtual reality. It allows users to see the real world around them with virtual objects superimposed on that physical environment. Augmented reality supplements reality rather than replaces it. The AR system has the following characteristics (Azuma): 1) Combines the real and virtual, 2) Is interactive in real time, 3) Operated in and with a three dimensional environment. This study focuses on augmented realities (AR) for learning that utilize mobile, context-aware technologies (e.g., smartphones, tablets), which enable participants to interact with digital information embedded within the learning environment.

The reasons mentioned above, this study recognize the importance of computer classroom learning environment design. The researcher applied the analytical thinking, constructivist theory and the augment reality attribution and symbols system used, synthesizing them as the framework for designing the constructivist augment reality learning environment to promote analytical thinking. The finding may help to promote the analytical thinking and knowledge construction to the students.

2. The Purposes of This Study

This study aimed to design of constructivist augment reality learning environment to promote analytical thinking.

3. Augmented Reality Learning Environment

Augmented reality learning environment is a media that design based on theory to practice; coordination between the method: cognitive constructivist, social constructivist theory, cognitive theory, analytical thinking and the media and technology: media symbol system, media attribute as hyper text, hyper link, hyper media, and technology for learning (AR-technology). Augmented reality learning environment with an emphasis on the affordances and limitations associated with AR as it relates to teaching, learning, and instructional design. As a cognitive tool and pedagogical approach, AR is primarily aligned with constructivist learning theory and analytical thinking, as it positions the learner within a real-world physical and social context while guiding, scaffolding and facilitating participatory and metacognitive learning processes such as authentic inquiry, active observation, peer coaching, reciprocal teaching and legitimate peripheral participation with multiple modes of representation.

4. Methodology

This study developed the constructivist augmented reality learning environment to promote analytical thinking. The research methodology is Developmental Research in Type I (Richey and Klein, 2007) consists of three processes, the first is product design, the second is product development, and the third is product evaluation. This research is in the first and second process as about product design and development. In this research will be presented the research results in the design and development process, which is the details of document analysis method research design, the synthesis of theory concept, and the synthesis of constructivist learning environment design concept through augment reality to promote the analytical thinking.

4.1 The Target Groups

The expert reviews for assessment the efficiency of constructivist augment reality learning environment were as follows: three content experts, two instructional designers, two augment reality learning designers, and one measurement and evaluation expert.

4.2 Research Design

This research methodology was documentary research and survey research comprised of 1) the synthesis of theory concept, 2) the synthesis of the constructivist learning environment design concept through augment reality to promote the analytical thinking, 3) development of the constructivist augment reality learning environment, and 4) evaluation of the learning environment.

4.3 Research Instrument

The instruments in this study consisted of experimental instruments: the constructivist augment reality learning environment to promote analytical thinking and data collection instruments. Both are described below. 1) The instrument for experiment included the constructivist augment reality learning environment to promote analytical thinking. The process of the design was as follows: (1) to examine the principles and theories, (2) to synthesize designing framework of the constructivist augment reality learning environment, (3) to design the constructivist augment reality learning environment based on above mentioned designing framework, and (4) to evaluate the efficiency of the constructivist augment reality learning environment. 2) The instruments for data collecting including: (1) the record form of document analysis, and (2) the evaluation form for the experts.

4.4 Data Collecting and Analysis

The researchers collected the data as follows: 1) Synthesis of theoretical framework and Components of the learning environment. The data were collected by analyzing principles, theories, related research of the constructivism theory, cognitive theory, media and technology theory, pedagogy and contextual study. 2) Synthesis of Designing framework of the learning environment: The above synthesized theoretical framework was taken into this process. The underlined theories base such as, context of school base, constructivist base, pedagogical base, analytical thinking base, and technology and media base (AR technology and media symbol system) for the synthesis of the theoretical framework of the learning environment. 3) Design and develop of the learning environment based on foundation of creating designing framework was adopted. 4) Evaluate of the learning environment by experts. The analytical description, summarization and interpretation were used to analyze data.

5. Research Results

The design and development of the learning environment that promote students' analytical thinking are follows:

5.1 The Components of the Learning Environment Model

5.1.1 Synthesis of Theoretical Framework

The results show that the theoretical framework of web-based learning environment comprised of five basic theories: (1) Context of school base are follows: Policies, Targets, Present situation, Processes, and Performances, (2) Constructivist base are follows: Constructivist cognitive (Piaget, 1992) and social constructivist (Vygotsky, 1962) theory and cognitivism; and Information processing theory (Klausmeier,1985), (3) Pedagogical base are follows: OLEs Model (Hannifin,1999), SOI Model (Mayer,1996), Situated learning (Brown, Collins and Dugoid, 1989), Cognitive apprenticeship (Brown and Collins, 1991), (4) Analytical thinking base are follows: Identify the elements, Identify the relationships reason, Classification of things (Sumalee et al., 2008) (5) Media theory and technology base are follows: Web-based learning, Augmented Reality (Donald, 2014) and the system of media. Figure 1 showed the relationship between the underlined basic theories components of the theoretical framework for augmented reality learning environment to promote analytical thinking on topic implementation of computer software for grade 8 student.

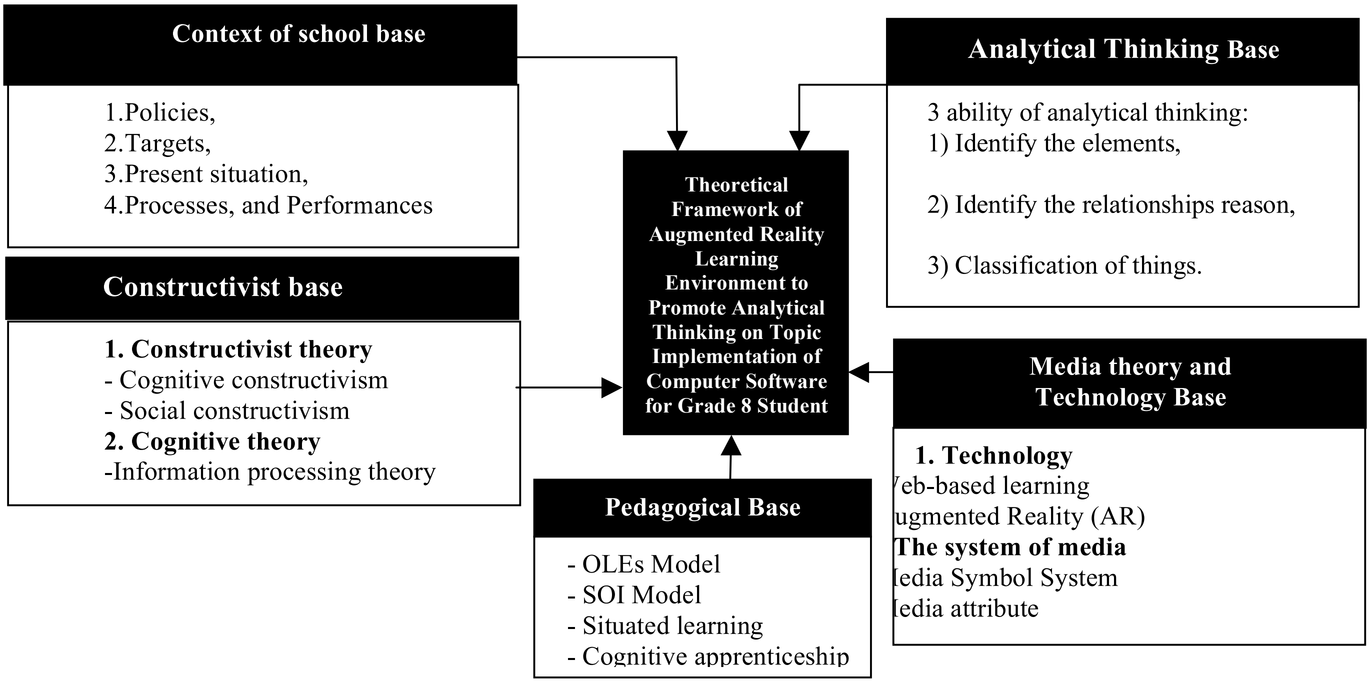


Figure 1. Theoretical Framework for Augmented Reality Learning Environment to Promote Analytical Thinking on Topic Implementation of Computer Software for Grade 8 Student

5.1.2 Synthesis of Designing framework

According to this study, the findings of synthesis of the theoretical framework which was used as foundation in synthesizing the designing framework of the learning environments to for promote analytical thinking and augmented reality found that 4 crucial bases follows. The findings from the study could be utilized as the basis for synthesizing the designing framework in the design of the learning environment model as follows:

5.1.2.1 Activating cognitive Structure, Analytical Thinking

Activating cognitive Structure, analytical thinking, it illustrated the relationship between the underlined theories and the component as follows: cognitive constructivism (Piaget, 1985); cognitive conflict, situated learning (Brown, Collins and Duguid, 1989); authentic context, OLEs (Hannafin, 1999); enabling context, analytical thinking (Sumalee et al., 2008) as follows of 3 ability: Identify the elements, Identify the relationships reason, and Classification of things. The composition of the problem base and learning task to promote analytical thinking. This may help activating cognitive structure of the students. Figure 2 showed theoretical framework designing problem base.

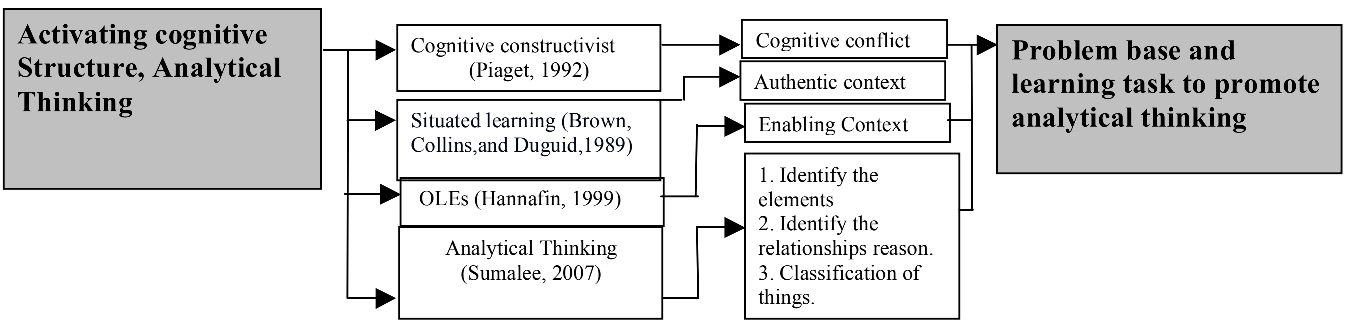


Figure 2. Theoretical Framework Designing Problem Base

5.1.2.2 Supporting Cognitive Equilibrium

Supporting cognitive equilibrium. It was illustrated the relationship between the underlined theories and the component as follows: information processing theory (Klausmeier, 1985); sensory register, short-term memory, long-term memory, analytical thinking (Sumalee et al, 2008); conceptual model, SOI model (Mayer, 1996); selection, organizing, integrating designing of the component of which was called Resources. It focused on how the students process the information effectively. This can help the students understand easily. Figure 3 showed theoretical framework designing resources.

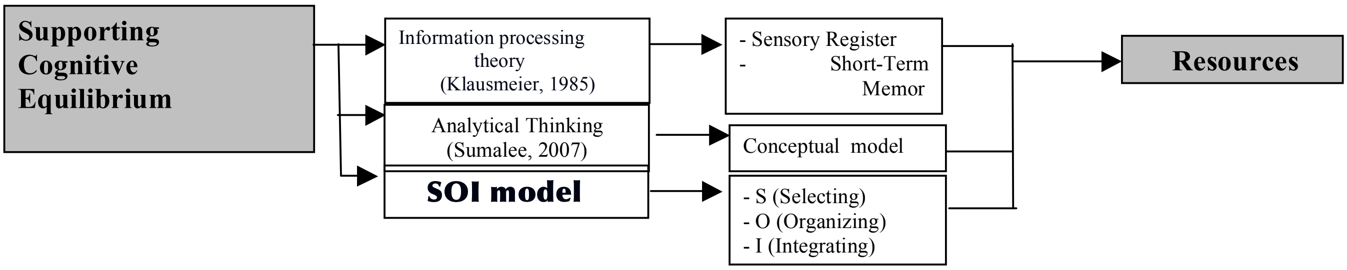


Figure 3. Theoretical Framework Designing Resources

5.1.2.3 Enhancing Knowledge Construction Analytical Thinking and Augmented Reality

Enhancing knowledge construction analytical thinking and augmented reality, it illustrated the relationship between the underlined theories and the components as follows theory: Analytical thinking (Sumalee et al., 2008) as follows of 3 ability: Identify the elements, Identify the relationships reason, and Classification of things. The composition of the Analytical thinking center; Social constructivism (Vygotsky, 1962); The composition of the Collaboration – which supports learners to share experiences, widen their perspectives, contemplate, and modify and prevent wrong understanding. The relationship between the underlined theories and components of the learning environment was shown in Figure 4.

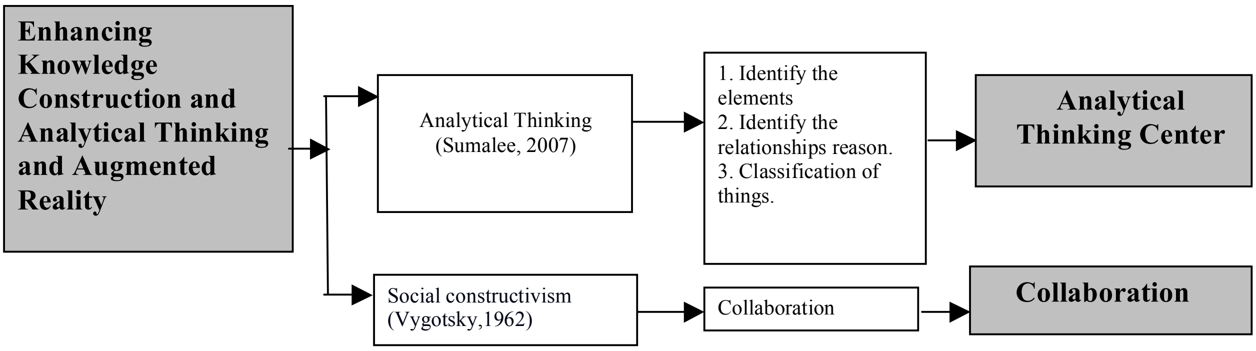


Figure 4. Theoretical Framework Analytical Thinking Center and Collaboration

5.1.2.4 Supporting and Enhancement for Constructing Knowledge

Supporting and enhancement for constructing knowledge, it illustrated the relationship between the underlined theories and the components, as follows: social constructivism (Vygotsky, 1962); zone of proximal development, OLEs (Hannifin, 1999); Scaffolding, The design of the component was called Scaffolding; CLEs (Jonassen and Henning, 1999); Coaching, The design of the component was called Coaching. The relationship between the underlined theories and components of the learning environment was shown in Figure 5.

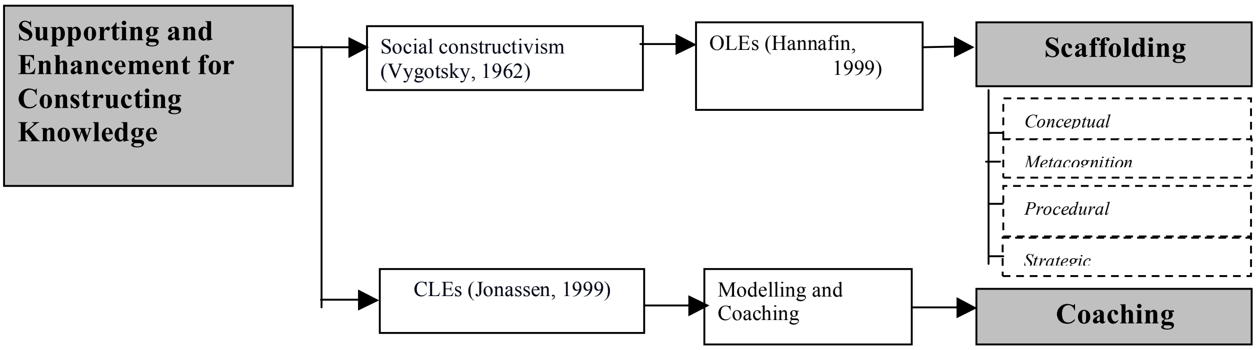
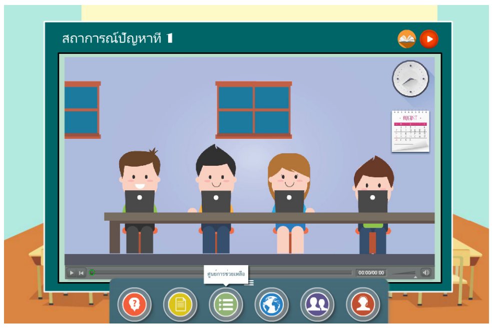
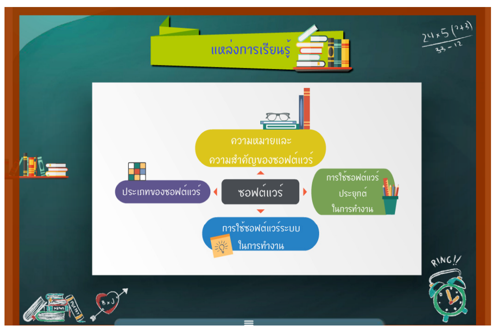


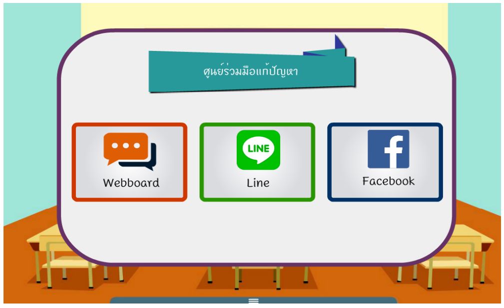
Figure 5. Theoretical Framework Designing Scaffolding and Coaching

5.2 The Constructivist Augmented Reality Learning Environment to Promote Analytical Thinking

Constructivist augmented reality learning environment to promote analytical thinking designing framework comprised of 6 components as follows: (1) Problem base and learning tasks to promote analytical thinking (2) Resources (3) The analytical thinking center (4) Collaboration (5) Scaffolding, and (6) Coaching center. An example of the constructivist augment reality learning environment to promote analytical thinking was showed in Table1.

Table 1: Components of constructivist augmented reality learning environment

Element	Describe the elements	Example of design Shot
(1) Problem base	Problem base: It was shown Problem base for enhancing the learners to construct knowledge and analytical thinking.	 Problem base and learning task to promote analytical thinking
(2) Resources	Resources: It was shown Resources to provide just-in-time information to help learners comprehend and solve the problem.	 Resources

Element	Describe the elements	Example of design Shot
(3)Analytical thinking center	Analytical thinking center: It was shown Analytical thinking center for enhancing analytical thinking. (Sumalee et al., 2008).	 Analytical thinking center
(4) Collaboration	Collaboration: It was shown Collaboration for supporting the learners to share their experience with experts.	 Collaboration
(5) Scaffolding	Scaffolding: It was shown Scaffolding for enhancing students to solve problems, to learn and construct the knowledge by themselves.	 Scaffolding
(6) Coaching center	Coaching center: It was shown Coaching center by teachers and experts in analytical thinking.	 Coaching center

5.3 The Results of the Efficiency of the Constructivist Augment Reality Learning Environment to Promote Analytical Thinking

The results of an expert on learning content, instructional design and the augment reality learning design, a way to check the quality of the specialists (Expert reviewer) Content Design and augment reality environment to learn from the evaluate form. The learning environment is designed according to the principles of the theory as a basis for the design. Overall fitness and help promote the creation of knowledge-based theory constructivist Whistler undertakings augment reality is a new technology that promotes analytical thinking as well. The assessment the assessment of the experts on the learning content, instructional design and the augment reality learning design, detailed as shown in Table 2.

Table 2: The result of the efficiency of the constructivist augment reality learning environment to promote analytical thinking

No	List assessment	Experts' opinions
		percent
learning content		
1	Appropriate learning content.	80
The design elements of the learning environment.		
2	Problem base	80
3	Resources	70
4	Analytical thinking center	80
5	Collaboration	80
6	Scaffolding	80
7	Coaching center	80
Comments about augment reality learning design		
8	Augment reality learning design promotes analytical thinking	70
	Total	77.5

According to Table 2, the results of the assessment of the experts on the learning content, instructional design and the augment reality learning design. Learning Environment found that the learning content, instructional design and the augment reality learning design. The synthesized; Consistent design principles along constructivist Whistler augment reality that promotes analytical thinking was 77.5 percent.

6. Conclusions and Future developments

This study designed the augmented reality learning environment to promote analytical thinking. The finding of this study show that both of theoretical framework and designing framework of the augment learning environment to promote analytical thinking. However, to enhance students' analytical thinking ability, we are going to study about the effect of augmented reality learning environment to promote analytical thinking learning with mobile technology on students' analytical thinking.

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Reliability Investigation of Automatic Evaluation of Kit-Build Concept Map by Comparing with Handmade Evaluation Methods

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Abstract: This paper describes an investigation of the reliability of automatic evaluation of concept maps in the framework of Kit-Build concept map. A concept map is a graphical tool for organizing and representing knowledge. In this framework, a learner is provided parts of a concept map and requested to build the concept map by combining the parts. This framework provides a kit-building task of a concept map which is a promising task to enhance and assess learners' comprehension in a topic that they already learned. The framework is practically used in several kinds of school. However, the assessment reliability has not been investigated. In this research, we try to investigate the reliability of assessment learner's comprehension of Kit-build concept map by comparing with handmade evaluation methods of the concept map. Two well-known handmade concept map evaluation methods that include the structural and propositional scoring method are chosen for comparison. These handmade methods can evaluate concept map meaningfully. Moreover, it is flexible for scoring because the human can understand the meaning of each proposition in concept map even the words of proposition do not appear in a learning material. So, the handmade methods are claimed they have reliability for evaluating concept map. To confirm our hypothesis, we designed the preliminary experiment in two learning comprehension situations. Those are learners' reading and instructor's teaching situations. In a preliminary experiment, the correlation between Kit-Build concept map and two handmade concept map evaluation methods in teaching situation has the marginal medium correlation. Even though this is a preliminary result, it suggests that Kit-Build concept map evaluation is reliable for evaluating concept map in the teaching situation.

Keywords: concept map, Kit-Build concept map, concept map evaluation, reliability

1. Introduction

Concept maps are utilized for evaluating learners' understanding widely. Various evaluation methods are proposed in different focus points. Kit-Build concept map is a learning task of exercise for checking learner's comprehension of a topic that they already learned. We have already used Kit-Build concept map in classrooms practically. It confirmed that the framework and results of the diagnosis were useful to support teachers in science learning in elementary school (Sugihara et al., 2012; Yoshida et al., 2013), geography in junior high school (Nomura et al., 2014), and the learning English as the second language (Alkhateeb et al., 2015). These reasons prove Kit-Build is good for using in teaching situation that instructor gives the direction following instructor's interpretation. However, we have not examined the quality of the propositional level exact matching evaluation method that is used in our framework. So we try to investigate the reliability of this method by comparing with handmade concept map evaluation method. These are the motivation of this research.

In the first phase since the 1980s, concept maps were evaluated by investigating the structure of propositions which was the one of an important feature of a concept map. However, some evaluators thought that only structure was not sufficient for evaluating a concept map. So, they provided a more meaningful evaluation method for scoring concept map. The latter method pays attention on the meaning of propositions in a concept map. This propositional method is reasonable for evaluating, but it takes a long time for scoring each concept map. Therefore, the automatic concept map evaluation is invented for decreasing time cost and human workload. It is useful for evaluating concept maps, but it does not get reliability for evaluating concept map as expected because it does not understand the relations which do not exist in the database. Although researchers try to apply synonym word matching which is very flexible for evaluating by using meaning of words, they have not yet accomplished enough level of accuracy. The propositional level exact matching is one familiar method for evaluating concept map by checking with the criteria map directly. It is very straightforward method that is used for assessing learner map in Kit-Build concept map. Nonetheless, it has been not investigated that it is reliable and proper for evaluating concept map. That is the reason why we want to confirm the reliability of the propositional level exact matching evaluation method by comparing with the reliable handmade evaluation methods.

Even though the reliability of the automatic concept map evaluation is still ambiguous, many educational researchers try to propose their method for using in a learning situation. The important features of concept map are differently focused on scoring. In this study, several automatic frameworks are investigated and compared with Kit-Build concept map about three important features that are the types of their criteria map, the level of evaluated meaning and the type of meaning matching. These features can be analyzed to identify a suitable situation to use Kit-Build concept map.

2. The Concept Map Evaluation Methods

In this study, many types of research about the concept map evaluation method are explained as the overview. First, we try to explore the handmade concept map evaluation method which is a typical one to compare with our framework reasonably. Moreover, detail of the automatic concept map evaluation method is described, and the automatic comparison concept map evaluating method is focused.

The Handmade Concept Map Evaluation Method

The evaluation methods in the handmade concept map evaluation method are used by a human who can understand the meaning of proposition well. 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.

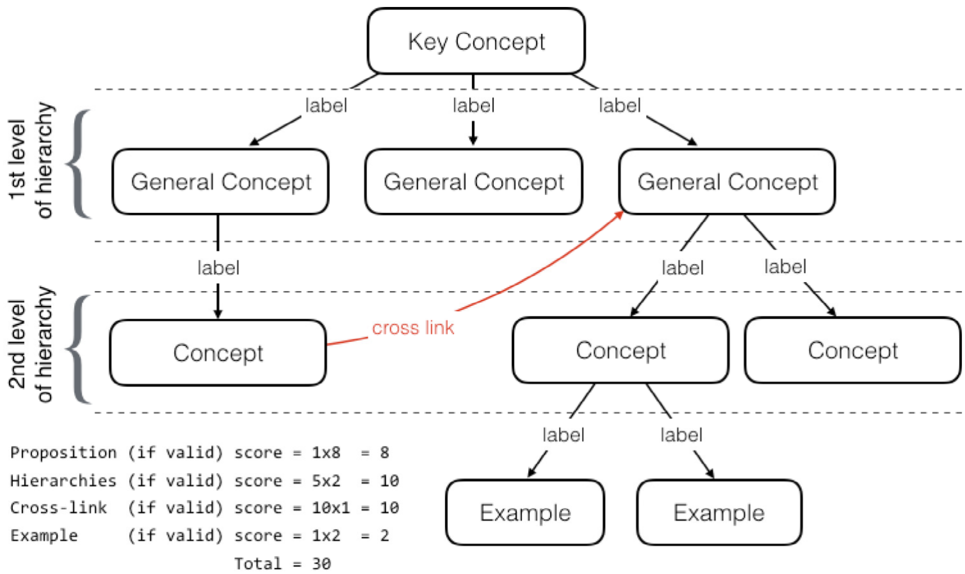

Figure 1. The example of Novak and Gowin structural scoring method

Several concept map evaluation methods evaluate concept map by investigating the structure of concept map such as the level of the hierarchy, the characteristic of the branch, crosslink and so on intentionally. These methods were developed from the 1980s. In this study, we introduce *the* *structural scoring method* of Novak and Gowin that was proposed in 1984 and it is a typical structural method (Novak and Gowin, 1984). 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. Nevertheless, it tends to the structure more than the meaning of the proposition. That is the reason why it gives only one score for each valid relationship of proposition and example. The example of the Novak and Gowin structural scoring method is illustrated in Figure 1. Furthermore, there are several methods that used concept map structure as the important criteria. The method that was developed by scoring from the connecting of the proposition is also grouped in the structural scoring method (Cronin et al., 1982).

The structural method tends to score the structure of concept map more than meaning may be the cause of important meaning leakage in a concept map. If concept map has much quantity of concepts in the concept map, it can get the point more than the concept map containing a few concepts. After the structural scoring method's phase, a lot of concept map evaluation methods were proposed to improve scoring by taking an interest in the meaning of the proposition.

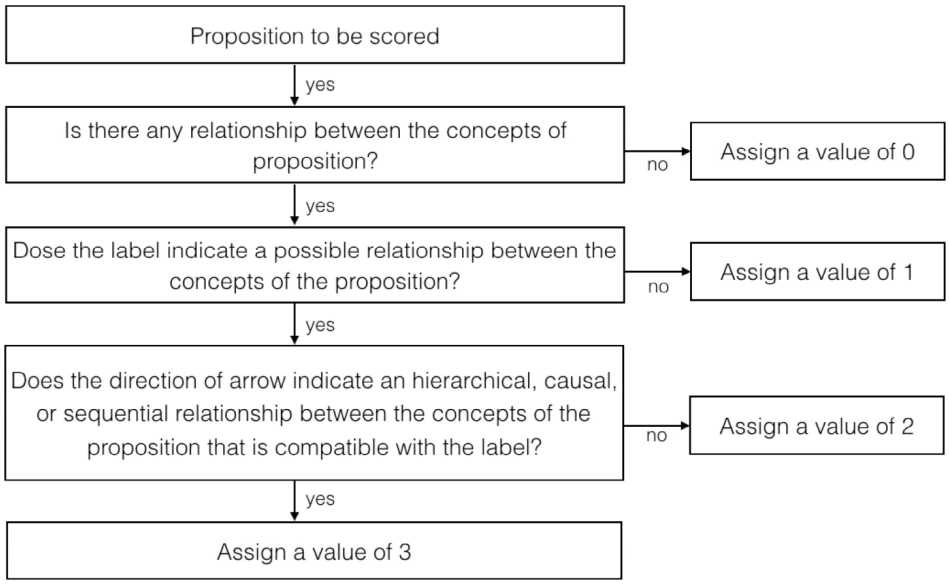

Figure 2. McClure and Bell relational scoring method

After the phase of the structural method, many handmade evaluation methods investigate the meaning of proposition for scoring concept map. They always consider on language and understanding representation, but they ignore the structure of concept map as the proposition precedence. In this study, we call the method of wide acceptance scoring which applies meaning criteria that *the propositional scoring method*. These meaningful methods always have a printed set of criteria as the rubric for assessing knowledge and giving feedbacks differently. However, we will focus on the relational scoring method from McClure and Bell in this study. It is one typical assessment method for concept map evaluation. In the method, the evaluator scores individual maps by evaluating each proposition on the concept map separately (McClure and Bell, 1990). So it will take very long time for scoring each concept map. Evaluator scores zero to three points for each proposition when considered by using a scoring protocol that occurs at Figure 2. Three points are assigned to a proposition which is correct label and representative a hierarchical, causal or sequential relationship between two concepts. Two points are given to proposition that can indicate a possible proposition's relationship. If it does not contain in two first conditions, it will be only checked about existing relation and get one point. Otherwise, the condition will be given zero point. For the reliability of this method, they claimed this method has the most reliability when using the master map by comparing with the holistic method and the structural method (Novak and Gowin structural scoring method). They confirmed the result by using g-coefficient value (McClure et al., 1999).

These handmade evaluation methods are obtained reliability more than the automatic evaluation certainly because the human consideration can understand the meaning of the relationship between concepts deeply, and it is more flexible than the automatic system. However, the evaluators have to consume much time for evaluating each concept map, and it is necessary to require the evaluator who is an expert in the study area for evaluating following the criteria.

The Automatic Concept Map Evaluation Method

Because of the time consumption and workload for the handmade evaluation, many researchers try to propose the automatic concept map evaluations. Most of the automatic concept map evaluation methods utilize the criteria map as the target of learning. They compare the learner map with criteria map to evaluate learners' understanding. In this study, we call these methods as *the automatic comparison concept map evaluation method*. This comparison inherits the property from the handmade concept map evaluation methods which are the structure of concept map precedence and meaning of proposition precedence. If learner maps are similar to the criteria map, it is obvious that learners can understand in instructor's objective well, which includes the understanding of structure and meaning of the proposition.

In the detail of the automatic comparison evaluation method, it assesses concept map by checking the property of concept map with the correct answer (the criteria map) automatically. This method is desirably used in automatic assessment because 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 constructed by using valid meaning in universe context and correct viewpoint of knowledge engineering. 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 even it was constructed by an instructor who understands in knowledge engineering fluently. That is different from the informal concept map. The informal concept map can be constructed freely by any words that the creators want to express. The informal concept map is easy to construct, but it is hard for evaluating the system because the system cannot guess the used words thoroughly. Besides the characteristic of the criteria map, we concern about the level of analysis and the type of matching method. For *the level of analysis*, some methods focus on the connectedness of selected concepts or topographical analysis methods to describe the overall geometric structure of concept map; we call the structure level analysis (Schwendiman, 2014). Nevertheless, 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 a valid proposition as the evaluating score. One more interesting 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 too strict so they proposed the synonym matching to support more flexible comparison.

The Concept Mapping Tool (CMT) is the automatic concept map assessment that evaluated the learner map by using rules-based to check link label and link direction (Cline et al., 2010). The criteria map in this system must create as the formal concept map for supporting university science level major. So it does not facilitate to adjust for appropriate with the instructor's viewpoint as expected. However, they proposed nine rules such as synonym and antonym for more flexible synonym matching in proposition level. In the result part, the CMT reports feedback to learners via the table of proposition accuracy and path rules. Learners can check their mistakes and try to understand the instructor's viewpoint. The other synonym matching that is interesting is the CRESST Human Performance Knowledge Mapping Tool (HPKMT) (Chung et al., 2006). This lenient method also evaluates at the proposition level.

While our framework, Kit-Build concept map framework (Hirashima et al., 2011, 2015) is one of the automatic concept map evaluation method that uses the criteria map to compare with learner map by using the exact matching in propositional level. The task of Kit-Build concept map is separated into two subtasks. The first is the segmentation task that instructor has to prepare the criteria map, which is called the goal map in our framework. The example of the goal map is illustrated in Figure 3. For our system, the goal map is constructed as the informal concept map because the goal map should follow the instructor's objective that requires learners to understand not the overall universe context. The instructor is not necessary to know about knowledge engineering and should feel free to construct his goal map. After submitting the goal map to the server, it is extracted to be the kit that contains a list of concepts and a list of relationships from the goal map. Moreover, 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. The second task is called the structuring task. Learners are given the learning task to reconstruct concept map by using the kit, which this map is called the learner map (Figure 4). After leaner maps are uploaded to our server, Kit-Build concept map will check leaner maps by matching each learner's proposition with goal map's proposition. That is the exact matching in propositional level. The system will generate a score of correction in a percentage format. However, the instructor can investigate learners' misunderstanding individually and can find the overview of all learners by overlaying the concept map as the group map (Figure 5) and the group-goal difference map (Figure 6) from Kit-Build concept map system immediately. In the group map, the link weight means the number of learners who link that relationship. From the example, the number of learners who connected "use to form" link between "Concept" node and "Propositions" node more than "used to form" link between "Linking Words" node and "Propositions" node. Furthermore, three types of error link are represented in the group-goal difference map. The lacking link is a link that exists in the goal map but does not exist in learner map. The excessive link is a link that occurs in learner map but does not occur in the goal map. Last, links that are not connected to any concepts in learner map are the leaving link. The instructor can use these links to find the holistic leaking understanding of all learners. Following Kit-Build concept map framework's ability, the instructor can use Kit-Build concept map to check understanding of individuals or group of learners and can use the diagnosis result to discuss with learners about the meaning of each error links. After error links analysis, the instructor can adjust the goal map or can teach learners about leaky content repeatedly.

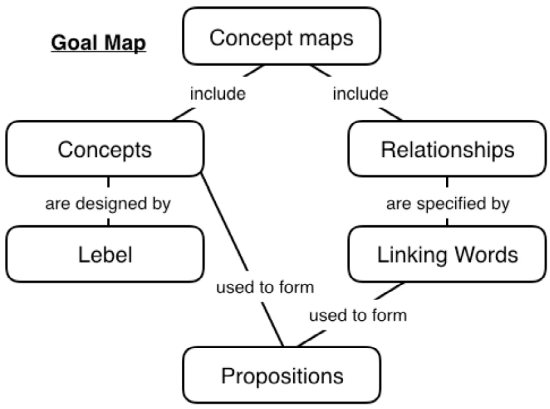

Figure 3. The example of goal map

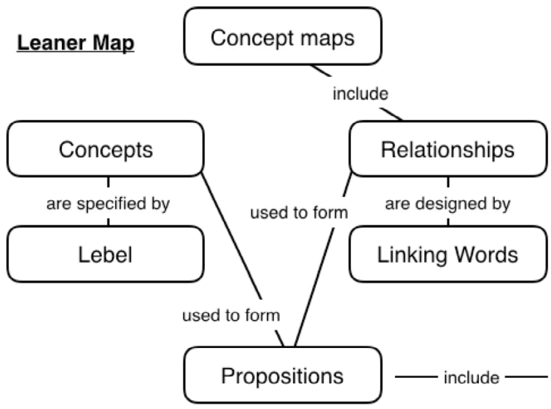

Figure 4. The example of learner map

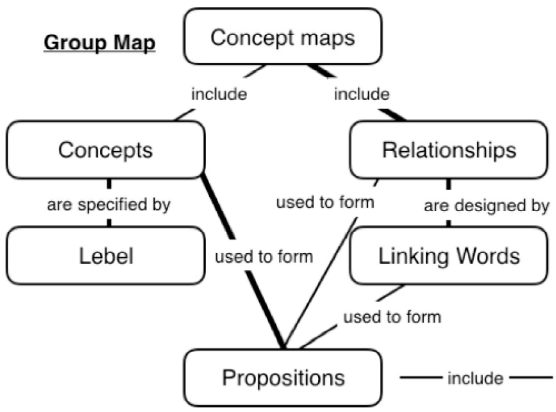

Figure 5. The example of group map

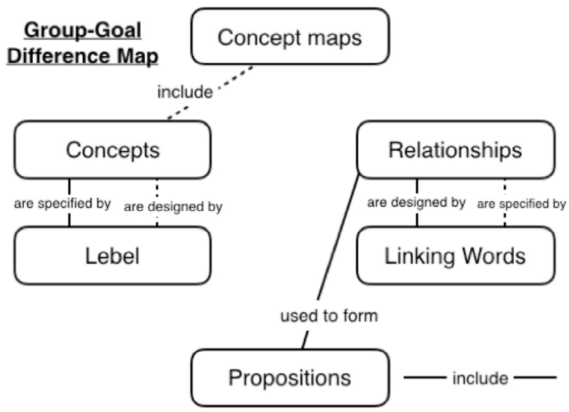

Figure 6. The example of group-goal difference map

3. Research Methodology

Because we have to investigate the reliability of Kit-Build concept map to confirm learners understanding, we tried to design the preliminary experiment for comparing Kit-Build concept map with the handmade concept map evaluation methods. The evaluators who use the handmade concept map evaluation methods can understand the meaning of each proposition even that relationships are expressed in a different viewpoint. So, the handmade concept map evaluation methods are claimed as the reliable evaluation methods. If the correlation between Kit-Build concept map and the handmade evaluation methods is a positive relationship, it means Kit-Build concept map is not much different from the handmade evaluation method and appropriate for using in concept map evaluation.

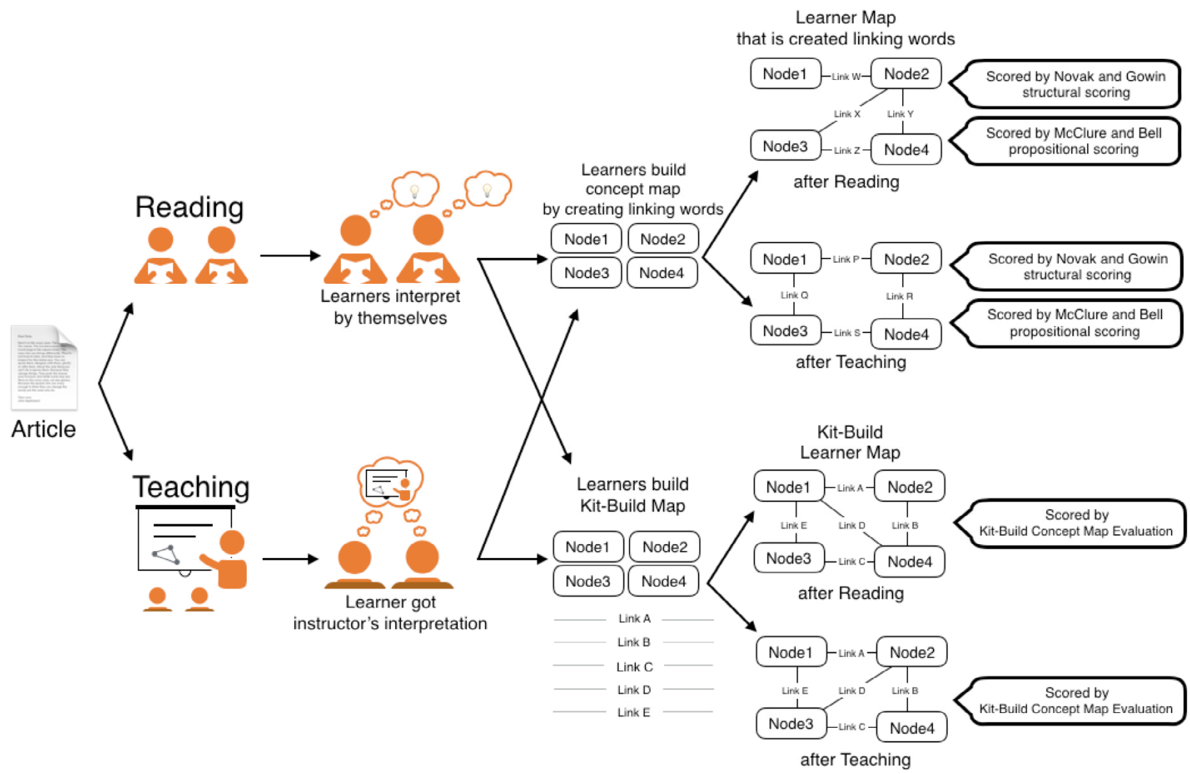

Figure 7. The preliminary experiment procedure

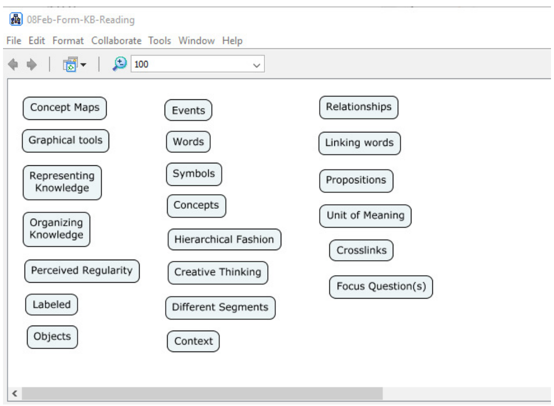

Figure 8. the experiment in CmapTools

Figure 9. the experiment in Kit-Build concept map

From the intentions that are expressed above, we designed the preliminary experiment for confirming our assumption displayed in Figure 7. In our preliminary experiment, ten university students were requested to read the article about "Introduction of concept map" (Novak and Cañas, 2008, p.1) and interpreted the article by themselves. After that, they constructed the concept map by using 21 provided concepts and had to create the linking words on their words in CMapTools application illustrated in Figure 8. These learner maps were evaluated by using the Novak and Gowin structural scoring and the McClure and Bell relational scoring which is the handmade concept map evaluation. Then, they were requested to build concept map again by using Kit-Build concept map. Participants had to connect each proposition by using provided kit. In this preliminary experiment, the kit contained 21 concepts that are same as provided concepts in CmapTools application and additional provided 22 relationships. The initial screen of Kit-Build concept map in this preliminary experiment is represented in Figure 9. After they connected the propositions completely and uploaded their map to our server, these learner maps were evaluated by Kit-Build concept map evaluation method that is the exact matching in propositional level. When we finished in reading situation, all participants are taught about the same article following instructor's interpretation. Then they had to construct the leaner maps following the same procedure as reading situation, which contains the constructing learner maps by creating linking words by themselves and constructing learner maps by using Kit-Build concept map.

4. Preliminary Experiment Results and Discussion

In this preliminary experiment, the score from two handmade methods was normalized to the percentage score already. The scores from Novak and Gowin structural scoring were normalized by the perfect score of the goal map and the scores from McClure and Bell relational scoring were normalized by the perfect score of each learner map. The average score of each method in reading and teaching situation are shown in Table 1. In this section, we will discuss the result of reading and teaching situation.

Reading Situation

Reading situation means the learners are given the article. They have to read and interpret by themselves. However, their understanding may be different from the others and instructor's viewpoint because each learner has distinct existing knowledge before they read. So it is hard to make an agreement of understanding.

The score of Novak and Gowin's structural scoring in reading situation obtains the lowest percentage, and the score of Kit-Build concept map is better than the first one a bit. The highest score is from McClure and Bell relational scoring. The result between Novak and Gowin structural scoring and the McClure and Bell's relational scoring in our preliminary experiment is in the same way with the study of (McClure et al., 1999) that the latter get scores more than the former. The reason that the participants obtain a low score in reading situation is participants who read the material and interpret the article by themselves constructed learner map by using the different viewpoint from instructor's objective. Following their reading interpretation, they cannot understand the extracted part of goal map that Kit-Build concept map provides. In this situation, participants said they could read and understand the article well, but it is very difficult to create linking words properly for building concept map from provided concepts. The most of the reasons that we received are about the number of concepts is too much. In addition, the problem, when they use Kit-Build concept map, is they cannot understand the relationship between the provided nodes and links. Many components can make learners confuse and worry to connect.

Table 1: Map scores in the experiment (*n*=10).

	Structural Scoring (Novak and Gowin's)	Propositional scoring (McClure and Bell's)	Automatic comparison (Kit-Build map)
Reading	24.56	35.09	30.30
Teaching	28.99	53.41	50.00

Teaching Situation

Teaching situation means instructor explains about the essence of the material to learners in the same time and same presentation. Learners will be conducted in the same structure of knowledge from the instructor. So, it is an easy way to make the learners understand in the same way. It is properly with Kit-Build concept map, which requests the situation that shared time and presentation in the same structure. The advantages of Kit-Build concept map are it utilizes these shared components to arrange learners' viewpoint and check their understanding following instructor's objective. In contrast, learners have to interpret by themselves in reading situation. There is no any guidance from anyone, and it maybe makes some different understanding from the instructor's objective. The reading situation is good for representing their thinking, but it is very hard to evaluate when the instructor has specific purposes.

After teaching, participants can improve their score for both constructing concept map by creating linking words and Kit-Build concept map. Score from Novak and Gowin structural scoring slightly increases from the reading situation while the others exceedingly rise. Because learners do not change the structure of their leaner map significantly. They paid attention to adjust the words of relationship that they understand from teaching context more than changing structure of concept map, and they do not try to think deeply about creating more level of hierarchy and cross-link. So the structure is not much different from the previous one. However, the score we got from McClure's relational scoring remarkably increases because the participants tried to agree on the context from the instructor. They adjusted the relationship following instructor's viewpoint. Additionally, the adjusted more meaningful words impact to this scoring method that tends to investigate on the meaning of each proposition. In the same way with the score from Kit-Build concept map, it rises extremely but still less than the relational method's score. Because learners' viewpoint is fulfilled by instructor's viewpoint in a teaching situation which uses wording the same as provided linking words, so learners can connect the relationship between each concept more clearly. Nevertheless, the reason that Kit-Build concept map is less than the score from the McClure and Bell relational scoring because the latter is evaluated by a human, who tries to understand each proposition in the maps so the score can increase extremely. On the other hand, the automatic system like Kit-Build concept map does not have this flexible feature because of the limitation of development. It does not try to interpret learner's thought, but it just compares the learner map with the goal map intently. Even though the score of Kit-Build concept map is less than the meaningful human evaluation method in both situations, it is acceptable because this automatic system can check and confirm learners' understanding and get a resembling score with the human evaluation.

From the result of the experiment, we found the correlation of results that is represented in Table 2. The p-values show that 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. On the contrary, the result of teaching situation has a marginal medium correlation between both handmade evaluation method and Kit-Build concept map. Moreover, we assume the handmade concept map evaluation method is reliable. It refers the lecture from instructors can make an agreement on that material by teaching and conducting the learners' understanding to the same direction with the instructor. These results suggest that Kit-Build concept map is suitable for the teaching situation more than the reading situation.

Table 2. The correlations between the handmade evaluation method and Kit-Build concept map

	Kit-Build concept map In a reading situation	Kit-Build concept map in a teaching situation
Novak and Gowin's structural scoring method	0.1406 (p-value=0.6984)	0.6209 (p-value=0.0553)
McClure and Bell's relational method	0.2702 (p-value=0.4503)	0.5520 (p-value=0.0980)

The one interesting aspect of this preliminary experiment is the improvement of learners when their use Kit-Build concept map after teaching situation. The score increases from reading situation obviously because participants cannot match their understanding with the provided nodes and links of Kit-Build in reading situation. However, teaching context can extend their viewpoint and makes them more acceptable the instructor's perspective. From the reason that the provided nodes and links will restrict the learners, it helps to keep their building following the instructor's perspective. In contrast, the teaching context can help participants to improve the concept map that is constructed by creating linking words slightly because learners try to represent their understanding including the instructor's viewpoint. However, it just expands their concept map not much and cannot go through the instructor's viewpoint properly.

Also, to think about the suitable situation for using Kit-Build concept map, three properties of Kit-Build concept map are discussed, because the goal map of Kit-Build is built in the form of an informal concept map. It suits for the situation that instructor need learners to understand in specific content and viewpoint. After the goal map is decomposed to be a kit and learners use it to reconstruct the learner maps, it is possible to use the exact matching for comparing between the goal map and leaner maps because of the restrictive set of words from the goal map's components. The semantic matching is not necessary when our framework provides the kit to learners. In addition, the words in the kit should be the common words that learners have to understand well. It is very important to discuss for making the common knowledge explanation with others. For the level of analysis, because our framework uses the goal map to compare with the learner maps, so the evaluating concept map by comparing in proposition level is very important for checking the meaning of the proposition. It is useful for generating informative diagnosis results. Our framework can show learners' misunderstanding or the part of the content that learners need more explain. While the reading situation learners must read the material by themselves and they may interpret in a different way from instructor's expectation. These reasons can support to confirm the exact matching in proposition level with the informal goal map of Kit-Build concept map is important and suitable in teaching context.

5. Conclusion

Our study tries to investigate the reliability of Kit-Build concept which is used in several kinds of school practically. We produce the preliminary experiment that compares Kit-Build concept map with the handmade concept map evaluation methods in two learning situation. The handmade concept map evaluation methods are categorized into two groups following the precedence. The structural scoring scores concept map by investigating composition straightforwardly. It is inconvenient for using in the classroom that instructor has to follow through the unit of instruction. On the other hand, the propositional scoring gives precedence to the meaning of propositions more than the structure. It is reasonable for evaluating understanding from concept map, but this method has to use an expert for checking and taking a long time for scoring. These methods are flexible and meaningful concept map evaluation, and the reliability of them is accepted widely. So we compare Kit-Build concept map with them for confirming our hypothesis. From our preliminary experiment, the results show the correlation between Kit-Build concept map and the handmade concept map evaluation methods in teaching situation has a marginal medium correlation. It means Kit-Build concept map is not much different from the handmade concept map evaluation methods. From the assumption that the handmade concept map evaluation method is reliable, so we can conclude that Kit-Build concept map is reliable and sufficient for evaluating concept map in a teaching situation.

For the future work, we desire to make more strong confirmation of Kit-Build reliability by using g-coefficient value in the full experiment. Moreover, the difficulty of evaluating by synonym matching of handmade evaluation may affect the reliability of evaluation. It depends on the evaluators who score concept map. While the exact matching of Kit-Build concept map always returns the score depend on the comparison between the goal map and learner map automatically. From this assumption, we try to confirm the reliability and stability of Kit-Build concept map is good enough for evaluating concept maps.

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The Incorporation of Inquiry-based Learning into Digital Game: A Pilot Study on Gender and Learning Style Differences in Students' Perceptions

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Abstract: With the profitable and advancement of using technology in learning, digital game-based learning is one of effective tools to support and enhance students' learning performance and to promote students' learning attitudes. It is very important to integrate the teaching and learning process into the digital game-based learning environment for encouraging knowledge construction. Inquiry-based learning approach has been recognized as an excellent teaching strategy to engage students in constructing knowledge and to make learning more meaningful. This paper has proposed a digital game-based learning by incorporating with inquiry-based learning approach. In this vein, this paper addresses what gender and learning style differences in playing and learning the digital game are by investigating gender and learning style differences in perceptions toward the game, such as perceived ease of use, perceived usefulness, attitudes towards digital game use, and behavioral intention to use digital game. A pilot study has been conducted on a Thai primary school in general science course. The results from 79 students indicate that the proposed digital game can decrease the difference between male and female and between visual and verbal learners' perceptions, reasonably. This suggests a need to develop the digital game that can provide the opportunities for interaction on game screen and with peers.

Keywords: Technology acceptance, individual difference, science education, educational computer game

1. Introduction

In recent years, more researchers have investigated the issue of technology-integrated education. It results that technology tool has attracted much attention for educational context for both formal and informal classroom. In general, online learning communities are gradually altering traditional learning style because of the pervasiveness of internet. In the same time, educational game has been regarded as highly impacted learning procedures (Shin Sutherland, Norris and Solovay, 2012), including enhancement the value of instruction (Meesuk and Srisawad, 2014). For example, Dori, Panjaburee and Srisawasd (2015) reported that the digital game-based inquiry learning approach could enhance students' learning in physics better than the traditional teaching approach. Kiili (2007) revealed that authenticity and learning by doing, the most important characteristics of effective educational games, can enhance students' problem solving abilities. Although digital game-based learning approach seems to be an effective tool, researchers have pointed out that such approach could create negative impact, such as less learning outcomes, when it has been designed without proper teaching strategies or learning process (Chang Wu, Weng and Sung, 2012; Charsky and Ressler, 2011; Hoffman and Nadelson, 2010). Several researchers indicated that one great challenge of educational computer game development is to provide support and to guide the learners while keeping the balance between learning and gaming and between challenge and individual learners' abilities (Kickmeier-Rust and Albert, 2010; Charsky and Ressler, 2011). Therefore, it is important to provide suitable learning strategies or tools when developing digital game for educational purposes.

Among various learning-teaching pedagogies, inquiry-based learning have been recognized as an excellent teaching approach to engage students in constructing knowledge and to make learning more meaningful (Benson and Bruce, 2001; Pedaste and Sarapuu, 2006). Consequently, the inquiry-based learning can be an instructional approach for stimulating students' thinking processes and promoting conceptual understanding (Lim, 2004; Looi, 1998). Although there are a number of researchers that developed the educational game integrated with inquiry-based learning approach showing that the game could help students improve learning performance, promote learning attitudes, and promote learning motivation (Dori, Panjaburee and Srisawasdi, 2015; Lin, Liang and Tsai, 2012). There is another human factor, which is learning style differences, is influences perceptions of ease of use, usefulness, and usage behavior of e-learning (Lu, 2012). However, the students' individual differences such as genders and learning styles, which are the key factors effecting learning, have not addressed yet. Therefore, in this pilot study, we has incorporated components of guided inquiry-based learning into the digital game and implemented into the force and motion topic. Moreover, to cope uninvestigated area of educational digital game, this pilot study aims to empirically evaluate there is interaction between learning styles (i.e., visual and verbal leaners) and genders (i.e., female and male) of students' perceptions about the developed digital game.

2. Relevant Research

Digital Game-based Learning (DBL)

Game consisted of challenge, control, curiosity and fantasy can be created persistence and enjoyment (Toro-Troconis and Patridge, 2010). Regards to its functions, many educational researchers and developers have developed games for teaching and learning in following three goals (1) Students can learn from playing the game; (2) the component of game can be supported the learning's ability and (3) students are motivated to learn via playing the game (Mcnamara, Jackson and Graesser, 2010). DGBL is a student-centered instructional approach, which incorporates learning content or learning principle into computer game to engage student and achieve the educational goals. In an educational game, learners are situated in gaming scenario to complete a series of tasks individually, collaboratively, or even competitively (Nelson, Erlandson, and Denham, 2011). The players need to be challenging enough to compete while acquiring educational goals according to specific rules and principles, contributing to the development of their cognitive skills and their construction of knowledge, while at the same time promoting their motivation (Erhel and Jamet, 2013; Huang, Huang and Tschopp, 2010). Moreover, DGBL can afford a meaningful environment for developing students' problem-solving abilities (Kiili, 2007; Kim, Park, and Baek, 2009).

In recent years, many studies have developed and reported that DGBL was able to promote students' learning interest and motivations (Ebner and Helzinger, 2007; Huang, Huang and Tschopp; 2010). For example, Huang, Huang and Tschopp (2010) survey 264 undergraduate students after playing online game, and found potential relationship between intrinsic motive and extrinsic rewards. Inal and Cagiltay (2007) further investigated the flow experience of children in an interactive game environment and found that the challenge and complexity elements of the games had a greater effect on the children's flow experiences than did clear feedback. Dickey's study (2011) investigated the impact of narrative design in a game-based learning environment and found that intrinsic motivation, curiosity and plausibility all benefited from game-like environment.

In addition, researchers have investigated the impact of DGBL from many aspects. For example, Lee and Chen (2009) studied the impact of different prompts and levels of prior knowledge on problem solving in non-routine mathematical situations, and reported that prior knowledge and comprehensive mathematical ability were important further related to the problem-solving effect. Kiili (2007) indicated authenticity, collaboration and learning by doing were the key factors of effectively conducting education game. Unlusoy, de Haan, Leseman, and Kruistum (2010) revealed that males show more interest in digital game than females. Paraskeva, Mysirlaki, and Papagianni (2010) and Dorji, Panjaburee, and Srisawasdi (2015) reported that the gender differences play the important role when playing digital game effecting the learning performance.

Inquiry-based Learning Approach

Inquiry based learning approach is a method that students are provided opportunity to carry out investigation to test their ideas and construct their own knowledge, making inquiries through experiment. It is based on constructivism theory of John Devery and Jean Piaget. This approach can help students to acquire scientific process skills. When engaging in inquiry, student describes objects and events, asks questions, constructs explanations, test the explanations against current scientific knowledge, and shares ideas with others. The students are asked to identify their assumptions, use critical and logical thinking, and consider attractive explanations. In this way, they actively develop their understanding of science by combining scientific knowledge with reasoning and thinking skill (NRC, 1996). Inquiry based learning could promote students to conceptualize a problem and then search for possible explanations related to that problem (Olson and Loucks-Horsley, 2000), so as for enhance their high-order thinking abilities and problem-solving skills. Ikpeze and Boyd (2007) indicated that it could encourage students to participate in explanations, reflections, and reinforcement of critical thinking abilities are significant in prompting inquiry for the high degree of complexity provided by nature problem-solving contexts. Therefore, appropriate learning situation are needed for students to perform tasks effectively (Endsley, 2000).

The progress of computer network technologies has provided the potential benefits of the inquiry-based learning (Ucar and Trundle, 2011). Many previous studies demonstrated positive impacts of technology-integrated inquiry-based learning environment on learning effectiveness (Hwang, Tsi et al., 2012; Kuhn et al., 2000). However when conducting inquiry-based learning activities in conventional classroom, it is a remain a dilemma to afford students the situations required to conduct meaningful inquiry activity (Lim, 2004).The classroom environment, using the traditional approach might not be suitable to facilitate student collection of the information necessary to carry an inquiry activities (Lee and Butler, 2003). Moreover, educators still face many challenges in designing inquiry activities in a computer and ill-structured learning environment (Lim, 2004). The inquiry based learning character, thus, has been more focused as it is originated in the scientific inquiry practices, engage student to investigate the scientific oriented questions, perform experiment, create explanations from evidence, evaluate the explanation, communicate to analyze the result possibility, justify and summarize the output (American Association for the advancement of Science, 1993). Among the different levels of inquiry based learning approach, this study has been basing on the guided inquiry-based learning approach. It has been characterized to be the guideline that teacher will provide problem/question, setup background and also determine the procedure/design and student have to perform the experiment based on the specified design, making the communication and conclude (Buck, et. al, 2008). The guided inquiry based learning approach will be used as the guideline to create and design the game environment in this study. Because in the purposing game, teacher has to make sure that student will have enough information to perform and summarize all information and concept from playing in game by themselves. The game stage and environment has to be design to guide and help student to get information until finish playing game.

3. The Incorporation of Inquiry-based Learning into Digital Game Approach

In this study, a digital game-based learning has been developed by incorporating the guided inquiry-based learning approach into gaming scenario for encouraging and promoting students' learning performance in physics course. The game has been implemented with Flash Maker. MySQL has been used as the system database. The 2D role-playing game has been chosen in this study because it is enough for presenting the game scenarios. It requires less computer power, which is supported in the most elementary school in Thailand. Moreover, researcher avoid situating elementary school students in a complex 3D interface, which may increase the difficulty for them to learn with the game (Hwang, Chiu, and Chen, 2015).

Figure 1 presents the structure of the game, which is composed of a main gaming interface, a communication interface and an assessment interface and a content management interface; furthermore, there are several database, consisted of a student information database, a test information database and a learning material database.

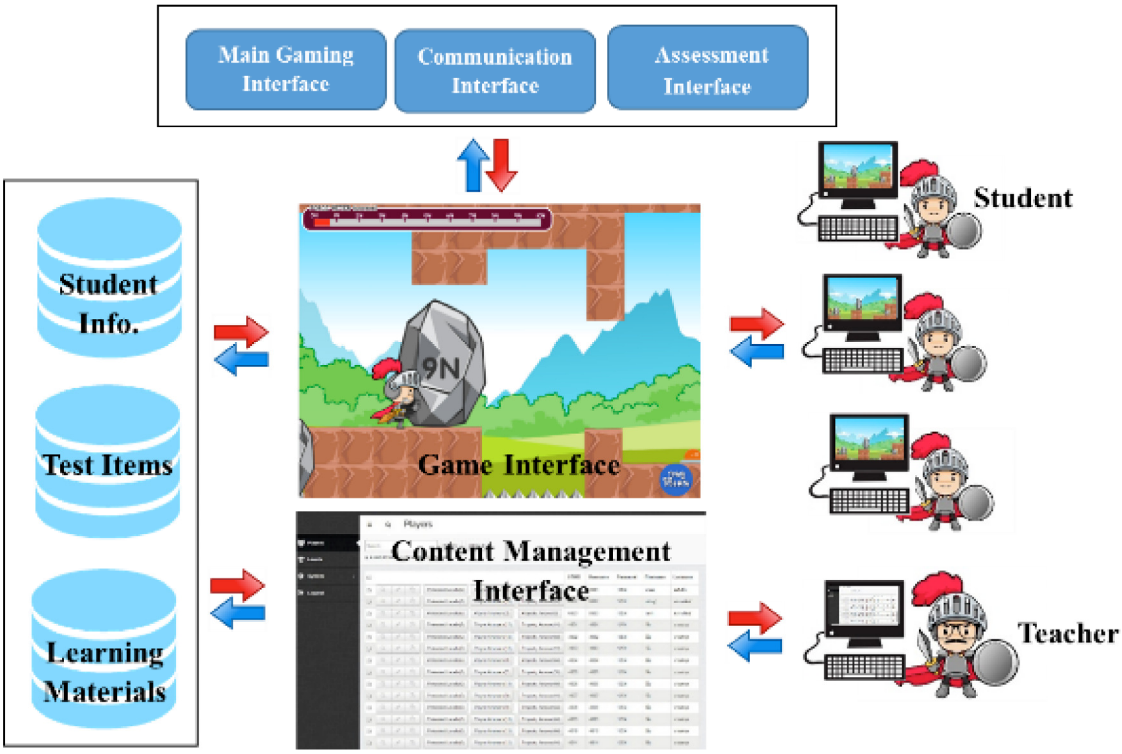

Figure 1. The structure of the digital game-based learning

The main gaming interface enables student to learn and explore in various gaming situation. The communication interface arranges some questions for student to deal with, so as, to enhance the collaboration between students and teachers. For instance, the students can see the answer from other students including hints or messages from teacher as shown in Figure 2. In this study, the "force and motion" of an elementary school physic course has been used to demonstrate the effectiveness of the proposed approach. In this game, the students need to learn the basic concept of force and motion and resultant force; moreover, they are situated in various stages embedded in the storyline of the role-playing game, so as, to explore and experience all stages, which may occur after answering the correct question in each stage.

The role-playing game is concerned with a story of an ancient kingdom in which the princess was caught and taken into the bad dragon island. The knight who was taking care of princess need to find and help the princess on that danger island. Therefore, the knight decides to go into the dragon island, which are in fact the context of force and motion concept to be explored in each stages to reach the princess. During the learning process, the students play the role of the knight to find the princess.

There are several barriers in five stages which student need to go through, magic beach, fire forest, trap hill, streaming cave and dragon henchman. Each stages were designed for each concepts. In addition, there are tests to ensure that the knight has power and concept enough to fight with the dragon. Once players finish the stage and answer question correctly, they are allowed to proceed to the next stage of the game. If the student fail the tests, the system will provide them some more information or illustrative examples.

Figure 2. The communication interface of other students and teacher

The game starts with the introduction to the background of the story. First stage, the knight stop the boat by the beach to get into the island. There are many obstacles with fire to deal with. The student will learn the characteristic of force and motion. Second stage, trap hill, there are many danger traps along the way. The knight need the big and huge stone to get across those traps. In this stage, the student will get the idea of force composition. Third stage, fire forest, the forest are burnt by the dragon. The knight get lost and need to escape by getting the fireball into an ancient jar to protect the forest. The concept of this stage is to understanding the direction of force. Fourth stage, streaming cave, the knight stuck in front of the big streaming cave. A big old log next to the stream is the key to get across and get out. The concept is the method to move the log and the same direction of forces accumulation. Moreover, the last stage, dragon henchman, the henchman are pulling to hide the key box which use to unlock and help the princess. The knight have to get that key. The student will face with the resultant force and understand the resultant force calculation from this stage. The students have to identify, explore and analyze those situations and record the data with the data grid provided during the game process, Figure 3. The role-playing is selected as the gaming type because it is to situate students in the authentic contexts of force and motion, so that the student can learn from exploring and solving the problems in context. Moreover, the students will be enabled to realize that the knowledge they have learned can be applied to some real-world contexts from this approach.

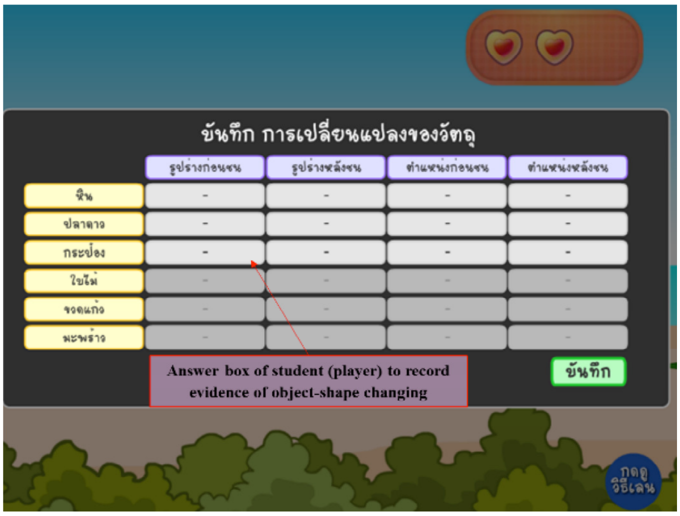

Figure 3. The data grid to be recorded during the game process

The learning system will be the same process in each stage, based on inquiry-based learning approach. And at the end of each stage, the system will have the formative assessment for student to be ensure that the student have clearly understand the concept by selecting the prepared tests from item bank of that unit. Once an item was answered successively and correctly, it will move the student to the next unit and the counter is reset; however, if an incorrect answer is given, the accumulative total of counter is added and system retrieve new item. When the student fail to answer correctly a test item, the system does not provide the correct answer to them; instead, it show some information to guide the student to make further analysis. That is, the students are prompt to find the correct answers on their own. The six formative assisted items have been prepared for each unit.

4. Research Design

Participants

A total of 79 fourth and fifth graders of elementary school under Office of the Basic Education Commission in Central part of Thailand were recruited in this pilot study. The students individually participated in the developed game, and shared the result in the game with their friend to construct their own knowledge. After finishing learning activities in the game, they were asked to take a questionnaire to clarify the degree of their perceptions toward the game.

Measurement Tool

The perception questionnaire were adopted from Teo's (2009) technology acceptance model questionnaire and translated to Thai language by the authors in this paper. It consists of 11 items with a five-point Likert rating scale. It consisted of four dimensions, perceived usefulness (3 items), perceived ease of use (3 items), attitude towards digital game-based learning use (3 items), and behavioral intention to use digital game-based learning (2 items). In this questionnaire, students have to respond each item within 5-point rating scale (1-strongly disagree; 2-disagree; 3-neutral; 4-agree; 5-strongly agree). The Cronbach's α value of the questionnaire in Thai version was 0.91, showing acceptable reliability in the internal consistency. Moreover, the composite reliability values for the perceived usefulness, perceived ease of use, attitude towards digital game-based learning, and behavioral intention to use digital game-based learning dimensions were 0.84, 0.79, 0.76, and 0.82, respectively, showing good internal consistency of each construct (Panjaburee and Srisawasdi, 2016).

The perception questionnaire is related to the technology acceptance model specifying perceived usefulness, perceived ease of use, attitude towards digital game-based learning use, and behavioral intention to use digital game-based learning. Perceived usefulness refers to which a person believes digital game-based learning will help him or her to perform a certain task in an efficient and productive manner. In contrast, perceived ease of use refers to which a person thinks that the use of digital game-based learning will be relatively free of effort. Attitude refers to which a person has opinion and feeling toward the digital game-based learning. In addition, behavioral intention to use refers to which a person desires to use the digital game-based learning.

Experimental procedure

The experiment was conducted in an elementary school science course as shown in Figure 4. Before conducting the experiment, the students were introduced the game and story line by researcher, and the basic functions of the game. Following that, the students played the game and took a perception questionnaire. During the learning activity period of 40 minutes, the students were monitored and facilitated by teachers. Moreover, the students were asked to response the perception questionnaire for a period of 25 minutes.

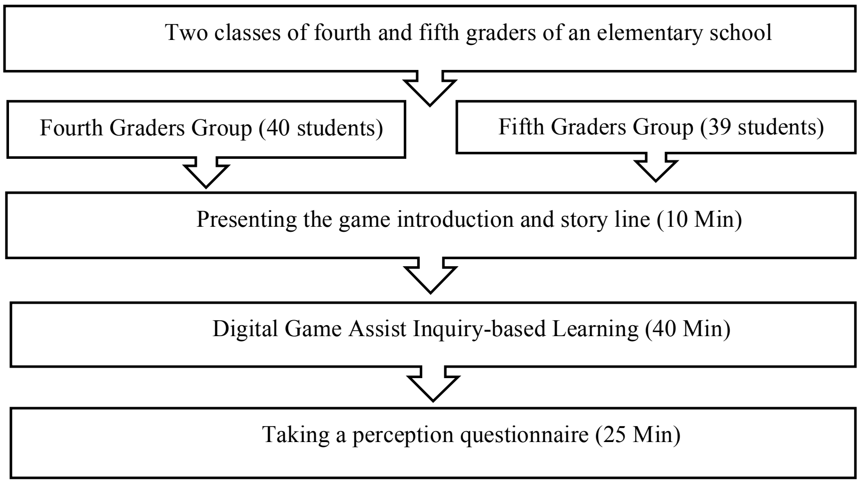

Figure 4. Experimental design for the learning activities

5. Research Results of Students' Perceptions

To understand interaction between learning styles (i.e., visual and verbal leaners) and genders (i.e., female and male) of students' perceptions about the developed digital game, the students were asked to response a questionnaire. Moreover, a two-way MANOVA was employed. The learning styles (i.e., visual and verbal leaners) and genders (i.e., female and male) were independent variables, while the questionnaire ratings of perceptions were a dependent variable. Before conducting the two-way MANOVA test, the assumption of Box's M test of equality of covariance matrices was performed. We found that the equality of covariance matrices was not violated with F = 1.580 (p > .062). Therefore, two-way MANOVA test can be used to analyze the questionnaire ratings of perceptions of the students. It is found that there is no a statistically significant interaction effect between gender and type of learning style on the perceptions about the developed digital game-based learning, $F_{(4,\ 72)}$ = .898, p = .470; Wilks' Lambda = .952.

Table 1 shows the descriptive data on the questionnaire ratings of the perceptions about the developed digital game-based learning. It clearly demonstrates that when learning with the developed digital game-based learning approach, female and male students perceived usefulness, ease of use, attitude of use, and intention to use the digital game similarly. In addition, female and male students with different types of learning style perceived usefulness, ease of use, attitude of use, and intention to use the digital game similarly.

Table 1: The descriptive data of the perceptions of the students who have different types of learning styles

Dimension	Gender	Learning Style	N	Mean	SD
Perceived Usefulness	Females	Verbal	7	12.71	2.059
		Visual	37	13.92	1.920
	Males	Verbal	5	14.20	1.095
		Visual	30	13.83	1.533
Perceived Ease of Use	Females	Verbal	7	13.86	1.069
		Visual	37	13.62	1.320
	Males	Verbal	5	14.60	.548
		Visual	30	14.03	1.829
Attitude towards Digital Game-based Learning Use	Females	Verbal	7	13.00	1.155
		Visual	37	12.92	2.191
	Males	Verbal	5	13.60	2.191
		Visual	30	13.53	2.224
Behavioral Intention to Use Digital Game-based	Females	Verbal	7	7.43	1.134
		Visual	37	8.43	.987

Learning	Males	Verbal	5	8.80	1.304
		Visual	30	8.73	1.484

6. Discussions and Conclusions

This study analyzed the perception of an incorporation of inquiry-based learning into digital game targeted at primary school students' learning of physics course on force and motion topic. This study indicates that there is no difference between male and female and between visual and verbal leaners perceptions about the proposed design of digital game incorporated with inquiry-based learning.

Although Lu (2012) revealed that learning style difference influences perceptions of ease of use, usefulness, and usage behavior of e-learning, but the main findings of this study clearly highlighted that female and male students who learned with the developed digital game-based learning approach similarly perceived usefulness, ease of use, attitude of use, and intention to use the digital game. Moreover, the study also pointed out that female and male students with different types of learning styles who learned with the developed digital game-based learning approach similarly perceived usefulness, ease of use, attitude of use, and intention to use the digital game. These findings shown that the proposed digital game can reasonably decrease the difference between male and female and between visual and verbal leaners perceptions.

Consequently, we could suggest that the proposed developed digital game-based learning approach could be support learning and decrease gap between females and males and gap between learning style differences. It means that the game can provide opportunities for interaction on game screen and with peers.

Acknowledgements

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Constructivist Learning Environment to Enhance Cloud based Collaborative Learning: Product Design and Development Phase

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Abstract: Collaborative Learning is the important key for constructivism learning because it is clarify knowledge of the learner. If collaborative learning is adapted with cloud technology, the learner would get more ideas. Thus, the objective of this research is to design the learning environment in constructivism learning which supports collaborative learning on cloud technology. This research methodology are synthesis designing framework, learning environment design, and pilot study. The result of the study was found that the design of learning environment based on constructivism with cloud technology consist of 1) problem situation 2) resource center 3) collaborative learning center 4) scaffolding 5) coaching. The evaluation of the collaborative learning with cloud technology found that the learner are encouraged to study with cloud technology ($\bar{x}$ = 4.52) regarding to online collaborative learning theory; Idea Generating ($\bar{x}$ = 4.67), Idea Organizing ($\bar{x}$ = 4.40) and Intellectual Convergence ($\bar{x}$ = 4.48).

Keywords: Constructivism, Learning Environment, Cloud Technology, Collaborative Learning, Higher Education

1. Introduction

Nowadays technology education has evolved dramatically. In order to comply with teaching in digital society, cloud processing technology becomes popular for online learning. At the present days, cloud technology used in widely in classroom such as Google Apps which can create, store document, communicate and support collaborative learning that broaden learners' point of view, create and manage ideas and intellectual fusing (Hararim, 2012). So it is interesting to develop learning environment based on Constructivist to promote cloud collaborative learning to apply in leaning that focus on learners' collaborative learning and knowledge with their highest potential.

2. Literature Review

Constructivist Learning Environment

Viewing constructivism as a different perspective from objectivism on the learning process and a complementary learning tool with objectivism, (Jonassen, 1999). Proposed a model for designing constructivist learning environments. The CLEs theory assumes that the problem drives the learning, rather than acting as an example of the concepts and principles previously taught. Social learning: Learning is to construct knowledge individually and/or socially based on learners' interpretations of experiences in the world. Instruction is to engaging learners in meaning making (knowledge construction) (Kanjug, Chaijaroen, and Samat, C., 2015). The CLEs theory suggests a set of instructional methods including selecting and providing appropriate problem, related cases or worked examples, learner-selectable information, cognitive tools, collaborative tools, social/contextual support. Instructional activities could involve modeling, coaching and scaffolding in the CLEs.

Collaborative Learning

It is an educational approach to teach and learn by groups of students to work together, think, and solve problems, complete tasks (Kanjug, 2014). Learners are encouraged to engage in discussion, active learning techniques, collaborative work, learn new things and share their ideas by reflects to their classmates. The collaborative learning was designed according the core design principles of Online Collaborative Learning Theory (Hasrasim, 2012). There are three phases of knowledge constructions through discussion. First, Idea generating means the brainstorming phase which their ideas are gathered and divergent. Second, Idea organizing means the phase that their ideas are compared, analyzed and categorized through discussion and argument. Third, Intellectual convergence means the phase of their ideas are synthesis and be able to apply their knowledge.

Cloud based Learning

Students learn from cloud technology by logging into a provider's site such as program system, application on internet network. It can facilitate students to learn new knowledge effectively because they can access into their learning material wherever they wish which support their learning, sharing information and reliable storage.

3. Method

This research consists of document analysis and survey and analyzes data in quantitative and qualitative method.

3.1 Learning Environment Design

Synthesis of learning design of learning environment base on Constructivist framework to facilitate learning on Cloud technology according to 5 bases as shown in Table 1

Table 1: Supporting for restructuring

Principles	Environment	Cloud Technology
Cognitive restructuring and collaborative learning	Problem Based and Task	WixTool, Fackbook
Support Cognitive structuring and problem solving collaboration	Resource center	WixTool,Youtube, Google App
Promote collaborative learning	Collaboration	WixTool,Youtube, Google App, Mindmeister
Facilitate and enhance intellectual balance	Scaffolding	WixTool, Fackbook
Facilitate and enhance intellectual balance	Coaching	WixTool, Fackbook

3.1.1 Cognitive restricting and collaborative learning

The design based on "problem base" The problem context: a description of the physical, organization, and sociocultural context in which the problem occur should be represented to the learners. The situations were created to use in the classroom related to computer and ICT to teach and learn. The text and pictures were modified to create problem representation to help the students understand better about the problem and situations. They need to help each other to solve the problem in their group through Google cloud. This theoretical concept was adopted into practice and designed as "Problem Base" as shown in Figure 1.

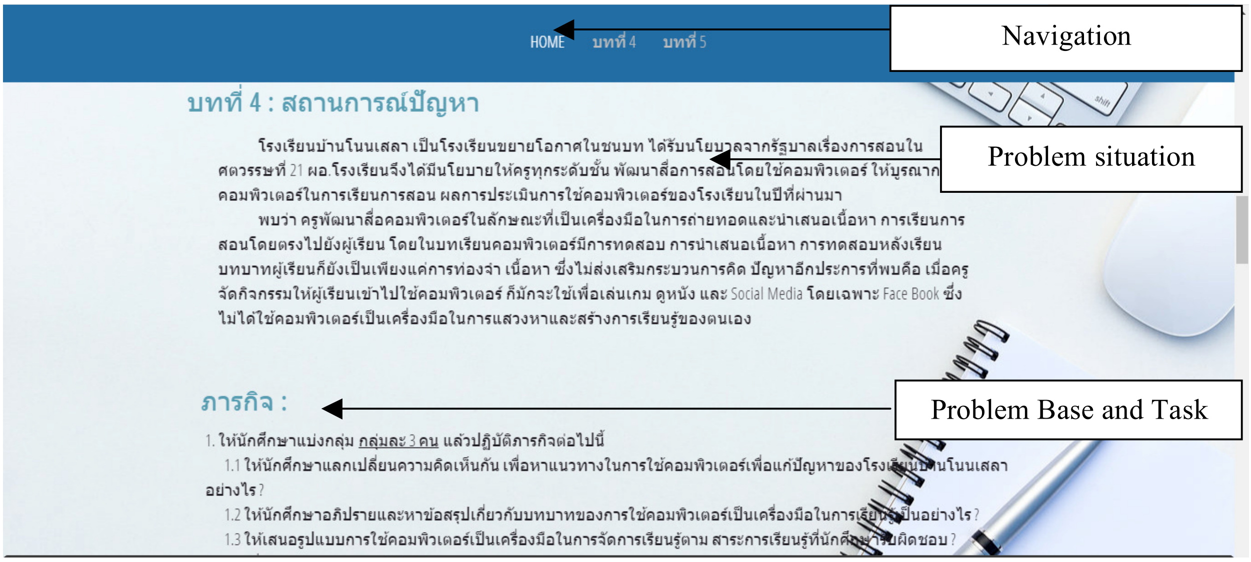

Figure 1. Problem Base and Task

3.2.2 Support Cognitive structuring and problem solving collaboration

It was designed as information resources and online collaboration. CLEs have to provide just-in-time information to help learners comprehend and solve the problem. Collaboration tools were used to work together such as doc, slide, form which the group members can share their ideas and work. This theoretical concept was adopted into practice and designed as "Resource center" as shown in Figure 2.

Figure 2. Resource center

3.2.3 Promote collaborative learning

When the students face with problem in their tasks but they cannot learn or balance their cognitive structuring. This was designed base on Online Collaborative Learning Theory (Harasim, 2012, Meepiaen, 2015) with three ideas; Idea generating, Idea organizing, and Intellectual convergence. Therefore, this design focuses on the students' interaction, exchange their ideas and discuss with their classmate. This can be another way to learn and balance their knowledge. This theoretical concept was adopted into practice and designed as "Collaborative Learning Center" as shown in Figure 3.

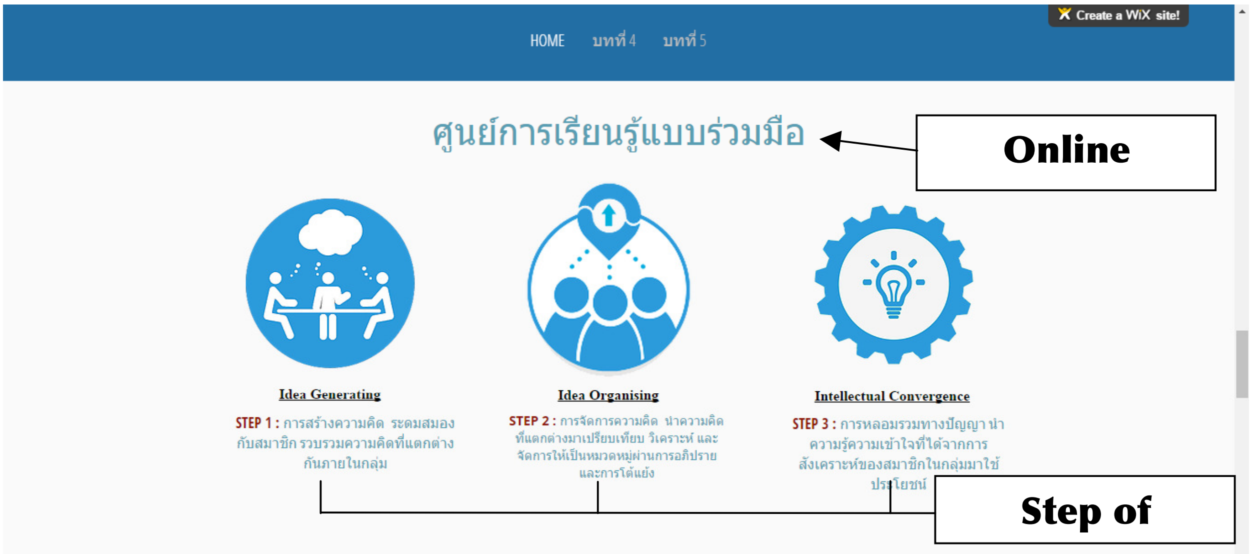

Figure 3. Collaborative Learning Center

3.2.4 *Facilitate and enhance intellectual balance*

The objective of design is for scaffolding and coaching. The constructivist learning influences teacher to become more coach rather than just teach which is to support, encourage, imply, and give the learner advice. Coaching can help students to generate idea and learn to gain knowledge themselves. Coach needs to be an observant, a listener, and a questioner in order to promote students critical thinking skill. Scaffolding is a systemic approach to supporting the learners in different aspects of the learning environment (the tasks, the teacher, the learner, the materials, the tools): based on learner's level of understanding and need, adjust task difficulty, restructure the task. This theoretical concept was adopted into practice and designed as "Scaffolding" as shown in Figure 4 and provide alternative assessments with the technology of Facebook, messenger and Google hangout. This theoretical concept was adopted into practice and designed as "Coaching" as shown in Figure 5.

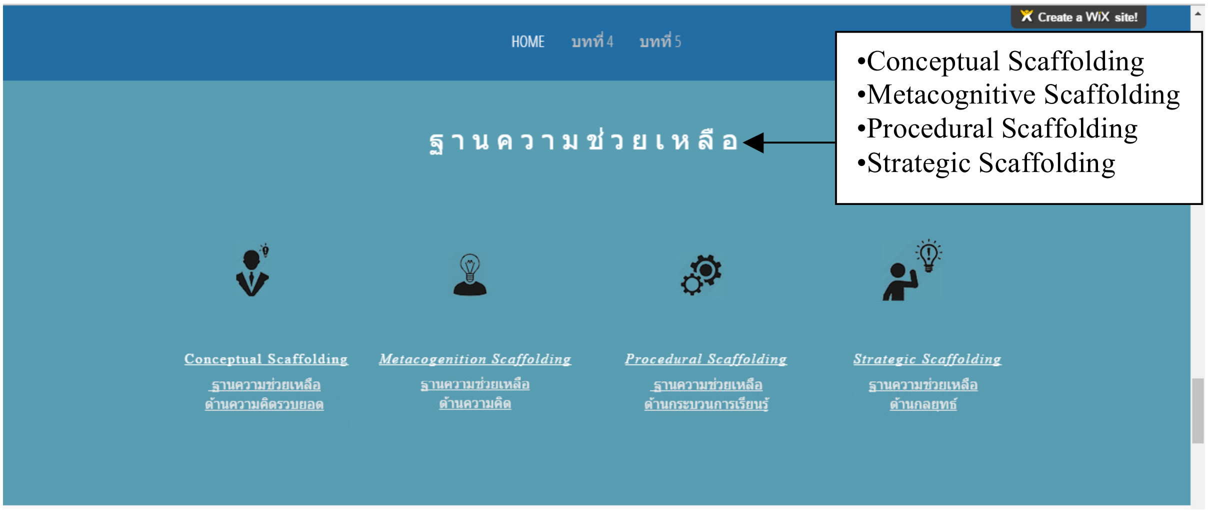

Figure 4. Scaffolding

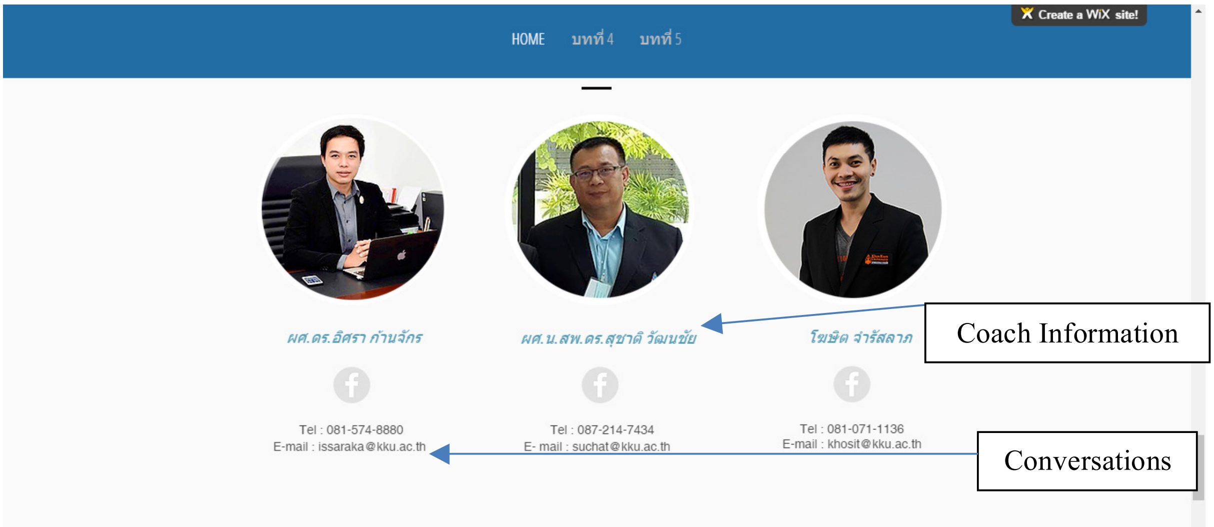

Figure 5. Coaching

3.3 Pilot Study

Constructivist learning environment to enhance cloud based collaborative learning which was developed according to theoretical framework and checked by expert and pilot to 29 undergraduate students to examine the context of learning environment.

3.3.1 Participants

1) A lecturer of Innovation and information technology for learning
2) An expert in Innovation and information technology for learning to check the validity of the content
3) 29 undergraduate students

3.3.2 Research Instrument, Data Collection and Analysis

3.3.2.1. Research instrument

1. Constructivist Learning Environment to Enhance Cloud based Collaborative Learning consist of
   a. Situation
   b. Resource
   c. Procedural scaffolding
   d. Collaborative learning center
   e. Coaching

2. Collaborative learning evaluation was developed on the basis of Online Collaborative Learning Theory (Harasim, 2012) and the assessment of collaborative learning form of Meepian (2015).

3.3.2.2. Data Collection

Introduce the task
1. Explain and guide the students to learning environment
2. Divide them in a group of 3 students to study the context

Learning Process

1) The students in each group join Constructivist learning environment on cloud where they had assigned task to finish
2) The students find the answers from the provided menu which consist of situation, resource, procedural scaffolding, collaborative learning center, and Coaching.
3) The students help each other to solve the problem and find the solution on their own on cloud
4) Teacher and researcher support and facilitate them to think and study the information in every provided design.

Then the group control has used network from the constructivist learning environment where emphasize on Cloud collaborative learning for 1 week and 4 hours for group discussion in class room

4. Results and Discussions

According to data analysis from the evaluation survey concerning to their collaborative learning on cloud technology under three phrases of knowledge construction through discourse in a group, it revealed that students participated and exchanged their ideas among the group members on cloud the most at ($\bar{x}$ =4.52). To consider the result according to online collaborative learning theory (Harasim, 2012; Kumpang, and Kanjug, 2015; Meepiaen, 2015), it found that the students in Idea generating phase, had significant role at ($\bar{x}$ =4.67). The members in group were able to share and reflect their ideas with the highest mean at ($\bar{x}$ =4.76) while gathering ideas to solve the problem at ($\bar{x}$ =4.52).

In Idea organizing phase, overall represent the highest number at ($\bar{x}$ =4.40). It showed that learners were able to share different point of view to compare and analyze together at ($\bar{x}$ =4.41). Leaners showed the lowest ability in sorting and categorizing ideas through discussion at ($\bar{x}$ =4.38).

In Intellectual convergence phase, the result showed their dominant role at ($\bar{x}$ =4.48). According to the highest mean, it revealed that every student agree to summarize what they discuss and converge their ideas from the group members at ($\bar{x}$ =4.59) while the lowest mean showed that the students create their knowledge and broaden their ideas at ($\bar{x}$ =4.31) as shown in Figure 6.

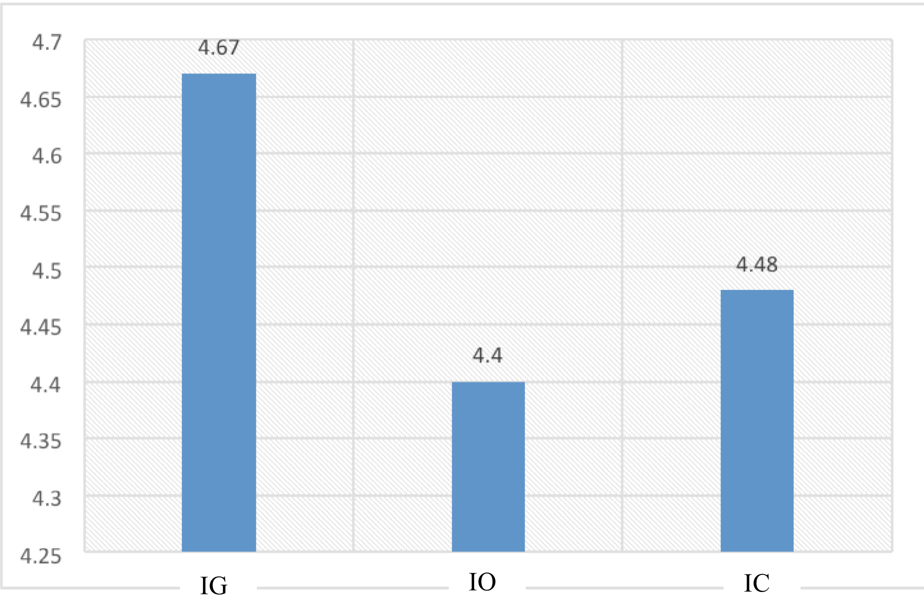

Figure 6. Result of Collaborative Learning Evaluation

Acknowledgements

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Design and Development of Web-Based Learning Environment to Enhance Learner's Analytical Thinking

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Abstract: The purpose of this research was to design and develop learning environment to enhance learners' analytical thinking. The target group were **1** experts who evaluated the content, 2 experts who evaluated conceptual framework of the web-based learning and its design, 2 experts who evaluated the cognitive innovation, and 1 expert for the assessment and evaluation. Document analysis and survey research was employed via the procedures as 1) studied the theory and principle, 2) studied the relevant context, 3) synthesized designing framework of web-based learning environment by analytical thinking framework, 4) designed and developed web-based learning environment, and 5) evaluated the effectiveness of the learning environment. The qualitative was collected from opinion surveying form, interviewing, and analyzed by interpreting and in descriptive analysis. The results were revealed that: the web-based learning comprised **6** components as the following: 1) Problem Base, 2) Resource, 3) Collaborative, 4) Analytical Thinking Center, 5) Scaffolding, and 6) Coaching. And the assessment on content was found that suitable for learning, on web-based learning was found that such 6 components were designed in consistent with the studied theory and principle, on designing of the web-based learning was found that was appropriated for enhancing learner's analytical thinking.

Keywords: Web-based learning environment, constructivist, analytical thinking

1. Introduction

Recently, information technology and communication has developed rapidly and has taken an essential role in daily living. The information technology era influences a number of Thailand's variation that affects human's learning in the 21th century. Due to a variety of information available, it has promoted a transformation of the society into the society of learning. Therefore, seeking knowledge in the society, where a wealth and variety of information exists, requires analytical thinking skills in order to enable the ability to differentiate the useful and useless information. Thus, analytical thinking in learning is in need of promotion.

According to the changing state, classroom instruction must be adjusted from the teacher-centered paradigm to student-centered. This paradigm encourages the learners' capacity and eagerness for self-learning. The essential approach to develop the learners' reaction towards information which comes along with social changes is based on a constructivist theory. The theory supports self-learning and the reaction towards the change of the learning paradigm through a cognitive process which encourages learners to learn through their actions based on their cognitive process. The old knowledge will connect with the new one that extends the cognitive structure (Chaijaroen, 2008). Especially, science is related to cognitive learning because this subject requires the ability on analysis and classification of the logical relationship. Therefore, it requires learners to be able to integrate and apply the gained knowledge to their daily life.

The previous study demonstrated that when applying the basic principle of a learning theory, namely a constructivist based on Piaget's concept, it stimulates learners' learning by the problem that led to a cognitive conflict or cognitive imbalance. They are required to improve the balance of their cognitive structure. The cognitive becomes balanced by extending the schema of experience through assimilation and accommodation. This kind of cognitive process focuses on self-learning and their actions combined with media networks including the media attribution and the media symbol system. The knowledge will be transferred through animation, slides, visual media, charts, videos, and hypertext from the network of a media symbol system. In addition, the hypertext acts as a hyperlink including node, main and sub, as well as the connection between each node. The hyperlink can build up the foundation and extend learners' knowledge effectively. Consequently, using a media symbol system to transfer knowledge affects learners' comprehension and their cognitive process, which in turn has an effect on their learning (Chaijaroen, 2008). Moreover, the learning environment with the combination of relevant principles, theories and media attribution is organized to encourage learners to create new knowledge. In so doing, they are able to study, think, research, conduct an experiment, and brainstorm from media or any other sources for learning. From this kind of learning, the old knowledge and the new knowledge will be associated under teachers' supports. For this reason, network-based learning environment is a foundation of knowledge that will be an effective tool to support the knowledge construction of learner as well as to extend learners' thoughts. Consequently, the learning environment is suitable for self-learning and supports their cognitive process and analytical thinking.

As discussed above, this study noticed the importance of designing and developing network-based learning environment on the basis of the constructivist theory, which promotes analytical thinking. The study was based on the principle and theory from previous research related to knowledge construction and analytical thinking. The reviewed principle and theory were designed and developed for network-based learning environment intended to promote learners' knowledge construction and analytical thinking. Then, the knowledge was synthesized into the elements of network-based learning environment; subsequently, designation and development of the environment were provided. The findings would develop the quality of learners' capacity, analytical thinking and self-development. They would develop the character of learners which should be in sync with basic education curriculum; specifically, they are able to apply the knowledge to daily life reasonably.

2. Research Purpose

To design and develop learning environment to enhance learners' analytical thinking.

3. Conceptual Framework

The design and develop of learning environment to enhance learners' analytical thinking consisted of 1) designing principles of web-based learning environment, 2) constructivist theory, 3) cognitivisim theory, 4) analytical thinking. Then, these were synthesized to be a theoretical framework of the web-based learning environment.

4. Research Methodology

The Developmental Research.

4.1 Target Group

The target groups were divided into 2 groups regards to these 2 processes as follows:

1) Design process: 2 experts to assess the designing framework in learning environment to enhance learners' analytical thinking of student.
2) Development process: 3 experts to assess the efficiency of the learning environment to enhance learners' analytical thinking of student for the aspects of content, media, and design.

4.2 Data Collection and Analysis

The data was collected and analyzed in each process as follows:

4.2.1 Designing Process

1) Literature review: studied and analyzed theories, principles, and related researches concerning the design of learning environment to enhance learners' analytical thinking of students in terms of a) constructivist b) cognitivisim including media attributes, media symbol system, multimedia as a study background, and then recorded in a document recording form. The data was analyzed by the methods of interpreting and analytical description.
2) Theoretical framework: reviewed, studied, analyzed the mentioned theories and researches in Literature Review process, and then recorded in the conceptual framework recording form. The data was analyzed by the methods of interpreting and analytical description. The framework consisted of 6 backgrounds as a) psychological learning base, b) pedagogy base, c) context base d) media theory base, e) technology base, and f) analytical thinking base.
3) Designing framework: synthesized the designing framework based on theoretical framework. The design focuses on the process of knowledge construction based on constructivist, analytical thinking, and transformed principles into practice by designing the elements of web-based learning environment. The data was analyzed by the methods of interpreting and analytical description. Its Quality was assessed by research adviser, experts to have suggestions for improvement.
4) Proposed the designing framework and learning environment components to the experts to verify the consistency between theory and designing framework of learning environment components by criticized and assessed in order to improve learning environment. The data was analyzed of interpreting and analytical description

4.2.2 Development processes

1) Developed learning environment to enhance learners' analytical thinking based on the designing framework and innovative components design.
2) Proposed to the experts to assess 1) content, 2) media, and 3) design thru the learning environment by using the quality assessment form for experts. The data was analyzed by interpreting in order to improve the learning environment quality.
3) Trailed the learning environment by studied the context of use, the most efficient students who learned with the learning environment, the instructional design with learning environment to enhance learners' analytical thinking, and students' opinion towards the learning environment use thru the learning environment-use surveying form, learning environment-opinion surveying form, and interviewing form of context of use. The data was analyzed by interpreting and in descriptive analysis.

5. Research Results

This research was purposive to design and develop the learning environment to enhance learners' analytical thinking which the results were presented in 2 processes as Design and Development processes. The designing components comprised 1) Problem Base, 2) Resource, 3) Collaborative, 4) Analytical Thinking Center, 5) Scaffolding, and 6) Coaching which each detailed were as follows:

5.1 Problem Base

To evoke the learners' schema. The design based on Cognitive constructivist of Jean Piaget (Piaget, 1964) which keys is the active learners who construct knowledge. This believes that when the learners have cognitive conflict or in disequilibrium condition, they try to adjust their Cognitive structuring into Equilibrium by the way of Assimilation or Accommodation. Regards the mentioned principles, they were then becoming the practicing as Problem base where the Enabling context was the situation in authentic context presented in kinds of problem consistent with real context of each related situations. This helped the learners to be able to refer or connect with their own prior experience. Also, the components design as cognitive constructivist as can be seen in Figure 1-2.

Figure 1. Screen of learning environment to enhance learners’ analytical thinking.

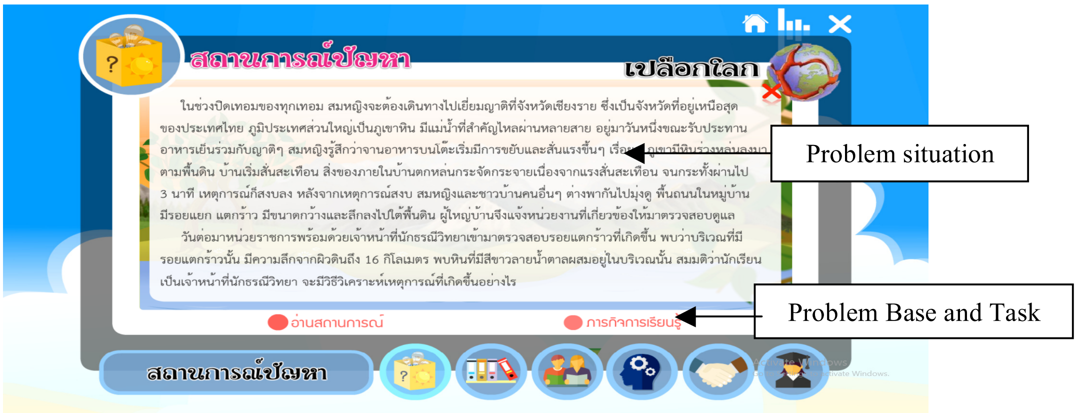

Figure 2. Problem Base

5.2 Resource

It was the collections of learning resources where the learners could use in solving a problem they confronted in Problem base. The design resource based on Information processing theory (Klausmeier, 1985) and SOI Model (Mayer, 1999) which enables understanding and selecting of cognitive processes in well designed as concept maps which presented the whole content thru graphic and animation in order to demonstrate object along with the various kinds of information in many resources presented shapes, highlighted important information with colors, sizes, underline, and several conceptual maps to demonstrated the relations of the information. Importantly, the learning resources as can be seen in Figure 3.

Figure 3. Resource

5.3 Collaboration

It was the component designed to elaborate cognitive structure by student's collaboration. They collaborated to solve problems by discussing and exchanging their similar objective of solving, so designed to have Social network as Facebook where they could express opinions and reciprocal their thoughts. This based on Social constructivism of (Vygotsky, 1999), and which was the tool to communicate among students, teachers, and experts at the same point of time as can be seen in Figure 3-4.

Figure 3. Collaboration

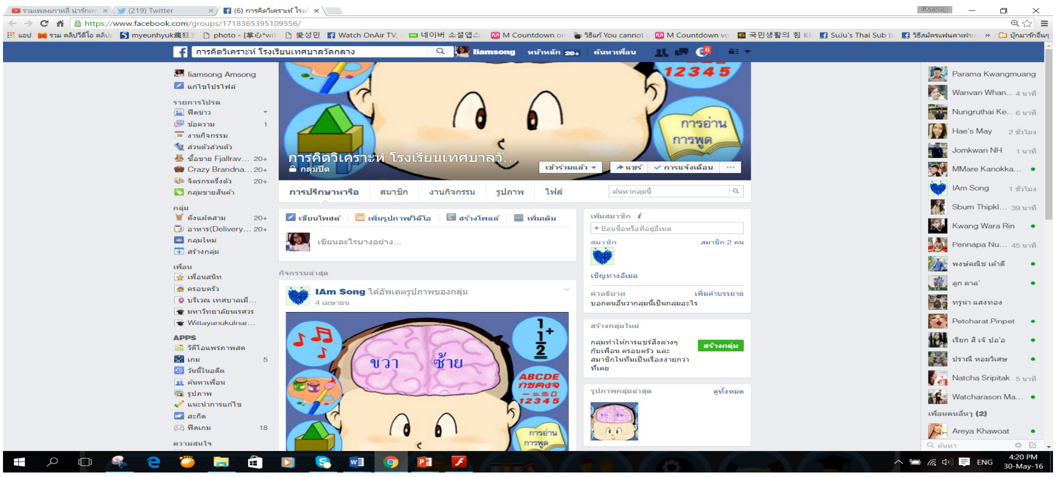

Figure 4. Chat on Facebook Messenger for brainstorming.

5.4 Analytical Thinking Center

It promotes analytical thinking based on analytical thinking (Chaicharoen et al, 2007), in order to help to encourage students to think analytically and solve problems. This was designed into three sub-centers center include: 1) the ability in classifying various factors of one thing or issue, 2) the ability in specifying the significance of cause-effect between those factors, and 3) the ability in organizing various things or issues into different groups. When the students choose a center to promote analytical thinking. The students found learning activities and a practicing of analytical thinking as can be seen in Figure 5-8.

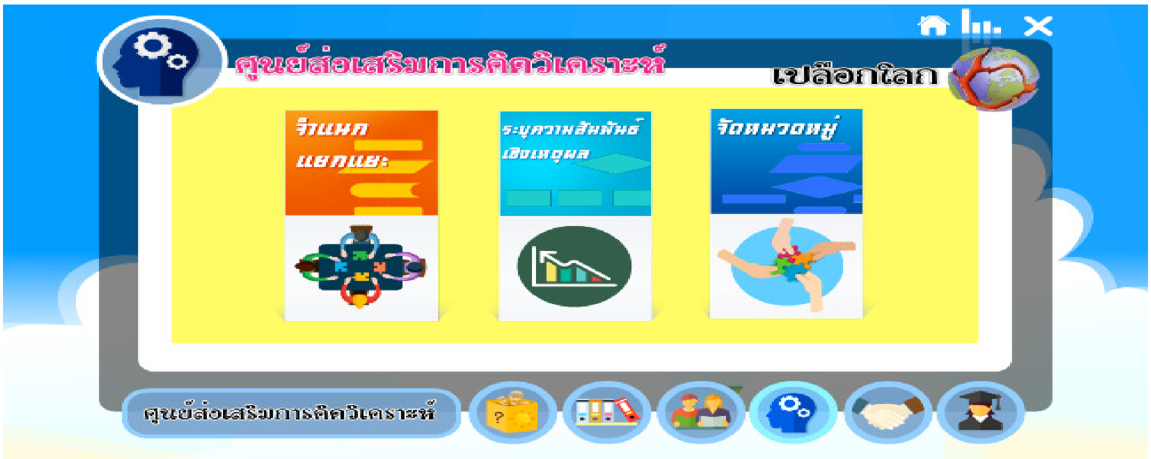

Figure 5. Analytical Thinking Center

Figure 6. The ability in classifying various factors of one thing or issue.

Figure 7. The ability in specifying the significance of cause-effect between those factors.

Figure 8. The ability in organizing various things or issues into different groups.

5.5 Scaffolding

It was the component to adjust the cognitive equilibrium to enhance problem solving based on Lev Vygotsky which believes that “the students who were in lower of the zone would have to have the Scaffolding which focused to help them in push the effort thru learning more than do a task, also “Zone of proximal development”. Based on (Hannafin, Land, and Oliver, 1999) the scaffolding consisted of 1) Conceptual scaffolding, 2) Metacognitive scaffolding, 3) Procedural scaffolding, and 4) Strategic scaffolding as can be seen in Figure 9.

Figure 9. Scaffolding

5.5.1 The Conceptual scaffolding

It helped the students to think conceptually and guided them to access the learning resources or other learning resources. The topics by summarizing the main ideas and designed in conceptual which they could fine the relations of each content as can be seen in Figure 10.

Figure 10. Conceptual scaffolding helped the students to create conceptual thinking.

5.5.2 The Strategic scaffolding

It was the scaffolding of an alternative to support analytical thinking, and strategic planning. This importantly presented in clarifying of required information, assessing of provided resources, and connecting the relations of both prior and new experiences in forms of picture of relationship which the students analyzed and then solved the problems as can be seen in Figure 11.

Figure 11. Strategic scaffolding helped the student thru problem solving.

5.5.3 The Metacognitive scaffolding

It supports students' learning process and guide thinking process in order to solve the problems via suggested strategies as a Guideline based on (Flavell, 1979), including the ability of the learner's existing knowledge. The need for a strategy to solve problems in basic or advanced further. The researchers transform theory into practice by design. The nature of the advice (Guideline) about how to think. Directed learners Monitoring and evaluation of the ideas that help to solve individual problems as can be seen in Figure 12.

Figure 12. Metacognitive scaffolding helped to enhance thinking process.

5.5.4 The Procedural scaffolding

It was the scaffolding to suggest to use resources and tools of the system and its working as can be seen in Figure 13.

Figure 13. Procedural scaffolding suggested the instruction of the cognitive innovation.

5.6 Coaching

The Cognitive Apprenticeship of (Collins, Brown and Holum, 1991) was used as a principle to shift them from being novice to expert. Coaching also gave hints when the students made a request. Coaching helped them by monitoring and relating them not to have the misunderstanding in the subject content and instead have the correct understanding immediately. Moreover, coaching could help them to develop to be an expert as can be seen in Figure 14.

Figure 14. Coaching

6. Conclusion and Discussion

Regards the design and development of web-based learning environment, it was found that the components consisted of: 1) Problem Base, 2) Resource 3) Collaborative, 4) Analytical Thinking Center, 5) Scaffolding, and 6) Coaching consisted with the study of Charuni's (2001) that used the constructivism as a basis of design and development of knowledge construction. But this study was different in focusing on learning with learning development in analytical thinking enhancement inside student's cognitive process. Hence, it was found that the designed and developed web-based learning had good quality, consistent with the constructivism theory used as a designing background to enhance analytical thinking in each components. This effected to its efficiency of the constructivism web-based learning which helped to improve learner's learning efficiency then.

Acknowledgements

Research Group for Innovation and Cognitive Technology of Khon Kaen University which hereby giving the thankfulness all through this.

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The Design and Development of Digital Learning Environment to Enhance Students' Problem Solving

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Abstract: Problem-solving skills let students apply what they learn instead of just recalling information. It is a valuable skill in a wide range of fields. Knowing how to solve problems enables students to think critically. The purposes of this research were to: (1) design and develop constructivist web-based learning environment to enhance students' problem solving, and (2) to examine the students' problem solving. The target group was 33 students who were studying in grade 10 in the second semester of the 2015 academic year at Demonstration School of Khon Kaen University Secondary School. The research methodology was one shot case study. The data were collected and analyzed both quantitatively and qualitatively. The quantitative data analysis included learning achievement for problem solving achievement through the use of basic statistics which are percentage, mean, and standard deviation. The qualitative data analysis included problem solving through protocol analysis. The results revealed that: (1) the constructivist web-based learning environment to enhance students' problem solving. These included (1) Problem base (2) Information Resource (3) Cognitive Tools (4) Collaborations Tools (5) Problem solving support tools (6) Related cases (7) Coaching (8) Scaffolding. And (2) Students' problem solving that the student show process in 4 step: 1) Articulate problem space and contextual constraints, 2) Identify and clarify the cause of the problem, 3) Generate possible problem solutions, 4) Select problem solution to problem solving and 87.87% of the total learners passed the 70% criterion of the specified scores.

Keywords: Learning environment, problem solving, constructivist, 21st century skills

1. Introduction

The development of knowledge and technology in current society is changing rapidly, as a result of education, efficiency and persons with knowledge of soils and various information. To develop and solve problems faced by them. In the current context, education has changed from teaching to rote teaching the students the knowledge with the attendees themselves. By learning environment for the students to face the situation in the context of learning and learning content that can be linked to the actual context. Educational policies of Thailand stressed that the students can learn and develop themselves. Focus on learning to learn skills, thought processes, to manage, to face the situation, and the application of knowledge to prevent and solve problems, learn from experience, practical training possible. It is also consistent with the core curriculum for basic education. Which defines the competencies of the learners focused on the ability to solve problems on the basis of rational, moral, and information. As well as understand the relationship of events and changes in society, the pursuit of knowledge, application of knowledge used in the prevention and resolution and the powerful. And led to the creation of knowledge or information to make decisions about themselves and society appropriately.

So learning the science needed to support the learning activities linked to knowledge to the process. To develop the idea of learning the key skills in researching and creating knowledge through a quest for knowledge, solve problems systematically, can make decisions using a variety of data and create knowledge that ensures accountability. Well skilled in the use of technology in information search and management. In the context of studying biology that are complex, difficult to understand, learning content with purely technical basis, resulting in the inability to understand or to know the contents of the unit. Learning Management need to learn the skills that created self-knowledge. The situation provoked by the context of the neighborhood and the students used to learn. The objective was to give the students' knowledge of processes and solutions can link new knowledge with prior knowledge to use in learning other content. The learning management is in line with the constructivist theory, believes that learning is a process that takes place inside the learner. Learners created knowledge of the relationship between what is seen with the knowledge that has come before, and try to understand about events and phenomena found their way to build a cognitive structure. Learning takes place when the students were motivated by problems that cause cognitive conflict, known as the disequilibrium. Students will try to restructure its intellectual equilibrium or learning, to balance the intellectual class must discover and seek answers for themselves by the second process is assimilation and accommodation, which the student is required to take a variety of information on the intellectual balance. So learning to be successful, students need to practice their skills in information, especially information technology, to help in learning. To help the students have sufficient information analyzed, classified to link new knowledge with prior knowledge. Design learning environments that use technology as a base, it is a good chance that students will be able to use the network for advanced troubleshooting. This research aims to develop an educational environment that promotes learning problems of students. By integrating learning theory, pedagogy, teaching, and digital media features. Moreover, the problem-solving skills of students learning with digital learning environment.

2. Methodology

The study consists of 33 students who were studying in grade 10 in the second semester of the 2015 academic year at Demonstration School of Khon Kaen University Secondary School, Thailand were all enrolled for the Biology course. The objective of this course was solve problem based on knowledge about the human digestive system. The skill test was adapted from Jonessen (1997). The skill test aimed to gauge their articulation a problem space and contextual constraints, identification and clarification the cause of the problem, generating possible problem solutions, and selection the problem solution to problem solving after learning with digital learning environment to enhance students' problem solving. The open-ended questions and problem-solving tasks was added to skill test. The research is qualitative data, the interpretation, scoring rubric and the average were used to analyze the data in this study.

3. Results

The design and development of digital learning environment that encourages students to the problems solving of the digital environment designing framework.

The design and development of digital learning environment to enhance learner's problem solving skill was found that the designing framework of digital learning environment which the researcher synthesized under the theoretical framework based on constructivism learning theory, pedagogy and learning model, technology for learning concept, and student's learning context comprised (1) Problem base (2) Information Resource (3) Cognitive Tools (4) Collaborations Tools (5) Problem solving support tools (6) Related cases (7) Coaching (8) Scaffolding.

Regards the designing framework, the research used it to develop the digital learning environment to enhance learner's problem solving skill which its components were;

1) Problem base: based on Cognitive Constructivism and CLEs which designed the situation on authentic context and complexity, and presented in problems situations along with learner's context in order to help the learners to be able to refer or connect to their own experience . This designed problem situation and learning tasks would have to enhance their problem solving skills which applied the design by problem solving principle of Jonessen (1997). In this study, the situations were designed concerning 4 main content as oral digestion, gaster digestion, small intestine digestion, and nutrient absorption as the situation samples in "Jack's Chewing Story" (content concerning oral digestion) presented in Figure1 and Figure2.

Figure 1. Main page of Problem base

Figure 2. Situation samples in “Jack’s Chewing Story” (content concerning oral digestion)

2) Information Resource: In order to investigate problems, learners need information with which to construct their knowledge and formulate hypotheses that drive the manipulation of the problem space we determine provide information sources are an essential part of learning environment that provide learner-selectable information just-in-time. The World Wide Web was used for this study, is the default storage medium, as powerful new plugins enable students to access multimedia resources from the net. These learning environments, however, embed hypertext links to Web sites based on the surface features of the site (Cunningham, Duffy and Knuth, 1993). These may include text, documents, graphics, video, and animations that are appropriate for helping learners understand the problem and its principles. Figure 3 showed the main page of Information Resource which inserted the link to minor content and Figure 4 showed the sample of Information Resource.

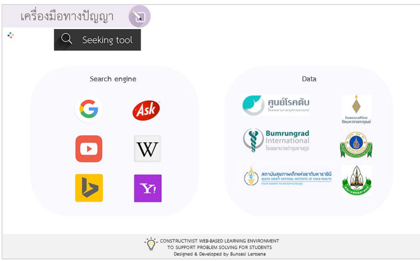

Figure 3. Main page of Information Resource

Figure 4. Information Resource

3) Cognitive Tools: Cognitive tools are generalizable computer tools that are intended to support and promote specific kinds of cognitive processing (Kommers, Jonassen and Mayes, 1992). They are cognitive tools that are used to visualize, organize, or displace thinking skills. Some intellectual tools replace thinking, while others promote students in constructive processing of information that would not occur without the tool. So the designing of cognitive tools consisted of (1) Seeking tool: supported the learner to search related information and addressed information reposition by search engines such as Google and wiki, (2) Collecting tool: helped them to collect related information by downloading on network, (3) Organizing tool: helped them to categorize information such as Google Docs and Word Online, and (4) Integrating tool: helped them to integrated information in according with their thinking concepts such as Google, Keep Blog, Google+ as Figure 5 presented the sample of Cognitive tools.

4) Collaborations Tools: Learning most naturally emerge not in isolation but by group of learners who working concurrently to solve problems. Learning environment should allow access to shared information and shared knowledge-constructing tools to support student to collaboratively construct socially shared knowledge. So in this study, the Collaborations Tools was design as Collaboration Room where provided them place to interchange thinking concepts, opinions, and solutions of their own and group. It was designed in Facebook group where they got familiar and were skillful of using. Figure6 presented the main page of Collaborations Tools

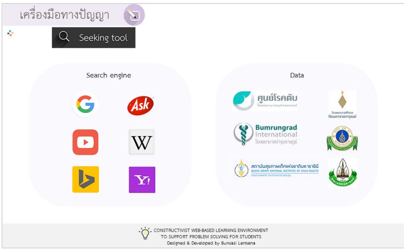

Figure 5. Seeking tools

Figure 6. Main page of Collaborations Tools

5) Problem solving support tools: The researcher designed the tool to enhance the learner's problem solving which mainly on learning with the authentic situations which could help them to practice problem solving skills. Problem solving principles of Jonassen (1997) which comprised (1) problem context and its limitation, (2) address the real problems and its causes clearly, (3) consider the possible solution, and (4) select the solution to be used to solve such problems; was hence used to design the web-based learning environment in form of Problem Base and learning tasks. Figure 7 presented Problem solving support tools.

Figure 7. Problem solving support tools

Figure 8. Related cases

6) Related cases: Understanding any problem requires the experience and generating mental models of it. What novice students lack most are experiences. This lack is particularly critical when trying to solve problems. So, it is important that learning environment provide access to a set of related experiences to which novice learners can refer. As that so, the researcher arranged the learners to be able to learn through experiences concerning the problems, presented complex knowledge via Case Study in the context of diseases or sickness conditions related problem situations. The learners then knew causes, solutions, and treatments as well as diagnosis which they could use to refer and connect to related experiences in order to solve such problems. This could enhance them to be able to solve a new problem in similar context. Figure8 presented the sample of Related Case main page.

7) Coaching: The researcher designed 2 communication channels as confronting in authentic situations where learning activity inserted, and as network communication where □□□□□□□□□□ with learning activity as Live Chat, and asynchronous which contacted the experts in different time as in form of Facebook group "Coach". Figure9 presented portal of coaching.

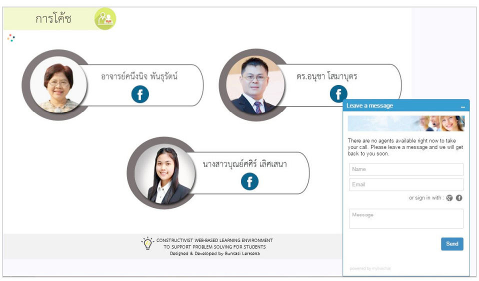

Figure 9. Portal of coaching

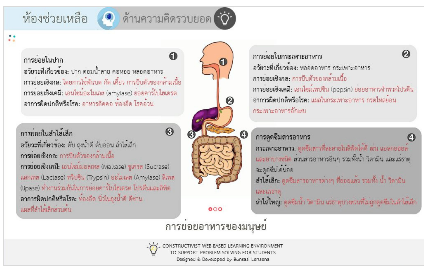

Figure 10. Conceptual Scaffolding

8) Scaffolding: The scaffolding concept show any kind of engage for cognitive activity that is provided by an adult when the leaners are performing the task together (Wood and Middleton, 1975). So, the researcher used such principle to design the component named "Scaffolding" which consisted of Conceptual Scaffolding, Metacognitive Scaffolding, Procedural Scaffolding, and Strategic Scaffolding which showed the sample of Conceptual Scaffolding in Figure 10.

Research results of learner's problem solving skill learned with digital learning environment enhancing students' problem solving skill

This results were from the data analysis through Descriptive Statistic and Protocol analysis through an Interview which found that the average solving score of the learners who learned with the learning environment was 15 scores or 75 percent of the entire scores. 87.87 percent of them passed the standard. And their problem solving skills recorded via the interview was found that they had 4 processes as (1) stated problem context and its limitation, (2) addressed the real problems and its causes clearly, (3) considered the possible solution, and (4) selected the solution to be used to solve such problems which based on the applying of Jonessen principles (1997).

4. Conclusion and Discussion

Design and development of constructivist web-based digital learning environment to enhance students' problem solving.

This study, the researcher designed and developed based on the importance of constructivism theory and web-based learning by considering on media attributes and media symbol system, and evaluating the environment according to the web-based learning environment evaluation of Sumalee (2014) in 5 aspects as products, context of use in authenticity, learning achievement, cognitive ability, and learner's opinion. This consisted of 8 components as 1) Problem base which provoke the students to feel as if they were part of the situations, feel enthusiastic, and try to find how to find the answers from various resources. This consists with constructivism learning theory which believes that learners are knowledge constructer by being an active learner while in disequilibrium and they try to adjust their schema by method of assimilation or interpret or receive the data from the environment into their schema, 2) Information Resource which based on cognitivism theory for example, conclude the key content in forms of graphics showing the relationship of its content in order to help them to understand, in forms of pictures and animation to help them to have attention, 3) Cognitive tool designed to support their problem solving based on OLEs in order to complete tasks in complex, new, and authentic situations; consisted of Seeking tool, Collecting tool, Organization tool, and Integrating tool, 4) Collaborations Tools to help them to collaboratively work in solving a problem, change opinions, enlarge thinking concepts, and correct the misunderstanding, 5) Problem solving support tools to provide them to practice to solve a problem in a case study in expertized perspectives based on stage of problem solving (Jonassen, 1997; Jonassen, 2011) as (1) Articulate problem space and contextual constraints, (2) Identify and clarify the cause of the problem, (3) Generate possible problem solutions, and (4) Select problem solution to problem solving, 6) Related cases based on CLEs to support their learning as helping the to remember meaningfully and presenting complex knowledge via various problems in order to connect with the confronting problem, 7) Scaffolding to support them to solve a problem with disability to complete a task which believes that when the learners are under the Zone of Proximal Development, they need to have help, 8) Coach or the changing of teacher role from transmitter to coach of problem solving and discovering continuously which the learners could have suggestion or consultant to have more understanding as well as evoke them to discover knowledge consisted with Suchart (2010), Issaa (2009), and Charuni (2009). The conclusion was that the web-based learning environment enhanced the learners to construct their own knowledge by being an active learner, supported them to have learning process and collaboration, helped them to enlarge schema and learned meaningfully. This was designed based in constructivism theory, cognitivism theory, problem solving skill, school context, as well as media attributes and web-based learning in order to be rich for the learners to learn in learning activities and enhance them to have the desired characteristics and finally the learners who were ready to use learning media would get success in learning.

Solving the problem of students who learning with constructivist web-based digital learning environment to enhance students' problem solving.

Regards the research results, the data were analyzed using descriptive statistics and protocol analysis via the interview, showed that the problem solving of the students showed average score as 15 or 75 percent of the total. 87.87 percent of them passed the standard. And their problem solving skills recorded via the interview was found that they had 4 processes follows as stage of problem solving (Jonassen, 1997). These findings might affect from the designing of constructivism web-based learning environment enhancing problem solving skills based on constructivism theory which mainly on knowledge construction by providing the situation to make them be in disequilibrium and require to be in equilibrium or construct the new knowledge. As well as the designing of learning tasks to enhance them to practice to solve a problem and reason which is the enhancing of cognitive process consistent with content of human digestion which complex and affect to their solving skill. The Problem Base was design in complex and authentic situations which provided them to confront the problems and search data towards conditions or diseases in digestion system. While they were in authentic situation, they got in meaningful which they could connect their own prior knowledge and look for new knowledge to solve a problem. Such process requires them to be an active learner to have skills as analytical thinking, hypothesis thinking, reasoning, assessing and applying skills to be used in solving a problem. Regards such findings, the learning with such constructivism web-based learning environment enhancing problem solving skills by proving them to be active learners via problem solving in authentic situations could enhance them to have skills throughout their life as well as new knowledge and technology. The enhancing of learner's thinking skills which consistent with the learning management of The Demonstration School of Khon Kaen University (Education) - Secondary School which highlights on learner's knowledge construction consistent with the study of Saksan (2011) and Problem Solving of Suchart (2012) which designed the learning environment to enhance the learners to solve a problem and construct knowledge on their own.

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Media and Information Literacy of the Students Who Learn with a Digital Learning Environment Based on Constructivist Theory

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Abstract: Technology alone cannot bridge the digital divide between and within countries. Knowledge societies ultimately depend on people's access to media and information and their ability to locate, evaluate and use information effectively. Media and Information Literacy (MIL) represents essential competencies and skills to equip citizens in the 21st century with the abilities to engage with media and information systems effectively and develop critical thinking and life-long learning skills to socialize and become active citizens. This study was conducted in the high school, Khon Kaen, Thailand and investigated students' attitudes and media and information literacy while working on a problem-based learning that was embedded within a digital learning environment based on constructivist. We studied the impact of learning with digital learning environment on high school students. Students worked in groups and created solution task with digital and media technology. From a survey questionnaire, the students showed positive attitudes towards the task with respect to their learning motivation and understanding, and skills. By incorporating multi-learning task into a constructivist learning environment, students learned to access, evaluate and use media and information, as well as to experience critical-thinking, creative, presentation and communication skills. The results from a MIL competencies test showed that the students who learn with a digital learning environment to enhance media and information literacy can access information effectively and efficiently, evaluates information critically and competently, and applies and uses information accurately and creatively. Our findings provide strong support and encouragement for Thai educators to incorporate media and information literacy task and constructivist learning into the classrooms for the enhancement of teaching and learning in 21st century.

Keywords: Media and information literacy, digital learning environment, constructivist

1. Introduction

The empowerment of human resources through the media and information literacy is an important prerequisite for the promotion of access to information and knowledge equally. Which is the basis for everyday life faced by the media and information in a wide range of changes and advances in all aspects of the local problems. Media and information literacy as key principles for freedom of opinion and access to information. This will enable people to understand the role of media and information sources, and assess critically about content. As well as the decisions of the users and producers of media content and information. The definition of such skills it can be seen that the media and information literacy skills are not only searching for information or access to information that is found in today's youth only. However, skills assessment, interpretation and implementation of critical information to meet their requirements and needs. However, today's youth is the lack of skills in this field. It can be seen from the results of the Programme for International Student Assessment (PISA), with three areas of knowledge include reading literacy, mathematical literacy and scientific literacy. Reading literacy is an assessment of the ability to understand what has been read, the ability to be used, to reflect the opinions of their own, and have a passion and commitment to reading for developing their knowledge and potential, and to participate in society. Such issues are discussed in accordance with MIL above. PISA tests from 2012 showed that the average reading scores of students in Thailand is 441 points. Scores of students Thailand is lower than other countries such as Shanghai - China (570) Hong Kong - China (545), Singapore (542), Japan (538), Korea (536), Finland (524), Ireland (523), Chinese Taipei (523.), Canada (523). Student Thailand has been classified as a Class testing is very low, therefore, need to be further developed and enhanced its ability to display the skills, knowledge, media and information literacy student Thailand.

However, pedagogy corresponding to the learning management and training in MIL is constructivist theory. Constructivism focuses on learning by giving students the knowledge itself, on how to manage learning for the students to face the problem in real time, teachers need to have integration between science and teaching methods, content, and skills needed. Including the provision of learning resources, tools, and guidance to help resolve issues for students, called "learning environment". In education and learning environment in the current integration of both a science and teaching methods, content, skills required, and the media, or technology that provides a little more. In the current study about designing and developing the learning environment with the integration of both pedagogy and teaching methods, content, skills required, and MIL that provides a little more. Especially in Thailand, most of which focus on specific skills or develop content without specific content knowledge, but no integrating the skills needed in a mission to learn. As a result, students cannot link the knowledge and skills for solving problems or for the operation. Moreover, the lack of appropriate technology tools used to develop the skills and knowledge.

For that reason, it is essential to develop a framework to develop a learning environment that promotes media and information literacy skills of students at the secondary level, the age group with the recognition and exposure to the media and information on a wide range of both positive and negative. Moreover, it will be the basis for learning in vocational or university level, as well as for troubleshooting in work and lifelong learning. By integrating pedagogies and teaching methods, content, skills required, and MIL, or the appropriate technology, which will be a guide for learning to develop students to be able to live for the world in the present day are. a wide range of information and technological progress has happily.

2. Constructivist Learning Environments

Constructivist learning environments: Case studies in instructional design, Wilson (1996) defines a constructivist learning environment as: “a place where learners may work together and support each other as they use a variety of tools and information resources in their guided pursuit of learning goals and problem-solving activities”. He emphasizes learning environments as opposed to 'instructional' environments in order to promote “a more flexible idea of learning", one which emphasizes "meaningful, authentic activities that help the learner to construct understandings and develop skills relevant to problem solving”.

To create a learning environment in this study, the researchers created the designing framework is based on constructivist theory, which has seven components: problem based, information resource, scaffolding, collaboration tools, MIL tools, coaching, and related case. Figure 1 showed the digital learning environment based on constructivist theory.

Figure 1. The main page of the digital learning environment based on constructivist theory

The problem based is designed to motivate students to achieve a balanced intellectual concepts of Piaget (1958) believes that learning takes place when students were motivated by the problem to a cognitive conflict or disequilibrium. When students' disequilibrium, the students will try to restructure its intellectual equilibrium and when the student can enter into a state of balance, intellectual or create new knowledge in them, means that learners achieve learning. Problem based include situations where a problem is occurring on a daily basis and the learning task that encourages students to practice media and information literacy. Figure 2 showed the sample problem based in the digital learning environment.

Figure 2. The problem based in the digital learning environment

The information resource created by the support of the restructuring of students, having been made to disequilibrium of the concepts of the cognitive constructivist theory. The information resource contains content that is useful for solving a problem and the learning task. The content of the information resource covers that require students to learn, and design theory using SOI Model. The scaffolding designed based on the concept of the zone of proximal development to the base for students who have problems or questions in the learning task. The collaboration tools are designed based on concepts of Social constructivist, believe that social interaction will promote the expansion of knowledge. The collaboration tools include technologies that provide for students and the students can communicate with each other easily.

MIL tools is provided for students in the training and skills about the media and information, moreover, has the tools provided in the relevant media and information technology as tools for accessing, organizing information, communication and creation. The related case was based on the constructivist theory, which will help students learn methods, procedures, and principles to solve problems. The related case to contain the situation, the problem is with the nature of the problem coincided with situations where students assigned to resolve. The coaching element is established based on the concept of social constructivist, which stated that the role of the teacher in the classroom of a learning environment by providing advice, counseling, and guidance, which called for the coach.

3. Methodology and Target Group

Target Group

The study consists of 48 students in grade 10 (m=21 and f=27), Khon Kaen, Thailand. All students must be enrolled in science courses is mandatory. The purpose of this course is that students have an understanding of the concept of science around them. Moreover, access to search and build scientific knowledge in their daily lives.

Methodology

At the end of research, students were given a thirty-item survey, to measure their attitudes towards learning with a digital learning environment based on constructivist theory in their learning process, to fill out. The survey was adapted from Irani (1998). The items measured on a 5-point Likert scale, and with 1 = Strongly Disagree, 2 = Disagree, 3 = Undecided, 4 =Agree and 5 = Strongly Agree. The survey aimed to gauge their motivation, critical-thinking and creativity skills, teamwork, presentation and communication skills, and overall attitudes towards learning with digital learning environment. However, media and information literacy of student were evaluated by MIL Test was adapted from

Global Media and Information Literacy Assessment Framework (UNESCO, 2013). Open-ended questions and tasks solutions was added tests to measure literacy. However, the learning environment that use for student, we designed and constructed based on constructivist theory which was synthesised in designing framework. The digital learning environment was validated by expert review and student opinion survey.

4. Results

Students' attitudes towards learning with a digital learning environment based on constructivist

The collected data were analysed with SPSS, and yielded a Cronbach Alpha coefficient of 0.9106, which satisfies the requirement of survey reliability. Results showed that students had very positive attitudes towards the learning task and their use of multimedia technology in this learning environment. From their responses from the survey, open-ended questions and the interviews, students' perceptions toward this study can be categorized into the following areas:

- Learning motivation
- Increased understanding and learning of subject domain
- Skills and real-world relevance

Tables 1-3 present the results of the questionnaire in the 3 areas, with the overall means (m) ranked for each items in these 3 areas, the percentage of responses (p) by students according to the 5-point Likert scale (i.e., SA = Strongly Agree, A= Agree, U = Undecided, D = Disagree, and SDA = Strongly Disagree) as well as their respective standard deviations (SD). In addition, student comments and feedback were also obtained from their journal reports and from the survey's open-ended question section. Students provided feedback on their learning process as a result of doing this learning with digital learning environment, which are also show in Tables 1-3 accordingly.

Table 1: Results for students' learning motivation

Learning motivation Items in the survey	mean	SA (p)	A (p)	U (p)	D (p)	SDA (p)	SD
1. Motivated to do learning tasks	4.25	30.2	64.2	5.7	0	0	0.55
2. Learning tasks made me want to do my best	4.25	32.1	60.4	7.5	0	0	0.59
3. I found the learning tasks to be challenging yet stimulating to do	4.19	30.2	58.5	11.3	0	0	0.62
4. I enjoyed working on a learning tasks like this	4.08	24.5	62.3	11.3	0	1.9	0.73
5. This course has given me confidence in my newly acquired skills	3.91	18.9	56.6	20.8	3.8	0	0.74
6. I was able to maintain contact with my lecturer	3.74	7.5	62.3	26.4	3.8	0	0.65
7. I am very satisfied with my contribution to the learning tasks	3.68	17.0	41.5	34.0	7.5	0	0.85
Students' comments on Learning Motivation: 1. "Very motivated. This subject is very fun. I get the chance to come out with my own ideas and creation on an application." 2. "I feel motivated from that cause I can learn some new skills that I can't learn from my faculty". 3. "I am so happy and motivated when do this task."							

From Table 1, it can be seen that students' motivation levels were high and their interest in doing the learning tasks was very much enhanced, as the three highest ranked items in the survey were motivation items. In particular, students felt highly motivated in completing their tasks, and reported that the task encouraged them to work hard. Most students (94.3%) reported favourable motivation levels (m=4.25) and 92.5% of students reporting that the learning tasks made them do their best (m=4.25), making these two items the highest ranking items in the survey. They also indicated that although the learning tasks was challenging, it provided much stimulation in their learning process -- 88.7% reporting in favour of the item (m = 4.19). Almost everyone in the class reported that they enjoyed working on such a learning tasks (m = 4.08, p = 98.1), whereas 75.5% of students reported that doing the learning tasks has given them confidence in the skills which they had acquired in the process (m = 3.91), and 69.8% were able to maintain contact with their lecturer during the learning tasks conducted period (m = 3.74). And as such, 92.5% of students reported that they were, on the overall, satisfied with their contribution to the task (m = 3.66). Support for this favourable report can also be seen in their comments and feedback. Students reported that they enjoyed doing the learning tasks as it made them feel very motivated and satisfied with their contributions. Students reported in their journals (Table 1) that they were motivated because the learning task was something that was relevant to them and elicited their curiosity. They also expressed excitement with the innovative way information was presented as they used multimedia technologies to create something that was digital and interactive.

For increased understanding and learning of subject domain**,** this construct was incorporated to gauge students' perceptions on whether doing the task resulted in an increased level of understanding for the subject matter and on their own learning process (Table 2).

Table 2: Results for students' understanding of the subject domain

Increased understanding Items in the survey	mean	SA (%)	A (%)	U (%)	D (%)	SDA (%)	SD
1. The task enhanced my learning of interactive multimedia	4.13	26.4	62.3	9.4	1.9	0	0.65
2. The task increased my understanding on how to manage and develop task solution	4.13	24.5	67.9	3.8	3.8	0	0.65
3. I am now a better learner	4.02	20.8	64.2	11.3	0	0	0.69
Students' comments on Increased Understanding: 1. "Before doing this task, I do not know much about Nai Rudee…but after working on this topic for past four months, I learnt Nai Rudee in detail. Now I am able to explain about Nai Rudee to my other friends". 2. "I believe my understanding towards media and information research has vastly improved after undergoing the task given to us." 3. "It helps me more understand the subjects in science."							

Results in Table 2 showed that students were favourable toward this construct. In the survey, students reported that in terms of their overall understanding of the task's objective, 88.7% of students reported that the learning task enhanced their learning of science (m = 4.13) and that the learning task increased their understanding of how to manage and develop and MI application (m = 4.13, p = 92.5). They also reported that they have now become better learners, (m=4.02, p=84.9). Again, these perceptions are well supported by their comments and feedback, which showed that students did perceive themselves to have increased understanding of the subject matter from the task. Many reported that they now understood what it meant to develop a solution and that hands-on experience made them understand solve problem that use MIL as well as on their chosen topic.

For skills and real-world relevance, this construct was to gauge students' attitudes and perceptions on their acquisition and experience with skills such as critical-thinking and creativity skills, teamwork and group skills, communication and presentation skills, multimedia technology skills, and the ability to properly apply them (Table 3).

Results from their survey shed more light and support for this construct, as, in terms of acquired skills, 88.7% of students reported that they were now able to apply their skills in a more effective manner on future learning tasks (m = 4.15), making it the highest ranking item in this category. They also reported being able to analyse, synthesise, and evaluate information (m = 4.08, p = 88.7). Critical-thinking skills were also enhanced, as 79.2% of students reported that they were now able to think critically about developing solution of task, (m=3.94), as were presentation and communications skills, as 67.9% of students reported that the task allowed them to improve their presentation skills (m = 3.72), and presenting their solution well using multimedia (m=3.89, p=75.5). Students also showed increased perception of the relationship between their work and the work in real-life situations. 84.9% of students reported that after completing their solution, they were now able to see the relevance between the learning tasks and the course, with real-world situations (m = 4.04), allowing them to develop skills needed in the real-world (m = 3.98, p = 81.1).

Table 3: Results for students' skills acquisition

Skills and real-world relevance Items in the survey	mean	SA (%)	A (%)	U (%)	D (%)	SDA (%)	SD
1. I am now able to apply my skills in a more effective manner on future tasks	4.15	26.4	2.3	1.3	0	0	0.60
2. The task allowed me to analyse, synthesise and evaluate information	4.08	18.9	69.8	1.3	0	0	0.55
3. I saw the relevance between the course and real world situations	4.04	22.6	2.3	1.3	3.8	0	0.71
4.This task allows me to develop skills needed in the real-world	3.98	18.9	2.3	17.0	1.9	0	0.66
5. I am now able to think critically about developing solution of task	3.94	17.0	62.3	18.9	1.9	0	0.66
6. We were able to present our task well using multimedia	3.89	18.9	56.6	0.8	1.9	1.9	0.80
7. The task allowed me to develop and improve my presentation skills	3.72	7.5	60.4	28.3	3.8	0	0.66
N=48							
Students' comments on Skills and Real-World Relevance: 1. "…from the experience of working with my group members, I am prepared to face different people I might meet in the near future." 2. "I get to know more about how to develop a good task in the future as if I have the chances to take on the multimedia task." 3. "I learnt a lot of skills and knowledge…which enable me to understand and may apply to my future as well."							

Students' comments and feedback further provided support to the results and showed that they were able to acquire and experience these skills and that they saw the relevance of these skills with that needed in the real-world. They also reported that the acquisition and experience of these skills increased their confidence levels in solving problem- and team-related problems in the future (Table 3).

Students' media and information literacy that learning with a digital learning environment based on constructivist

The analysis of data from the MIL Test by interpreting and average. The results shown that, more than 70.83 percent of students can access information effectively and efficiently, evaluates information critically and competently, and applies/uses information accurately and creatively. Table 4 shows the number and percentage of students that can be done as indicators of MIL.

Table 4: Number and percentage of students that can be done as indicators of MIL

Indicators of MIL	Students that can be done	
	Number	Percentage
1. The student accesses information effectively and efficiently;		
Definition and articulation of media and information need	46	95.83
Location and retrieval of media and information	43	89.58
2. The user evaluates information critically and competently;		
Assessment of media and information	40	83.33
Organization of media and information	39	81.25
3. The user applies/uses information accurately and creatively;		
Creation of knowledge information	35	72.92
Communication and ethical use and media and information	34	70.83

Table 4. summarizes the results of that; 95.83% of students can definition and articulation of media and information need, 89.58% can location and retrieval of media and information, 83.33% assessment of media and information, and 81.25% can organization of media and information. Meanwhile, 72.92% of students can creation of knowledge information and 70.83% can communication and ethical use and media and information.

5. Discussion

The results show strong support for using a multimedia project in a constructivist-based learning environment. From the survey and their feedback, students' demonstrated positive attitudes and perceptions to developing a multimedia project within this learning environment. They were able to reveal that they had acquired several key constructivist learning skills through doing the learning task, which would enable them to become better skilled workers in the new Century.

Specifically, the development of this multimedia project within this learning environment allowed students to experience the following:

1) In this constructivist-based learning environment using multimedia, it can be seen that students experienced high levels of motivation and self-esteem when doing the multimedia project as shown in their comments and survey results, and is in line with Reeves' (1998) perspective that, "multimedia can stimulate more than one sense at a time, and in doing so, may be more attention-getting and attention-holding.". More importantly, it enhanced their confidence levels in their newly acquired skills, knowing that they can use the same skills in their future undertakings.
2) Students showed increased understanding of the topic and being able to see the relevance of the project to real-life situations. This falls within the realm of authentic learning (Herrington et. al, 2004).
3) Digital and multimedia technology was successfully integrated in this constructivist learning environment as an enabler and catalyst to support the students in successfully using the tools to demonstrate their creativity and MIL. By incorporating multimedia into this constructivist learning environment via their multimedia project, students were able to design using multimedia and experience critical-thinking, creative, presentation and communication skills, as well as enhancing their motivation and understanding levels. Using various combinations of media elements to illustrate their messages in the application gave students the opportunity to think critically about their messages and the flexibility to present them. Using Web communication tools also gave them the opportunity to solve group meeting problems and to conduct any meetings or discussions, and any exchange of ideas amongst themselves whenever they had scheduling conflicts for face-to-face meetings.
4) Results of this research study provide good evidence for using multimedia technology and a project-based learning approach within a constructivist learning environment, as adapted from Jonassen's (1999) framework, for Thai educators in tertiary education, who want more flexible options in their classroom teaching methods, and to inculcate their students with better real-world skills. More research can be done, however, in investigating further the role of multimedia in motivating students, and the group dynamics within such a learning environment.

6. Conclusion

The study was thus successful in providing students with the experience in access / retrieval of information, evaluation / understanding information, use / create / communicate information and problem-solving, critical-thinking and creativity skills, communication and reflection, and in improving their overall understanding of the project's objective, as students reported satisfaction with their contributions. They also became active participants in their learning process. The problem base and learning task also allowed students to become more independent in their thinking and as a whole, enabled them to improve their learning process.

Adapting Jonassen's (1999) proposition for building a constructivist learning environment using technology in this classroom environment created a digital learning environment where students were able to solve a problem, via the problem base and learning task, that was authentic and relevant to them, and allowed them to collaborate and work together as a team to complete the task, and to claim responsibility and ownership of their development process. This digital technology learning environment allowed students to experience a constructivist-based approach in their learning process where they became active participants and constructed their own knowledge. Therefore, this research study has shown that incorporating digital technology into a constructivist learning environment can lead to innovative teaching and learning methods for the improvement of classroom learning.

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The Design and Development of the Cognitive Innovation to Enhance Problem Solving

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Abstract: The purpose of this research was to design and develop a cognitive innovation to enhance problem solving. The target group were the 3 experts who reviewed document and designing framework and the 3 experts to evaluate the cognitive innovation. Research designs was the Developmental Research Type 1 which comprising of 3 processes: 1) Design Process and 2) Development Process, which comprising of synthesis of theoretical and designing framework and develop the cognitive innovation and 3) Evaluation Process which evaluated the efficiency of the cognitive innovation. The results were revealed that: the synthesis of the designing framework based on theoretical framework which then put into practicing comprised of 8 components as the following: 1) Problem base, 2) Learning resource, 3) Related case, 4) Cognitive tool, 5) Collaboration, 6) Center for enhancing problem solving, 7) Coaching and 8) Scaffolding; and reviewed the effectiveness by experts in the evaluation process as follows: 1) product assessment, 2) contextual utilization assessment, 3) learner's opinions assessment; the cognitive innovation to enhance problem solving is appropriate on 3 aspects: content, media and designing, 4) assessment of learners' cognitive ability; The problem solving abilities were found 6 procedures of student's problem solution as (1) identified problem gap, (2) identified and explained exact problems, (3) created possible solutions, (4) evaluate the possibility of solution use, (5) applied the solution, and (6) adjusted such solutions, and 6) assessment of learning achievement ($\bar{X}$=18.75, S.D. = 1.78) that every learner passes the 70%criterion of the specific scores.

Keywords: Cognitive innovation, pedagogy, problem solving, instructional design

1. Introduction

The continuous fast developing of technology in recent many decades makes people live in the world without territory. Able to communicate and access to data anytime at the same time together, meanwhile; confront of various kinds of problem such as politic, economic, and social issues which all effect to people life. These troubles cause from natural crisis which human cannot stop them, however; the most serious problems cause from human. Presently, this kind of knowledge and complex society influence the big changes in Thailand and other parts of the world. This is risk to opportunity growing and country development. Hence, the education is the key to improve human skills and potentials to live in this high competitive society. Able to prepare and adapt into the circumstance. Furthermore, able to face and solve any problems regards the internal and external changing of a country, in according to learning skills in the century 21st, ASEAN Economic Community, and The Eleventh National Economic and Social Development Plan (2012-2016) (Office of the National Economic and Social Development Board, 2011) especially the strategy 2- the development of human for the sustainability of lifelong learning society which emphasizes on lifelong learning enhancement, fostering the social norm that each people realize their role to learn, reading lover since primary age and promoting to integrated learn among different age of people. Moreover, enhance organizations, society, people, and all kinds of media to be as a creative learning resources via simple language of communicationas well as support people to have learning alternatives which most appropriate to them. Also, create knowledge society with high quality in order to foster people to have lifelong learning and to be able to create an innovation due to the strong background of being open-mind, sincere, and disciplinary. They are enhanced through integrated knowledge in order to work in many job functions depends on work hiring trend and AEC.

So, the learning management which most appropriates to the current era of knowledge society, the learning is not only about the transmitting of knowledge that not enough to be adaptively used to solve complex problems nowadays, but learning is about the knowledge construction by students themselves which they can be solve such kind of problem. As mentioned, the learning paradigm should be emphasized on the changing of "teaching" to "learning" which the learner is focused as a center. The design enhances them to be developed naturally and fully efficiently. The information and technology is used to foster them to construct knowledge in the whole their life (Chaijaroen et al, 2008), in accordance with the National Education Act of B.E.1999 and Second Amendments of B.E. 2003 which states that the learning management must emphasize the learner to be able to learn and develop themselves, also the learner is the most important people in the learning processes. In learning design, the skills practicing, thinking process, confronting and managing of problems, and knowledge adaptation should be highlighted in order them to have the ability to solve a problem, love to learn, and use educational technology to serve for knowledge throughout their life. The solving problem skill is one kind of a complex thinking process. It consists of various cognitive components including knowledge construction structure for example, knowledge network, thinking network, including cognitive process with purposive thinking, knowledge construction, knowledge assessment, error assessment process (Jonassen and Tessmer, 1996). These components are created from several kinds of science as learning theory, pedagogy, technology, media attribute, and related context. Then they are synthesized as theoretical framework and used to design learning environment in the purpose of enhancing such learner's thinking processes, especially the ability to solve a problem and have lifelong learning according to such National Education Act pf B.E.1999.

The integration is here explained as it is the integration among neuroscience and related pedagogies as constructivism which mainly on learner's knowledge construction, complex problem solving, and authentic situation. Also, media attribute, media symbol system, and the advantages of technology can as well help the learner to have more efficiency on learning. The contructivist theory hereby explains how the learner have knowledge construction by themselves and response to paradigm changing through cognitive processes. The prior knowledge or experience is connected to the new knowledge through schema, this believes that the learner constructs new knowledge by enlarging or adapting their schema. The teacher hence cannot do anything with their schema but have important role to design and develop learning environment for them to be able to construct knowledge and be in authentic problem situation. The learner is actively constructed the knowledge throughout their own cognitive processes. Therefore, this research is the integration of theory and principles as well as the pedagogy in purpose to solve the ill-structured problem in authentic situation and combination with media attribution and symbol system and technology (Chaijaroen, 2014). The previous research results found that the learning with constructivist learning environment could help the learner to have deeper understanding more than passively received data. Likewise, social constructivist or learning with other people in social interaction had positive effect to leaning which consistent with the studies. The design and development of learning environment which mainly fosters on the intensive of cognitive process and problem solving skills was found that the problem solving under several condition processes could help the learner to construct their conceptual thinking which hence used in and promoted process and certainly knowledge construction. Furthermore, the problem solving by using computer was found that the learner could significantly have the better work than working alone, also the good attitudes towards problem solving by using a computer to problem transferring skills (Uribe et al, 2003)

Regards the mentioned rational and background, the researchers realized the importance of the development of cognitive innovation to enhance problem solving based on several backgrounds, and then synthesized thetheoretical framework based on theories and related researches in area of knowledge construction and problem solving. After that, designed and developed the cognitive innovation to enhance problem solving by emphasizing on cognitive process and then integrated with neuroscience in order to affirm the evidence what happen in their cognitive processes; as well as to deepen the research findings and expand the research connection for both national and international. The results effected to the human potentials which very important to the cooperation and competition among countries according to the policy of the national research of enhancing cognitive innovation to be able to have new and more foundation of economic innovation.

2. Research Purpose

To design and develop the cognitive innovation to enhance problem solving.

3. Research Methodology

The Developmental ResearchType1 was employed (adapted from Richey and Klein, 2007) which consisted of 3 processes asfollows1) design process, 2) development process, and3) evaluation process.

4. Target Group

The study target groups were divided into 3 groups regards to these 3 processes as follows: 1) Design process: 3 experts to assess the conceptual framework in innovation design and the designing. 2) Development process: 3 experts to assess the efficiency of the cognitive innovation for the aspects of content, media, and design. 3) Evaluation process: 24 students of Pratomsuksa 6 of Hinladwangtoe School who studied in Science subject in semester 1/ 2015.

5. Data Collection and Analyze

The data was collected and analyzed in each process as follows:

5.1 Design Process

- Literature review: studied and analyzed theories, principles, and related researches concerning the design of cognitive innovation to enhance problem solving in terms of 1) constructivist 2) cognitivism including media attributes, media symbol system, multimedia as a study background, and then recorded in a document recording form. The data was analyzed by the methods of interpretation and analytical description.
- Theoretical framework: reviewed, studied, analyzed the mentioned theories and researches in literature review process, and then recorded in the theoretical framework recording form. The data was analyzed by the methods of interpretation and analytical description. The framework consisted of 5 foundations as 1) psychological learning base, 2) pedagogical base, 3) contextual base, and 4) technological base.
- Contextual study: studied the school polices, instructional management in Science Learning Substance which focused on problem solving. The data was collected by surveying on context of instruction and learning in the science classroom and interview both teachers and students by focusing on problem solving context. The data was analyzed by the methods of interpretation and analytical description.
- Designing framework: synthesized the designing framework based on theoretical framework and contextual study, and recorded in the designing framework synthesized recording form. The data was analyzed by the methods of interpreting and analytical description.
- Synthesized the cognitive innovation components to enhance problem solving based on designing framework by emphasizing on knowledge construction and problem solving and transformed theory into practice as the 9 components.
- Proposed the designing framework and the innovation components to the researchers to criticize and assess in order to use its results to improve the innovation.
- Proposed the designing framework and the innovation components to the experts to verify the consistency between designing framework and the innovation components and criticized and assessed to improve the innovation.

5.2 Development Process

- Developed the cognitive innovation to enhance problem solving based on the designing framework and the design of innovative components.
- Proposed the innovation to the researchers to criticize and assess the innovation quality. The data was analyzed by interpretation and in descriptive analysis to be used to improve the innovative quality.
- Proposed the cognitive innovation to the experts to assess 1) content, 2) media, 3) design and recorded on the innovation quality assessment form for experts. The data was analyzed by data interpretation to be used to improve the innovation quality.
- Try out the innovation to study: the context of utilization, the most efficient students who learned with the innovation, the instructional design with cognitive innovation, and students' opinion towards the innovation use thru the innovation-use surveying form, innovation-opinion surveying form, and interviewing form of context of use. The data was analyzed by interpreting and in descriptive analysis.

5.3 Evaluation Process

The cognitive innovation quality was verified by the experts in phase 1 and try out with the students who apart of target group in the purpose of studying the contextual utilization in phase 2, however; was used with the target group in authentic context then. The teacher in their classroom was trained in instructional design and cognitive innovation workshop. The researcher hence studied students' cognitive process as terms of 1) their problem solving while learning with the cognitive innovation via protocol analysis by interviewing and interpretation based on Problem Solving principles (Jonessen, 1997), 2) studied their problem solving with learning with the cognitive innovation through assessment of Executive function in problem solving process by Tower of London, and analyzed data by using descriptive statistics as ratio, mean, S,D., and percentage by comparing the proportion of the number of time spending while processed problem solving, 3) their learning achievement was analyzed by using descriptive analysis as mean, S.D., and percentage, and 4) their opinion towards the cognitive innovation analyzed by interpretation and descriptive analysis.

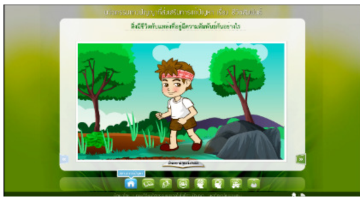
6. Research Results

This research was purposive to design and develop the cognitive innovation to enhance problem solving which the results were presented in 2 processes as Design and development process and Evaluation process

6.1 Design and Development Process

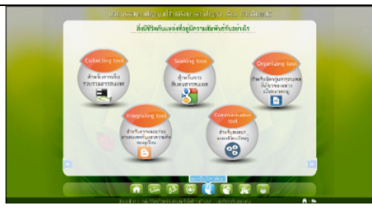
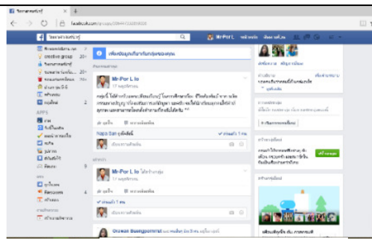
In this process, the results of the design and development based on the designing framework consisted of 1) activated cognitive structure and problem solving, 2) fostered to adjust cognitive structure and problem solving, 3) fostered to enlarge cognitive structure and problem solving, and 4) supported to equilibrium cognitive structure and enhance problem solving. The innovation was verified by the expert reviewer in term of the theoretical and designing framework validation as well as 9 components as 1) Problem base, 2) Learning resource, 3) Related case, 4) Cognitive tool, 5) Collaboration, 6) Center for enhancing problem solving, 7) Coaching, and 8) Scaffolding. Each was explained for the designing of the cognitive innovation to enhance problem solving below, detailed in Table 1.

Table 1: The design of the cognitive innovation to enhance problem solving

Components	Description of components	Design
Problem base	The important component of the cognitive innovation which is like a door to evoke the learners' schema. The design based on Cognitive constructivist of Jean Piaget which emphasize on the active learners who construct knowledge. This believes that when the learners have cognitive conflict or in disequilibrium stage, they try to adjust their cognitive structuring into equilibrium by the way of assimilation or accommodation. Regards the mentioned principles, they were transformed theory into practice as problem base where the enabling context was the situation in authentic context related to their daily life.	 Screen of the cognitive innovation to enhance problem solving
	This helped the learners to be able to connect with their own prior experiences. Also, the components design as ill-structure problem based on Jonassen (1997) comprised step 1 the learner specified space of problem, step 2 clarify and explain the real problems, step 3 create possible solutions, step 4 assess the possibility of selected solution, step 5 use the solution to solve the problem, step 6 refine the solution. There were 5 situations in conceptual content of Life relationship as 1) Relations of life relationship, 2) Relation of life and habitat, 3) What is life cycle?, 4) What is food chain ?, and 5) How does it live? which all led the students learned and solved the problems.	 Problem base and learning tasks about Relation of life and habitat
Learning resource	Learning resource was the collections of learning resources where the learners could use in solving a problem they confronted in Problem base while they had the process of knowledge construction by themselves, along with the various kinds of information in many resources presented in well designed as concept maps which presented the whole content thru graphic and animation in order to demonstrate object shapes, highlighted important information with colors, sizes, underline, and several conceptual maps to demonstrated the relations of the information. Importantly, the learning resources must be enough for them and be designed to be alternatively selected for them to solve the problems and construct knowledge. Moreover, the Extraneous cognitive load of Sweller (1988) was used in designing to reduce the extraneous cognitive load since they were too much information over the information process working function. So, the designing worked on categorizing in Hierarchical, in conceptual models, in sufficient information, and in appropriateness of media attribute and media symbol system. As that so, they were designed the learning resources as follows 1) conceptual maps presented the whole relations of content, 2) graphic, animation presented object shape moving, 3) information highlighted as colors, sizes, underlines, 4) conceptual models in Figures presented each connected concepts, and 5) information categorizing in Hierarchical	 Learning resources  Learning resourcesshowed Relation of life and habitatwhere the learner could click anywhere

Components	Description of components	Design
Related case	Related case based on CLEs (Constructivist learning environments) - the design of constructivist learning environment of Jonassen (1999). The important principle was to design to relate the experiences that similar to the problem which the students could refer and connect to their prior experience. The related case supported the students in 2 kinds as 1) helped them to meaningfully processing the information because they most understood the lesson which they got involve and put their effort in their learning process, and 2) helped to present the complex knowledge with various thinking concepts or problem interpreting of their own. The related case was design based on the theory of cognitive flexibility which designed and presented in various context in many complex levels embedded in information. So, in this case, the designing was designed in cases study related their daily life such as Fish Housing- the students could study this information and use to solve the problems about Life and its habitat relations. This would help them to think and solve other problems in the similar situation. This presented in terms of case samples, solution methods, and reasons.	 Related case presented Fish Housing the related case to Life and its habitat relations
Scaffolding	was the component to adjust the cognitive equilibrium to enhance problem solving based on Lev Vygotsky which believes that "the social interaction is important to develop the cognition", also "Zone of proximal development" presented the concept that the students who were in lower of the zone would have to have the Scaffolding which focused to help them in push the effort thru learning more than do a task. The scaffolding importantly presented and designed conceptual framework to help them to learn and act in learning process more than focused in their competency. Based on Hanafin (1999), the scaffolding consisted of (1 Conceptual scaffolding (2Metacognitive scaffolding (3 Procedural scaffolding (4Strategic scaffolding. The Conceptual scaffolding helped the students to think conceptually and guided them to access the learning resources or other learning resources. The research team design to show the relationship of each topics by summarizing the main ideas and designed in Figure which they could fine the relations of each content. The Metacognitive scaffolding was the scaffolding to support their learning process and guide thinking process in order to solve the problems via suggested strategies as a Guideline based on Flavell (1979), so they could monitor and assess their own thinking of problem solving. The Procedural scaffolding was the scaffolding to suggest to use resources and tools of the system and its working. The Strategic scaffolding was the scaffolding of an alternative to support analytical thinking, strategic planning, and problem solving strategy while learning. This importantly presented in clarifying of required information, assessing of provided resources, and connecting the relations of both prior and new experiences in forms of Figure of relationship which the students analyzed and then solved the problems.	 Scaffolding  Conceptual scaffolding helped the students to create conceptual thinking  Metacognitive scaffolding helped to enhance thinking process  Procedural scaffolding

Components	Description of components	Design
		suggested the instruction of the cognitive innovation  Strategic scaffolding helped the student thru problem solving
Center for enhancing problem solving	Center for enhancing problem solvingthe research team designed the innovation to create the problem situation in authentic context, to practice their problem solving skills, and to collaborate them on solving problems, so this made them deeply understanding. The problem solving process of Jonassen (1997) was applied as follows: process 1 identify the space of problem, process 2 examine the exact problems, process 3 create the possible solution, process 4 assess the selected possible solution, process 5, create the guideline of use such solution, process 6 adjust such solution. The designed situation was designed to be ill-structure such as “Miss Ink-orn gardens on her house, they are many big and small trees and a fish pond. However, there are many problems of planting and fisher for example; “Miss Manee feeds tilapia fish in naturally. She plants water tree in the pond and can have the big tilapia fish. But then, the frog spawn spreads out rapidly and water plant died. She solves the problem by get the frog spawn out to make the pond clean but it is no food for the fish instead. So, the fish size becomes small.” The learning tasks was provided to the students to practice problem solving in 6 tasks as follow: task 1) the learners analyzed the problem space towards the questions of problem, solutions, and conditions after solved the problem; they also verified and reviewed such problems, the problem concise, the validity and sufficiency of the resources, and how to provide information to solve such problem, task 2) the students identified and explained the real problems, the causes of problems by thinking about the possible problems that could happen and also the possible causes, they had to analyze to explain the problem and its causes, task 3) they created the possible solutions which designed for the students to find their problem solving process, their analysis of problem causing, their identification of problems and solutions, their thinking towards the possible solutions as in flowchart, task 4) the assessment of the use of possible solution, designed for the students to assess their solution (from task3) which could have be able to solve authentically by discussing to have the agree and disagree with reasoning, hypothesizing, assessing, and creating the most possible solution which could be reflect to find the decision towards the solution selecting, task 5) applied the selected solution which the students applied such solutions and monitored by using these questions: Does this solution make the student to want to use with the problem?, Is this possible acceptable in groups?, Does this solution get efficiently success in being used to	 Center for enhancing problem solving

Components	Description of components	Design
	solve the problem?, the students had to consider the solutions, adjusted it and concluded in real solution, and transfer it into other context, task 6) adjusting the solutions which designed to the students to adjust the solutions by giving feedback of solution, the success of solutions towards such problems	
Cognitive tool	Cognitive tool was a tool to help the students to construct their knowledge, the design based on (Hannafin, 1999) which hold the cognitive tools designing based on Constructivist along the principles of Information Processing theory and Cognitivism theory. The students had to be supported to do the tasks. The cognitive tool was designed under the advantages of computer competency which able to help them to process information. The tool consisted of 1) Seeking tool: supported them to search related information, addressed information site by Search engines as Google, 2) Collecting tool: help them to collect related information by using Google drive, 3) Organizing tool: help them to organize related information and to connect related concepts via information organization as external link, and 4) Integrating tool: help them to integrate related information with their thinking concepts.	 Cognitive tool
Collaboration	Collaboration was the component designed to elaborate cognitive structure by student's collaboration. They collaborated to solve problems by discussed and exchanged their similar objective of solving, so designed to have Social network as Facebook where they could express opinions and reciprocal their thoughts. This based on OLEs- Communication tool of Hannafin (1999) and which was the tool to communicate among students, teachers, and experts at the same point of time, for example; Facebook messenger which they could share opinion and perspectives among classmates, teacher, and experts during the entire time they spent in the Collaboration.	 Chat onFacebook Messenger for brainstorming
Coaching	Coaching was the component mainly to help the students to be able to do complex tasks with two models as observable process model and expert practicing model including cognitive process which invisible. Hence, the good practice should let the student learn with demonstration or expert model with explanation, especially in Science subject which required student's practice. Coaching helped them to learn the correct procedures, its own reasons with the explanations. Also, learned with cases which helped them to meaningfully learn. Importantly, coaching helped them by monitoring and relating them not to have the misunderstanding in the subject content and instead have the correct understanding immediately. Moreover, coaching could help them to develop to be an expert. The Cognitive Apprenticeship of Collinset al (1989) was used as a principle to shift them from being novice to expert. Coaching also gave hints when the students made a request. Bransford (1989) stated the effective coaching is the monitor student's task in order to prevent the misunderstanding by giving students time to survey and solve the problem in classroom, reflect	 Coaching

Components	Description of components	Design
	and compare their tasks. so this component was designed in accordance with this principle by setting the teacher to analyze student's feedback, guide them in learning process, provoke their cognitive processing including problem solving and active learning thru effecting on their performance both in learning and doing tasks. The researchers design this coaching as in the classroom and online where they could raise a question to the expert all the time.	

6.2 Evaluation Process

In evaluation process based on Chajaroen (2014), it consisted of 1) evaluation of innovation, 2) evaluation of context of use, 3) evaluation of students' opinions, 4) evaluation of cognition, and 5) evaluation of student's learning achievement as follow:

6.2.1 Evaluation of The Innovation

Evaluation of the innovation: Evaluated the cognitive innovation by the expert thru content which found the validity of background theory in designing. The designing framework consisted of 1) Problem base, 2) Learning resource, 3) Related case, 4) Cognitive tool, 5) Collaboration, 6) Center for enhancing problem solving, 7) Coaching and 8) Scaffolding which all components consistent with the mentioned background theory obviously.

6.2.2 Evaluation of Context Of Use

Evaluation of context of use: the appropriate group size was 3 students to collaborative solve a problem, they collaborated to study and do tasks such as solve a problem, search information, allocate group member task in order to complete the tasks in time and quickly. 2 group members were too small to complete tasks in time, and more 3 group members could lead the member not to see the screen clearly and not to have the attention in the tasks.

6.2.3 Evaluation of Students' Opinions

Evaluation of students' opinions: Studied their opinions towards the innovation throughout the survey from and the interviewing which comprised 1) content: found that the content of Life relationship was appropriated with the student's level. It was not too difficult and too easy, and was up to date, complete, and clear for them to study and solve the problems, 2) media: found the designing of Navigator which helped them to easily search information and suited to their need, the Icon showed the meanings of information resources and connected to links to access to other information, Post helped them to learn via Facebook, the Architecture in the innovation was suitable, highlighted, interesting via Figures, alphabets sizes and colors. The students thought that the graphic in the innovation was good and appropriated to the content, the colors and sizes was very interesting to them, and 3) designing: found that all components in the innovation were appropriated.

6.2.4 Evaluation of Student's Cognition

Evaluation of student's cognition: evaluated their cognition via 2 kinds as 1) interviewing and protocol analysis which found 6 procedures of student's problem solution as 1) identified problem gap, 2) identified and explained exact problems, 3) created possible solutions, 4) evaluate the possibility of solution use, 5) applied the solution, and 6) adjusted such solutions; and 2) evaluated via Executive function by Tower of London which was the comparing of counting time and duration used in solve a problem before and after classroom. The results was found that they had a better on problem solving after learned with the cognitive innovation where they moved the dished in 6 times (least time) and spent less time than earlier.

6.2.5 Evaluation of Learning Achievement

Evaluation of learning achievement: The learning achievement of the 24 target group was found that the posttest was $\bar{x}$ = 18.75, S.D. =1.78 more than pretest $\bar{x}$ =5.25, S.D. =2.23 which 85% of the students passed 70% of the subject standard.

7. Conclusion and Discussion

Regards the design and development of the cognitive innovation to enhance problem solving, it was found that the innovation consisted of: 1) Problem base, 2) Learning resource, 3) Related case, 4) Cognitive tool, 5) Collaboration, 6) Center for enhancing problem solving, 7) Coaching and 8) Scaffolding. It consisted of Kwangmuang et al (2012), Chaijaroen et al (2012), and Yampinij and Chaijaroen (2012) studies that used Constructivist theory to be basis of the design and development of the innovation to construct knowledge. But this research had the originality in student's knowledge construction with problem solving by focusing on cognitive processes. Its finding hereby helped the students to solve the complex problems eventually.

The evaluation of the innovation comprised 1) evaluation of designing framework by expert reviewer which found the theoretical validity in background, 2) evaluation of the innovation which found that appropriateness of all 3 aspects as 1) content, 2) media, and 3) designing, 3) evaluation of context of use which found that 3 members in a group was appropriate, 4) evaluation of their opinions which found that the appropriateness of content, media, and designing, and 5) evaluation of cognitive process which found that they could solve the problem better after learned with the innovation based the evaluation of Executive functionby usingTower of London where they moved the dished in 6 times (least time) and spent less time than earlier, and 6) evaluation of learning achievement which found that the posttest score was higher than pretest and passed 70% of the standard.

The above results might be influenced from the instructional design based on ID theory which designed to bring the theory into practice and exactly into the innovation components based on Jonessen (1997) of 6 processes problem solving. It fostered the students to authentically practice to analyze, identify, create possible solution, select the best possible solution, and use in real situations. In Problem base, the media attribute of computer was used to help the students to be able to collaboratively work with their classmates to solve the problems. Also they could interact and record their solving processes in the innovation suddenly it came up while learning throughout authentic situations. Moreover, the designing process, development process, and evaluation process were all focused on the outcomes to be used to improve the innovation quality efficiently. The feedback was recursive and used to improve its quality. This effected to the development of human efficiency which was important to develop the quality of human resource and response to the National Research framework of cognition and innovation development in order to be ready for the competitive and cooperation among AEC and world countries,

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The Development of Social Media Interactive Learning Environments to Enhance ICT Literacy Skill for High School Students

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Abstract: Design and develop learning environment of social media to enhance ICT skill for high school students and study students' learning motivation. The target group in this research was 34 students in Matthayom Suksa 1 (grade7) at demonstration school of Khon Kaen University (secondary level). Data collection performed in the first semester of the academic year 2016 with computer subject. Developmental research Type I including 1) Designing and development 2) Evaluation 3) Validation. Descriptive statistic was used in this study. The result of pilot study found that the components learning environment composed of 1) Problem base 2) Information resource 3) Cognitive tools 4) Related Case 5) Scaffolding 6) Coaching 7) Social/context support. Students' learning motivation was the questionnaire of motivation scale has 25 items by developing from Science Motivation Questionnaire (Srisawasdi, 2013). This instrument was a Likert-type scale putting items that five motivation components. The pilot results are as follows: The Intrinsic Motivation there is value in learning more about computer solutions significantly (IM, Mean = 4.50, SD = 0.90). That consists of five items, Career Motivation is at the most about the students see the advantages to doing problem-solving skills, computer adapted to a career involving computers (CM, Mean = 4.26, SD = 0.85). That is consists of five items, Self-determination. In the most about the dedication to learn. The turnout on PC (SD, Mean = 4.21, SD = 0.84.). That consists of five items, Self-efficacy. A lot about the level of confidence in the class. The test content knowledge and skills on the computer (SE, Mean = 3.35, SD = 0.67). That consists five items, and Grade Motivation is at a high level. The confidence to learn to score and grade at the school to their own computer (GM, Mean = 3.99, SD = 0.80).

Keywords: Social Media, Interactive Learning Environments, ICT Literacy Skill

1. Introduction

The modification in advancement of information and communication which role and influence on lives of people with all ages at the present. Globalization, is shifted the information news that is reoccurred and rapidly changed, as a result of advances in science and information technology affect the change of the education, economic, politic and society. In the world of the 21st century, to improve the qualitative and sustainable population is the most important thing, which would be served as the basis for the key of developing people. Moreover, it would encourage students to eligible to live in the modern world. The skills for livelihood in 21st Century are fundament, which should encourage students to achieve in learning and innovating skills. It determines the readiness of students to enter the working world that has more complex today, such as creativity and innovation, critical thinking and problem solving, communication and collaboration Skills, and knowledge of information technology.

The literacy of information technology and communication skills, students could use as a learning tool by learning from online textbook which could response learning of them. The literacy of information technology and communication skills could help students to define scope of the problem. Data accession, data management, evaluation, creation and integration are contributed to learning. UNESCO also emphasizes to support and develop the information technology literacy and communicated skills.

Communication, which is quickly respond the modification today is social media or electronic media; this is a mediator that allows guests to participate in creation and share their opinions about

Education through internet in the present increasingly because more features, which have been added, they are conducted to learn in the 21st century and they could respond to cooperative learning and sharing knowledge. Whether it was received popularity in high usages and easy accession. The instructor could offer lessons via social media. Students could study or seek more knowledge easily from social media, which they are being used. It could also be applied to the current teaching, which focuses on less teaching to gain more learning.

Constructivism theory is a comprehensive theory about the rationality of faith, which encourages students to seek knowledge with focusing on individual idea and definite creation. Constructivist with the new viewpoint has expanded scope that gives the concept of culture and social learning. Then it is the creation of learning management which is reacted to techniques by designing in learning by doing environment.

From the importance and necessity above, the researcher is interested in designing and developing interactive learning environment through social media to promote the literacy of information technology and communication skills for secondary school students.

2. Literature review

Constructivist Learning Environment

Constructivist learning environments (CLE) are characterized as hands-on learning environments that strive to imitate real-life contexts. CLE has a social learning component as well. In a CLE, learners construct knowledge, solve novel problems, and test the truth or accuracy of their conclusions through social negotiation, otherwise known as collaboration. CLEs stress the flexibility of the learner's mind and its ability to actively construct meaning (Jonassen, 1999)

Social media technology

In a matter of a few short years, innovations in social media technologies have multiplied on a scale never before seen, revolutionizing not just the way in which we communicate, but also how we interact with others (Weisgerber and Butler, 2010). The ascent of social software provides new avenues and new opportunities for increased participation and collaboration (Parker and Chao, 2008). The participatory web, including social networking sites such as Facebook and content sharing sites such as YouTube and Flickr, allow individuals to establish or maintain connections with others, establish their social networks, and share information in the form of wikis, blogs, tweets, podcasts, video, RSS feeds, and more (McCarthy, 2010; Weisgerber, 2008). Instructors have been embracing and looking for innovative ways of using social media in the classroom. Sponsored by the university's Information Technology Services, the author led students enrolled in a software development class in designing and implementing a web-based social media interactive learning environment. The learning environment aims to create an impactful social engagement within a lecture-based classroom. (Chao and Parker, 2011; Kumpang and Kanjug, 2015).

ICT literacy

Discussions of Information Technology in Education typically emphasize the Technology rather than the Information. Widespread technology has meant that people encounter more information, in a greater variety of formats, than ever before. Technology is the portal through which we interact with information, but people's ability to handle information to solve problems and think critically about information tells us more about their future success than their knowledge of specific hardware or software. These skills known as Information and Communications Technology (ICT) Literacy comprise a 21st century form of literacy, in which researching and communicating information via digital environments are as important as reading and writing were in earlier centuries. ICT literate students master content faster, are better problem-solvers, become more self-directed, and assume greater control over learning (Katz, 2007).

3. Method

Synthesis Designing Framework

Synthesis design environment to learn in this episode. Research presented three main points below. Synthesis of theoretical concepts (Theoretical Framework) found. The framework consists of basic theoretical research. The four basic theories: (1) the underlying psychology of learning. (Psychological base) constructivist learning theory which Whistler. The theory is based on two principles constructivist Whistler Piaget's intellectual properties. Constructivist theory and Whistler oriented society. Victor Burgos pot (2), based on the design of learning (Pedagogical base) Constructivist Learning Environments (CLEs) aimed at promoting the ability to solve problems. Develop the concept of the situation is complicated. By learning from the questions that the case is complex. Or aim to learn from the students themselves. Learning alertness and focus on real conditions. (3)The underlying technology (Technology base) social media affect performance, speed, and ease of management. (4) The fundamental skills and knowledge (Knowledge and skill base), Information Technology and Communications of The iSkills with7standard adapted from Educational Testing Service as shown in Figure 1.

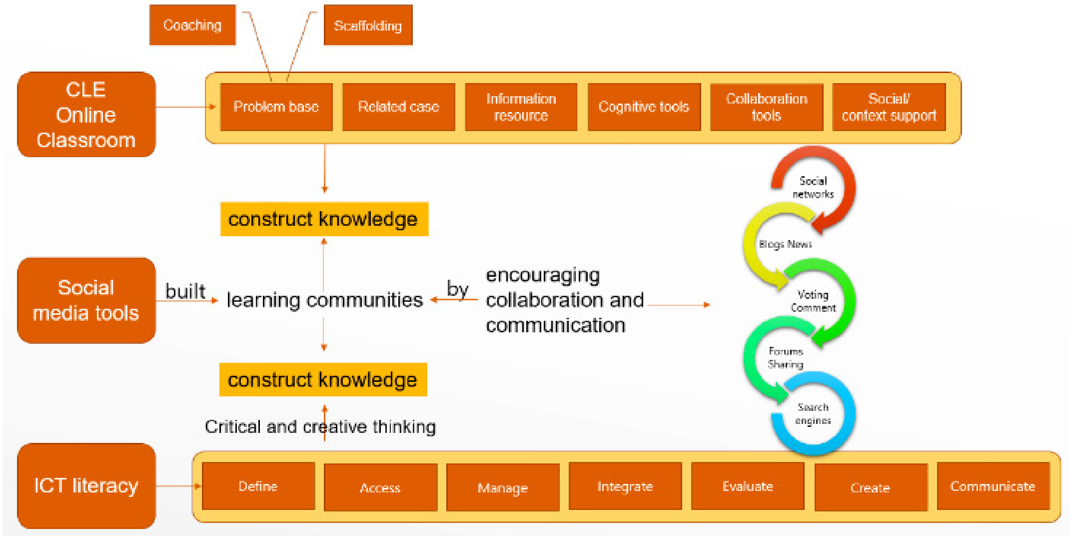

Figure 1. Designing framework of social media interactive learning environments to enhance ICT literacy skill (Kanjug, 2016)

Learning Environment Design

Cognitive restricting and ICT literacy skills

To stimulate the intellectual skills and knowledge of information technology and communications. Problem base is an important component of the learning interaction. Promoting skills and knowledge of information technology and communications. Learning is designed to focus on the issues that define the context, and the mission of learning skills that promote information and communications technology. According to the conceptual framework Educational Testing Service 7 Skills include 1) Define 2) Access 3) Manage 4) Integrate 5) Evaluate 6) Create 7) Communicate as shown in Figure 2.

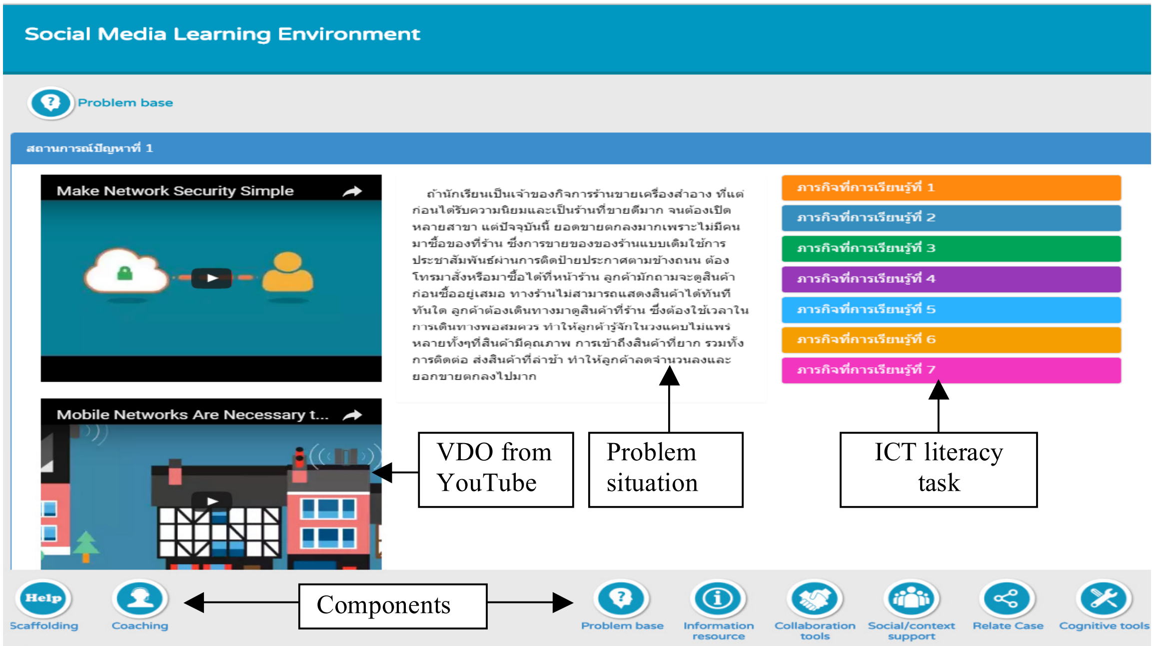

Figure 2. Screen design of Problem base

Supporting for restructuring the intelligence and knowledge of information

Table 1: Supporting for restructuring

Principles	Component	Characteristic	Social media
Supporting for restructuring the intelligence and knowledge of information technology	Information	static	Web base
	resource	dynamic	Blogger
	Cognitive tools	Search	Google
		data collection	Google Docs
		classification	Mindmeister
		integration	Blogger
		communication	Facebook
	Relate Case	YouTube	

Table 1 shows technology and communications. Key elements are (1) Information resource support to discover the answer to solve the problem by discovering knowledge from various sources. Based on the theory of Cognitive popular (2) Cognitive tools to support their mission to solve complex problems. It is a tool to expand the concept, design tools, intellectual basis of the theory of information processing, and a theory of rationality (3) Collaboration tools to encourage students to share experiences between students, teachers, and experts expanded view of thinking. Helping adjust misunderstandings. (Misconception) occurred while learning based on the concept of Social Constructivist of Vygotsky (4) Related Case encourages students to personalize the experience to close the case. To expand the view to change the perception.

Support for social interaction

Key element are (1) Coaching. Coaches will encourage students to develop self- motivate and help students to complete the mission by principles of cognitive apprenticeship model (Cognitive Apprenticeship) (2) Social / context support social learning solutions or to learn if the mission cannot be achieved manually as shown in Table 2 and Figure 3.

Table 2: Support for social interaction

Principles	Configuration	Social media
Support for social interaction	Coaching	Facebook
	Social/context support	YouTube and Blogger

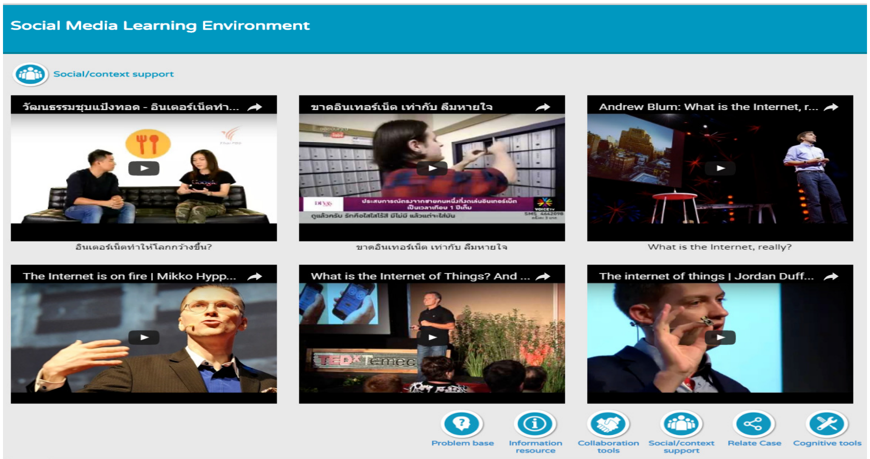

Figure 3. Screen design of Social/context support

Pilot study

3.3.1 Participants

1. Experts including 1) Content expert was teacher in school who was teaching in this subject 2) Learning media expert and 3) Learning environmental design expert.
2. The target group of 34 students in Matthayom Suksa 1 at Demonstration School of KhonKaen University (secondary level).

3.3.2 Research Instruments, Data Collection and Analysis

3.3.2.1 Research Instruments

This study used instruments that is questionnaire for explore computer learning motivation of student. The questionnaire of motivation scale has 25 items by developing from Science Motivation Questionnaire (Srisawasdi et al., 2013). This instrument was a Likert-type scale putting items that five motivation components such as Intrinsic Motivation (IM) that consists of five items, Career Motivation (CM) that is consists of five items, Self-determination (SD) that consists of five items, Self-efficacy (SE) that consists five items, and Grade Motivation (GM) that consists of five items. Students answer the questionnaire to each item on a five-point-scale of ranging from "never" (1 point) to "always" (5 point). as shown in Table 3

Table 3: shows example information of item on the questionnaire

Subscale	Description	Sample items
IM	Which involves learning computer for its own sakes	Interesting.
CM	Which involves learning computer as a means to an end	Understanding computer will benefit me in my career.
SD	Which refers to the power or ability to make a decision for oneself without influence from outside	I put enough effort into learning computer.
SE	Which refers to students' confidence that they can achieve well in computer.	I believe I can master computer knowledge.
GM	Which refers to the debilitating tension some students experience in association with grading in computer	I like to do better than other students on computer tests.

3.3.2.2 Data Collection and Analysis

The researcher provides computer motivation questionnaire to students around 15 minutes. After finishing the questionnaire, they learning with environment of social media to enhance ICT skill for high school students 1 hour 30 minutes. After finishing the learning.

Result

The pilot results are as follows: The Intrinsic Motivation there is value in learning more about computer solutions significantly (IM, Mean = 4.50, SD = 0.90). That consists of five items, Career Motivation is at the most about the students see the advantages to doing problem-solving skills, computer adapted to a career involving computers (CM, Mean = 4.26, SD = 0.85). That is consists of five items, Self-determination. In the most about the dedication to learn. The turnout on PC (SD, Mean = 4.21, SD = 0.84.). That consists of five items, Self-efficacy. A lot about the level of confidence in the class. The test content knowledge and skills on the computer (SE, Mean = 3.35, SD = 0.67). That consists five items, and Grade Motivation is at a high level. The confidence to learn to score and grade at the school to their own computer (GM, Mean = 3.99, SD = 0.80) as shown in Figure 4.

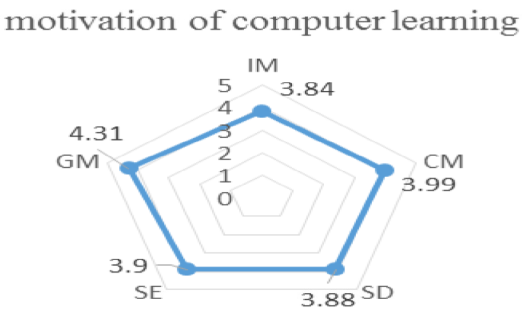

Figure 4. Show learner's motivation in computer learning

4. Conclusions and Future Work

The design and develop learning environment of social media to enhance ICT skill for high school students should carefully realize its context and quality relevant to realities as well as able to adapt for use in the future. This is an example experiment for interactive learning environment follows: internal motivation can be used to make a learning plan for problem-solving skills. In term of the computerizes, this can be adapted for increasingly supporting computer use. Whereas, external motivation can be used to operate learning course for those interested. Motivation to computer-testing can lead to context changes to understand easily. Finally, Motivation to results can result in encouraging and inspiring those to occur more learning.

Acknowledgements

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Mobile Technology-enhanced Flipped Learning for Scientific Inquiry Laboratory: A Comparison of Students' Perceptions and Engagement

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Abstract: Many educators have been widely recognized flipped learning as a pedagogic approach in 21st century education. While, advancement of mobile and wireless communication technologies provides a new learning opportunity for students via mobile devices as anywhere, anytime, and anyone learning. In this study, the researchers compared high school students' affective domain of learning such as perception and engagement between flipped inquiry learning and conventional flipped learning via mobile technology. The study was conducted with 61 eleventh graders in Northeastern region of Thailand who agreed to participate, and they were assigned into one experimental group, receiving mobile flipped inquiry learning, and another of control group, receiving mobile conventional flipped learning. Both were examined their perceptions and engagements using 20 and 21 items of 5-points Likert-scale questionnaire after interacting with the interventions. The results showed that students in experimental group who have learned with the mobile flipped inquiry learning have better perceptions and engagements than students in control group. This finding implied that flipped inquiry learning with mobile technology could be a better pedagogic strategy for engaging high school students into scientific laboratory class than conventional flipped mobile learning. In addition, the integration of mobile technology into classroom with effective strategy could enhance students' development of affective domain for learning science.

Keywords: Flipped classroom, mobile learning, inquiry, science education, high school

1. Introduction

Numerous studies about the use of mobile and wireless communication technologies in education have been reported, in which these technology-enhanced learning approaches (Chu, Hwang, Tsai, and Tseng, 2010). Mobile learning definitions have been recognized by researchers, such as "learning that happens learner takes advantage of learning opportunities offered by mobile technologies" (O'Malley et al., 2003) and "learning that happens without being limited at a fixed location by using mobile technologies (e.g., mobile phone or Personal Digital Assistant PDAs). On the other hands, several researchers suggest that to develop effective learning activities and plans for helping students learn across context, features of mobile and wireless communication could integrate into flipped classroom (Hwang, Lai, and Wang, 2015)

The flipped classroom was defined simplistically as "school work at home and homework at school" (Flipped Learning Network, 2014). In recent year, researchers have become increasingly interested in flipped classroom. For example, Lai and Hwang (2016) concluded that integrated self-regulated approach in flipped classroom could improve students' learning performance in a mathematics. Moreover, Chen, Yang, and Hsiao (2015) found that the students' interest, well-organized course might be affected students' achievement in flipped course and learning performance was affected by gender difference. Sohrabi and Iraj (2016) tried to implement digital media in flipped classroom. In the same time, Davies, Dean, and Ball (2013) claim that technology can enhanced flipped learning and facilitated student's learning than regular classroom. Equally important, researchers have indicated some of reason flipped learning adopted by so many educators, there are the subject area for learning in schools, with enough prior knowledge, students have more time to conduct higher level activities and questions (Hwang, Lai, and Wang (2015). For learning in science, inquiry approach has been effectively approach and suggested by researchers.

Inquiry-based learning is an educational strategy which students follow methods and practices like scientists to construct knowledge (Keselman, 2003). It can be defined as a process of discovering new phenomena with the learner making hypotheses and testing them by conduct experiments and/or making observations (Pedaste, Mäeots, Leijen and Sarapuu, 2012). Moreover, it is viewed as an approach to solving problems and involves the application of several problem solving skills (Pedaste and Sarapuu, 2006). With the benefit, Inquiry-based learning has been extensively studies. However, less attention paid to integrating mobile learning and flipped classroom for improve students' learning and their affective domain. This study is survey students' engagement and perception from flipped inquiry learning with mobile technology and flipped learning with traditional approach to investigate the following research questions:

- Do the students who learn with mobile technology on flipped inquiry learning approach have engagement better than those who learn with flipped traditional learning approach?
- Do the students who learn with mobile technology on flipped inquiry learning approach have perception better than those who learn with flipped traditional learning approach?

2. Literature Review

Digital Technology in Science Education

Over the past few decades, digital technologies and learning resources have important roles in education, and recent research found that the digital technologies can effectively support teachers' teaching practices in integrating inquiry-based instruction into science classrooms (Srisawasdi, 2014). In Thailand, learning objects and computer simulations (e.g. Yenka, PhET) have been used to encourage inquiry-based science learning by visualizing scientific phenomena and examining them in their everyday experiences (Srisawasdi,2016). Recently, numerous researchers have been designed course for promoting students' learning with digital technology, Vrerman-De Olde, De jong and Gijlers (2013) studied compared learning from designing instruction in the context of simulation-based inquiry learning with learning from lecture teaching and the result showed that students who learn by designing instruction performed conceptual knowledge test better than students who learn from traditional way. Furthermore, Pinatuwong and Srisawasdi (2014) and Buyai and Srisawasdi (2014) suggested that Students who may have positive or negative attitude toward computer simulation can learn from this digital technology resource and it can facilitate teaching and learning in school science.

Flipped Learning with Digital Technology

There are various definitions of the flipped classroom. One of them is ''Students watch the video before the class and use the class time to solve complex concepts, answer questions, and students are encouraged to learn actively'' (Stone 2012; Hwang, Lai, and Wang, 2015). In flipped classrooms, the teacher's role should be guiding students to think and discuss, and to give feedback and advise them. Consequently, in the process of the flipped classroom, students play the role as active learners. Teachers become facilitators and assistants, instead of instructors. Along with the increasing emphasis on the concepts of the flipped classroom, the ideas of technology teaching have shifted from the application at school to self-learning at home (Hwang, Lai, and Wang, 2015). In this paper, terminologies "flipped learning and flipped classroom" are not strictly distinguished.

Previous finding from flipped learning researches indicated that this approach encouraged students to learn and be an active learner, and it can be integrated into many subject areas. Lai and Hwang (2016) concluded that in mathematic integration of self-regulated approach into flipped classroom could improve students' learning performance. Moreover, Gomez, Jeong and Rogriguez (2016) examined performance and perceptions of students in general science classroom along with flipped classroom and result showed that students who leaned with flipped classroom have higher performing, positive perception than other and increased individualized learning.

Inquiry-based Science Learning

Teaching science as inquiry is important pedagogical approach, which allows students to answer questions using data analysis and information exchange (Wang, Wu, Yu, and Lin, 2015). According to Buck, Bretz and Towns (2008), six characteristics represent area in activities and experiments. There are (1) Problem/Question, (2) Background/Theory, (3) Procedure/Design, (4) Results Analysis, (5) Results communication and (6) Conclusions. In addition, the "level" shows the extent to which a laboratories investigation provides guidance in terms of the six characteristics. Each level can be described as follows: level 0 Confirmation; An activity which all six characteristics are provided for students, level ½ Structure inquiry; The laboratory manual provides the problem, procedures, and analysis by which students can discover relationships or reach conclusions that are not already known from the manual, level 1 Guided inquiry; The laboratory manual provides the problem and procedures, but the methods of analysis, communication, and conclusions are for the student to design, level 2 Open inquiry; The problem and background are provided but the procedures/design are for the student to design as well as the analysis and conclusions, level 3 Authentic inquiry; The problem, procedures, analysis, communication, and conclusions are for the student to design.

3. The Exploration of Students' Engagement and Perceptions

Participants

The study was conducted in a medium-sized public high school located in the northeastern region of Thailand. The 61 eleven-grade students were divided into a control group (N = 31) and an experimental group (N = 30). They age ranging from 16 to 17 years. They have no experience in using flipped classroom and simulation on mobile before. Figure 1 illustrated information about participants and learning environment.

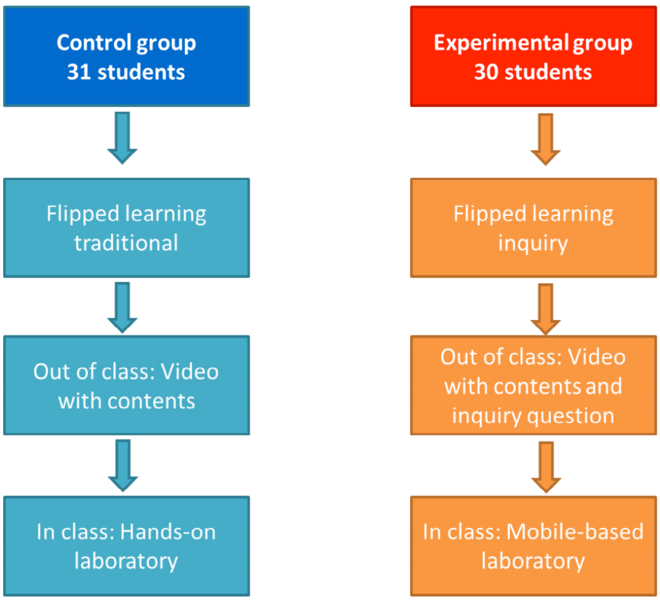


Figure 1. Diagram of participants and learning environment

Research Instruments and Data Analysis

This research used two instruments for determining students' engagement toward flipped learning and perception toward flipped learning. First, the engagement toward flipped learning is the questionnaire developed from mathematics and technology attitudes scale (MTAS) developed by Pierce et al. (2007) consisting of 20 items. All items were classified into five scales, including scientific confidence (SC) (4 items), attitude to learning science with technology (ST) (4 items), confidence with technology (TC) (4 items), affective engagement (AE) (4 items) and behavioral engagement (BE) (4 items). Second, the perceptions toward flipped learning is a questionnaire developed from Peng et al.(2009) consisting of 21 items which are divided into two scales, including learning experience (12 items) and Impression(9 items). Students are asked to indicate the extent of their agreement with each statement, on a five-point scale from strongly agree to strongly disagree (scored from 5 to 1). To develop a Thai version of the questionnaire, the original English version was translated identically in Thai language. One expert was recruited to identify communication validity of the items. The statistical data techniques selected for analyzing were arithmetic mean and t-test for investigate engagement toward flipped learning and perceptions toward flipped learning.

Learning Materials

In this study, technology materials which bring to support learning are simulation from PhET (Physics Education Technology) and online video. They can play on mobile devices. First, simulation was related to content of static fluid pressure. It provided primary information which visualized phenomena. Second, Video consisted of theory/background that related to daily life phenomena and an inquiry question. Figure 2 showed a simulation on mobile devices (Left) and online video (Right).

Figure2. Illustrate a simulation "Under pressure" (Left) and Online video (Right).

Result and Discussion of Students' Engagement and Perceptions

To compared students' engagement toward flipped learning and perceptions toward flipped learning, Table 1 shows mean and t-test of engagement which consisted of attitude to learning science with technology (ST), scientific confidence (SC), confidence with technology (TC), affective engagement (AE), behavioral engagement (BE) and perceptions consisted of learning experience, impression. Moreover, Figure 3 displayed arithmetic mean graphics of students' engagement and perceptions toward flipped learning.

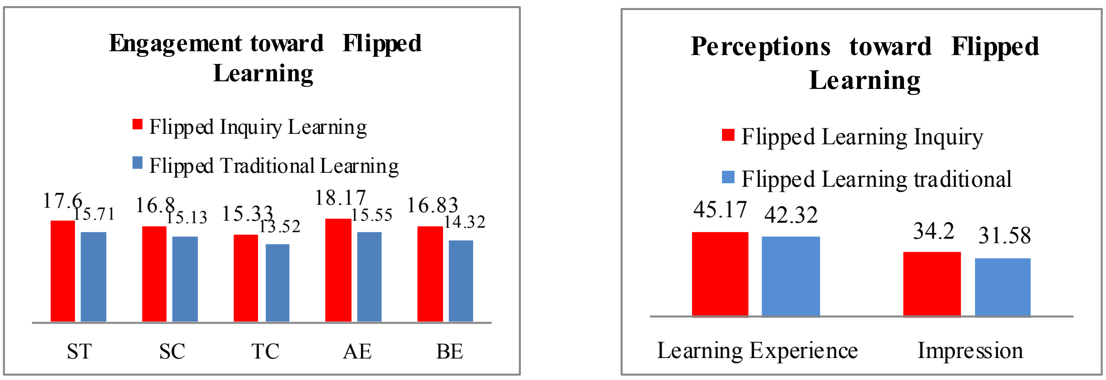


Figure 3. Illustrated arithmetic mean graphics of students' engagement (Left) and perceptions (Right) toward Flipped Learning

Table 1: Descriptive statistic for Engagement and Perceptions toward flipped learning.

Scale	Mean(SD.)		*t*	*p*
	Flipped inquiry learning	Flipped traditional learning		
Engagement				
Attitude to learning science with technology (ST)	17.60(2.24)	15.71(2.43)	3.16	.002*
Scientific confidence (SC)	16.80(2.19)	15.13(1.71)	3.33	.001*
Confidence with technology (TC)	15.33(2.41)	13.52(2.46)	2.91	.005*
Affective engagement (AE)	18.17(1.64)	15.55(3.00)	4.21	.000*
Behavioral engagement (BE)	16.83(2.04)	14.32(2.24)	4.58	.000*
Perceptions				
Learning Experience	45.17	42.32	2.51	.014*
Impression	34.20	31.58	2.92	.005*

*$p < .05$

According to Table1, the results of statistical analysis using independent t – test of students in flipped inquiry learning and flipped traditional learning posttest could examined students' engagement toward flipped learning. This results showed that there was significant mean difference between group in all scales consisted of attitude to learning science with technology (t = 0.002, p <.05), scientific confidence (t = 0.001, p <.05), confidence with technology (t = 0.005, p <.05), affective engagement (t = 0.000, p <.05), and behavioral engagement (t = 0.000, p <.05). From the results, it indicated that flipped inquiry learning with mobile technology could engage student's affective domain to learn in science better than flipped the class with traditional instruction. This finding conforms to those previous studies that have used flipped learning into classroom (Chao, Chen, and Chuang, 2014, Davies, Dean, and Ball, 2013.)

Moreover, the results of statistical analysis using independent t – test to examined posttest students' perception toward flipped learning in flipped inquiry learning and flipped traditional learning. The results showed that there was significant mean difference between group in all scales consisted of learning experience (t = 0.014, p <.05), and impression (t = 0.005, p <.05). From this results, it indicated that students' perceptions were positively to learn in science classroom with flipped inquiry learning and integrated mobile learning related to their learning experience and impression. In addition, flipped learning and mobile learning can improve students' attitude, achievements, and students' positive perception of a leaning unit (Sohrabi and Iraj, 2016, Peng et al.,2009, Hwang and Chang, 2010).

4. The Design of Flipped Inquiry Learning

In this part, the researchers would like to present combing flipped classroom, open inquiry (Buck, Bretz and Towns, 2008) and mobile learning into science classroom to support students' conceptual understanding and meaningful learning about scientific concept. As illustrated on Figure 4 it consisted of out of class and in class. Firstly, out of class is session with a video that has problem/question and theory/background. The video is based on phenomena in daily life and an inquiry question. Secondly, in class is session of practice for learning science which flow as Buck, Bretz and Towns (2008), Moreover, procedure/design allows students to investigate for solve problem by using simulation on mobile devices individually. An example of flipped inquiry learning was showed in Table2.

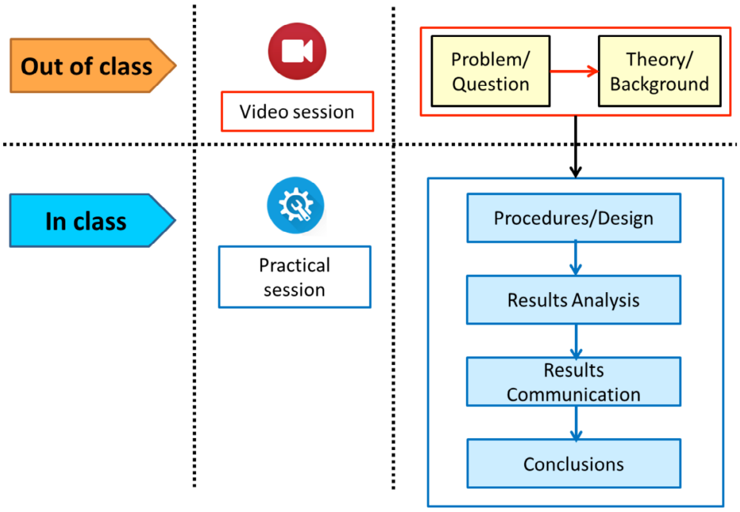
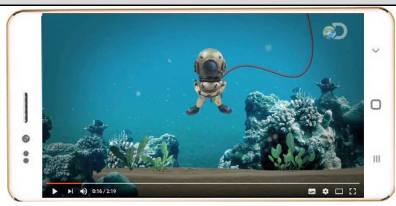
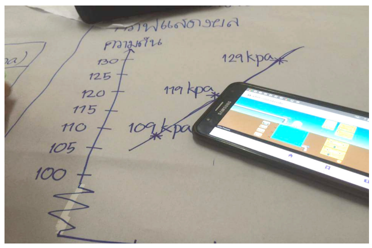


Figure 4. The Flipped Learning with Open Inquiry adapted from Buck et al. (2008)

4.1 An Example of Flipped Learning with Inquiry on Static Fluid Pressure

Before class, teacher provided video about the myth in science of static fluid pressure then students watched video lesson out of class. In class, students came with an inquiry question and started with design their procedure for finding answer. After that they shared group finding to class for discuss and conclude results. Finally, they tried to connect the result to answer the myth from video

Table 2: An example of learning process in Flipped Inquiry Learning classroom.

Components	Description of learning process	Example of learning activity
Learning material: Mobile mediated video lesson		
Out of Class 1.Problem/Question 2. Theory/Background	• Teacher oriented a course then provided an online video link about the myth in science of static fluid pressure, phenomena in daily life and an inquiry question.	
Learning material: Virtual mobile –based experimentation		
In Class 3. Procedure/Design	• Students came to class with a question which provided in online video. Then, teacher introduce under pressure simulation from PhET that can perform experiment from their mobile devices. Students were designed procedure by themselves.	
4. Results Analysis	• After gathered data, students grouping and brainstorming to analyzed the information from their experiment. After that they graphed and made group conclusion.	
5. Results	• In this part, students shared their	

Components	Description of learning process	Example of learning activity
Communication	conclusion to class and discussed about the graph. Teacher used formative assessment by asking questions to check their conceptual understanding.	
6. Conclusions	• From discussions, teacher induced students to answer the inquiry question from video. At that time, students concluded results from the experiment and made their conceptual understanding.	

5. Conclusion and Future work

This study designed the integration of mobile learning to flipped inquiry classroom with flipped traditional learning then surveys students' engagement and perceptions toward flipped learning. The finding of this study show that both of students' engagement and perceptions toward flipped inquiry learning better than flipped traditional learning. However, to enhance students' learning performance we are going to study about the effect of using flipped inquiry learning with mobile technology on students' conceptual understandings.

6. Limitation of the study

In this study, it should be noted that researchers selected the participants. The number of participants involved was relatively small (N = 31) and the ratio of females and males was unequal. Therefore, these factors could pose a threat to results generated from the independent t – test analysis.

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A Comparative Study of Students' Perceptions and Engagements toward Smartphone-based Inquiry Laboratory on Solution Concentration

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Abstract: Currently, mobile technology plays important role in education and the instructional practice of science education has been changed by the advancement of mobile learning and apps. This article presents a combination of physical and virtual smartphone-based experimentation in guided-inquiry chemistry learning of concentration of solution. In this pilot study, 95 eleventh-grade students in northeastern region of Thailand were recruited to participate in a series of inquiry laboratory and they were divided into three groups for receiving different setting of learning environment. They were administered 21-items perception and 20-items engagement questionnaires after interacting with the assigned learning environment. The results revealed that gender difference has a significant effect on students' perceptions, but there was no effect of gender difference on their learning engagement regarding the smartphone-based inquiry laboratory learning module. This implied that it is possible to use smartphone-based inquiry laboratory to facilitate chemistry learning of solution concentration for high school students.

Keywords: Mobile learning, blended laboratory, guided inquiry, chemistry education, high school

1. Introduction

Chemistry is a branch of science that deals with matter, properties, structure and change of matter, and the main field of investigation of chemistry involves atoms, ions, molecules, the interactions occuring at atomic and molecular levels. For secondary and thertiary education, topics in chemistry learning include abstract atomic level or complicated symbolic representations, and students have to face with difficulty in chemistry education. Research on students' chemistry learning has consistently indicated that students have great difficulty understanding chemistry concepts and they often hold alternative conceptions on chemical phenomena (Suits and Srisawasdi, 2013). In chemistry, concentration of solutions is a complex chemical concepts refered to the amount of substance dissolved in a certain volume of the solution, and it is one of the most conceptually difficult subjects on the school curriculum (Childs and Sheehan, 2009).

One of the important topics in school chemistry is concentration of solutions and an effective learning environment addressing the abstract and complicated nature of the concentration concepts is chemistry laboratories. Laboratories in chemistry education are considered to have potential as a crucial medium not only for improving science process skills, but also for improving conceptual understanding by making abstract subjects to be more concrete and visual (Karatas, 2015; Laredo, 2013). In addition, researchers has also pointed out that laboratory activities may positively affect students' attitudes and interests toward chemistry (Cooper and Kerns, 2006; Karataş et al., 2015).

Recently, smartphones can serve as powerful and convenient laboratory tools on a mobile platform, which potentially encourages chemistry learning for students. The smartphones are actually a portable and powerful computer that can be very valuable in chemistry laboratories. To enhance chemistry education, three major ways to use smart phones are giving access to the wealth of material on the World Wide Web (WWW), employing inexpensive applications (commonly called apps) for specific purpose of instruction, and creating smart objects by using two-dimensional barcode labels (Williams and Pence, 2011). By the way, Hwang and Chang (2011) suggested that integration of mobile devices into learning environment can encourag students' learning interest and motivation. Moreover, Hwang, Wu, and Ke (2011) reported that the use of an interactive concept map with mobile learning can promote learning attitude and achievement for students. To the best of our knowledge, there is no study involving a compararison of students' perceptions and engagement toward smartphone-based inquiry laboratory in chemistry education. Accordingly, the purpose of this study was to compare high school students' perceptions and engagement between traditional chemistry laboratory, smartphone-based hands-on laboratory, and smartphone-based virtual laboratory.

2. Literature Review

Digital Technology in Thailand Science Education

In recent years, researchers, educators, and teachers have become increasingly interested in digital technology in education. Digital technologies have been recognized as effective teaching tools in inquiry-based science learning (Srisawasdi, 2014). In context of Thailand, implementation of digital technologies as a pedagogical tool to support inquiry-based learning in science was still limited, terms of curriculum coverage and alignment in national science curriculum (Srisawasdi, 2015). One of an effective digital technologies implemented in Thailand science education is computer simulation, which features the learning of science by visualizing things at a molecular level and may directly link unobservable processes to symbolic equations and observable phenomena. This kind of digital learning technology is an alternative of curriculum in which content is broken up into discrete pieces or learning objects, ranging from a small chunk of instruction to a series of resources. These simulations are used as pedagogical tools to promote active learning in science and also enhance students' development of conceptual learning in science. In Thailand, computer simulations (e.g. Yenka, PhET) have been used to encourage inquiry-based science learning by visualizing scientific phenomena and examining them in their everyday experiences. However, the use of both visualized digital technology still remains rare in Thai science course.

Recently, the use of smartphone in science laboratory is becoming popular in the filed of educational technology. From a science education perspective, there have been interests in developing curricula that specifically consider the affordances of these mobile technologies. To support the improvement of science-based education through inquiry-based investigation, a number of international high schools in Thailand and public schools for gifted and talented students in science and mathematics employ mobile devices or apps to support students' practical work in the science laboratory. These devices have many valuable capabilities that have tremendous potential for use in science education (de Morais et al., 2016). Furthermore, A number of Thai educators and science teachers are driving change in Thailand science education research and practices by promoting digital technologies, such as mobile device and app., as appropriate inquiry tools to bring about benefits to investigative and inquiry learning environments for both science-based and integrated STEM education (Srisawadi, 2015).

Affordance of Physical and Virtual Laboratory in Science Instruction

Recently, computer-based technology has become commonplace in the science education as an integrate of the science classroom and laboratory experimentation. de Jong et al. (2013) concluded that students are able to take advantage of computer-transformed representations to interact with and investigate how the real world works by using the tools, techniques of data collection, models, and science theory in physical laboratory or in virtual laboratory. Both physical and virtual laboratory concern numerous overlapping applications. Olympiou and Zacharia (2012) concluded that physical laboratory can present experience of students that involve the manipulation of the actual items of an experiment, and only virtual laboratory can provide students with opportunities to manipulate the conceptual objects involved in an experiment and may be used to visualize things at a molecular level and may directly link unobservable processes to symbolic equations and observable phenomena.

Furthermore, many researchers found that advantage about both physical and virtual laboratory tcan provide high levels of interaction and learner engagement. The National Research Council (2006) stated that using both physical and virtual laboratory can achieve similar educational objectives, such as exploring the nature of science, enhancing conceptual development, developing scientific inquiry skills, and cultivating interest and motivation in science.

3. The Smartphone-based Inquiry Laboratory on Solution Concentration

The advancement of personal, portable, and wirelessly networked technologies leads us into a new phase in the evolution of technology-enhanced learning. Currently, smartphones are clearly ubiquitous in the hands of students. In this study, the researchers design our mobilized chemistry lesson to be student-centered, inquiry-based and personalized in nature. With the use of the smartphone as an inquiry tool to conduct chemistry laboratory learning activity, each student controls their own learning and investigation of concentration of solutions based on their own mobile devices. To create student-centered, inquiry-based learning activities with smartphone, the researchers model a guided-inquiry learning process and foster students' self-directed inquiry by initial teacher's facilitation of their inquiry-based learning. Figure 1 displays the smartphone-based laboratory environments used in this study.

Figure 1. An illustration of smartphone-based laboratory environments of solution concentration in chemistry: physical (hands-on) mobile laboratory (Left) and virtual (computerized visualization) mobile laboraotory (Right)

For the smartphone-based inquiry laboratory on solution concentration in this study, the use of smartphones coupled with data collection and analysis via Google applications, such as google spreadsheet, can make sophisticated lab experiments more feasible, especially for teachers with limited budgets. After completing the experiment with a mobile laboratory, students were assigned to interact with interactive spreadsheet, called excelet, for visualizing the relationship between varaibles. The excelet shows a relative graph that demonstrates relationships between H-value and concentration of measured solution. Moreover, the excelet shows chemistry equation of decomposition which represents symbolic levels, and it can changes a variable in the form of slide bar. For example, when students move the input slider bar, the experimental result will changs immediately. Consequently, excelets are an effective tool that incorporates easy-to-change variables so as to quickly illustrate their impacts on output. Figure 2 illustrates the excelet of the concentration of solution.

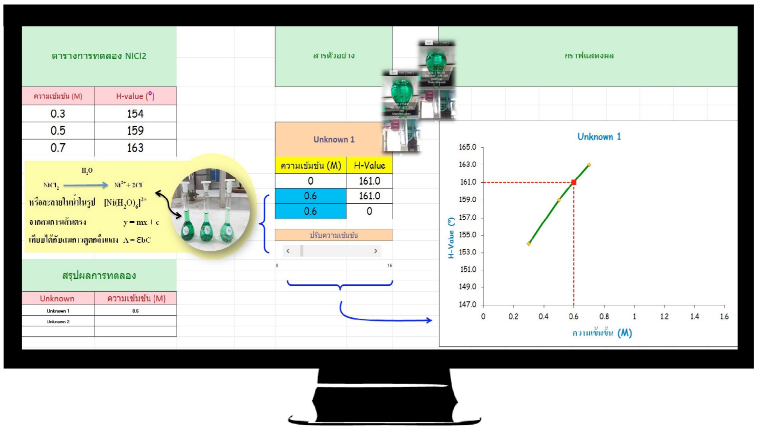

Figure 2. An Illustration of the excelet sheet for solution concentration laboratory

4. Methods

In this study, the researchers conducted a preliminary investigation to examine effect of smartphone-based inquiry laboratory on high school students' perceptions toward the laboratory on chemistry topic of solution concentration and their learning engegaments. The findings of this investigation provided us as a basis in order to redesign and develop a blended smartphone-based inquiry laboratory by combining mobile physical and virtual laboratory into guided-inquiry learning process as a novel learning experience for chemistry teaching and learning.

Participants

The participant of this experiment included 95 of 11th grade students, aged between 16-17 years old, attending three intact classes in a local public high school at northeastern region of Thailand. Two classes were assigned to the experimental groups (EG#1 = 30 and EG#2 = 31) and the other was the control group (CG = 34). The differences between the two experimental groups were the mobile learning tool to be utilized (physical or virtual lab). To be precise, the learning activity for the EG#1 was virtual (computerized visualization) mobile laboratory learning and the EG#2 was physical (hands-on) mobile laboratory learning. For the control group, they were taught with the traditional laboratory (hands-on laboratory without mobile app.) instruction.

Research Instruments

This research used two instruments for evaluating students' perceptions toward smartphone-based inquiry laboratory and their learning engagements. The perception questionnaire consisted of 21 5-points rating scale items (Peng et al., 2009) that focused 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. Another, the engagement questionnaire consisted of 20 5-points rating scale items (Barkatsas, Kasimatis and Gialamas, 2009) that focused on five constructs consisting; scientific confidence (SC), attitude to learning, science with technology (ST), confidence with technology (TC), affective engagement (AE) and behavioral engagement (BE), which each dimensions has four items. To develop a Thai version of the questionnaires, the original English version was translated identically in Thai language, and then translated back into English again. For each item, respondents were assigned to rate how much the respondent agree with into five scale, ranging from 1-strongly disagree to 5-strongly agree. Validity and reliability had established the instrument.

Data Collection and Analysis

In this study, students were exposed to interact independently with the assigned laboraotry environment for 30-40 minutes. Figure 3 illustrates students' learning interaction with the smartphone-based inquiry laboratory on solution concentration. After completing the experiment, they were asked to complete both perception and engagement questionnaires for 10-20 minutes.

Figure 3. An illustration of students' interaction with smartphone-based inquiry laboratory: working with virtual (Left) and physical (Right) mobile inquiry laboratory

Figure 4 shows the procedure of the experiment on this study. Before the interaction with the mobile laboratory of concentration, teacher provided an introduction of solution concentration concepts and the procedure of the mobile laboratory. After participating with the laboratory learning activity, all students were administered and took both questionnaires

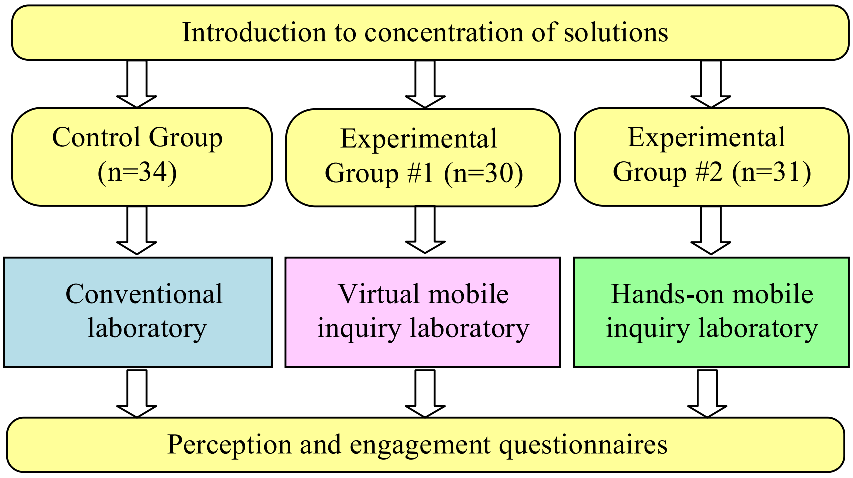

Figure 4. A diagram of the experimental procedure of this study

To compare the obtained data, the statistical data techniques for analyzing students' perceptions and engagements were performed by one-way MANOVA in IBM SPSS 20.0 for comparing the effect of the laboratory interventions (tradional/hands-on, physical mobile, and virtual mobile laboratory).

5. Results

5.1 Effect of the Three Different Laboratory Interventions on Students' Perceptions

The one-way MANOVA were conducted to determine the effect of the three types of laboratory delivery methods on the two dependent variables, i.e. learning experience and overall impression. As reported in Table1, the MANOVA indicated a significant main effect for gender (Wilks' lambda=.852, $F(4,88)=7.665$, $p=.001$, partial $\eta^2=.148$), but there was no significant main effect for intervention (Wilks' lambda=.918, $F(4,88)=1.933$, $p=.107$, partial $\eta^2=.042$). However, there was a significant difference for its interaction effect (Wilks' lambda=.884, $F(4,88)=2.805$, $p=.027$, partial $\eta^2=.060$). The result in Table 1 suggested that both genders had almost non-equal perceptions to learn with smartphone-based laboratory after participating with the laboratory learning.

Table 1: Descriptive statistics, means and standard deviations for students' perceptions of traditional, virtual mobile, and physical mobile laboratory by gender

Perceptual constructs	Male			Female			Overall
	Traditional	Virtual	Physical	Traditional	Virtual	Physical	
Experience	49.67 (6.16)	53.10 (6.12)	56.79 (2.83)	48.12 (5.82)	51.20 (4.55)	47.35 (5.34)	50.58 (5.97)
Impression	38.11 (4.17)	38.90 (3.81)	41.43 (2.90)	37.04 (4.69)	38.70 (4.33)	36.88 (4.03)	38.31 (4.30)

The finding from this result indicated that students' perceptions toward smartphone-based inquiry laboratory in chemistry depended on their gender. It implied that the gender difference had an influence on their perceptions. Moreover, it was found that males expressed more positive perception toward the smartphone laboratory environment compared to female.

3.2.2 Effect of the Three Different Laboratory Interventions on Students' Engagements

In order to investigate effect of students' learning engagements for the two experimental groups (virtual and physical mobile laboratory environment), Table 2 shows descriptive statistics, means, and standadard deviations on scientific confidence (SC), attitude to learning science with technology (ST), confidence with technology (TC), affective engagement (AE), and behavioral engagement (BE) dimension. The results of the one-way MANOVA indicated that there was no significant main effect for both gender (Wilks' lambda=.844, $F(2,56)=1.956$, $p=.100$, partial $\eta^2=.156$) and intervention (Wilks' lambda=.945, $F(2,56)=0.623$, $p=.683$, partial $\eta^2=.055$). Furthermore, there was also no significant difference for its interaction effect (Wilks' lambda=.935, $F(2,56)=0.740$, $p=.597$, partial $\eta^2=.065$).

Table 2: Descriptive statistics, means and standard deviations for students' learning engagement of traditional, virtual mobile, and physical mobile laboratory by gender

Engagement characteristic	Male		Female		Overall
	Virtual	Physical	Virtual	Physical	
Scientific confidence (SC)	17.70 (2.06)	18.00 (2.48)	17.40 (2.01)	15.53 (3.06)	17.07 (2.59)
Attitude to learning science with technology (ST)	18.40 (1.71)	18.07 (2.46)	17.90 (1.92)	16.76 (2.59)	17.70 (2.25)
Confidence with Technology (TC)	18.00 (1.49)	18.00 (2.39)	16.90 (2.53)	15.29 (3.18)	16.89 (2.74)

Engagement characteristic	Male		Female		Overall
	Virtual	Physical	Virtual	Physical	
Affective Engagement (AE)	18.30 (2.21)	17.79 (2.04)	18.00 (1.65)	16.65 (2.85)	17.62 (2.25)
Behavioral Engagement (BE)	18.60 (1.65)	17.71 (2.27)	17.35 (2.52)	15.94 (3.19)	17.25 (2.66)

According to the aforementioned results, the overall results suggested that the learning engagement of female and male students regarding scientific confidence, attitude to learning science with technology, confidence with technology, affective engagement, and behavioral engagement was homogeneous after participating in the three different laboratory interventions. This means there was no effect of gender difference on students' learning engagement based on the smartphone-based inquiry laboratory learning. This implied that both females and males can learn chemistry laboratory with smartphone-based inquiry laboratory environment.

6. Conclusions and Future Study

This study reported an impact of smartphone-based inquiry laboratory on high school students' perceptions toward the mobile laboratory and learning engagements. The finding showed that significant difference in students' perception was detected between females and males after their participating with different laboratory intervention, i.e. traditional lab, virtual smartphone-based lab, and physical smartphone-based lab. As such, the results suggested that gender disparity was found on their perceptions. However, the finding indicated that gender difference had no impact on students' learning engagements on the use of smartphone-based inquiry laboratory for solution concentration. According to the preliminary findings, the researchers will design an appropriate pedagogy regarding gender to promote high school students' learning performance in the next study. The three chemistry knowledge representations, including macroscopic, sub-microscopic and symbolic, will be used to create an emerging pedagogy for smartphone-based inquiry laboratory environment for chemistry teaching and learning.

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How do They Perceive Model-based Inquiry with Computer-simulated Science Experimentation?: A Case of Thai Middle School Students

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Abstract: Computer-simulated experimentation, which is a visualization technology in science education, can imitate dynamic systems of authentic objects for making scientific sense to teachers and learners. To enhance science learning, the computer-simulated experimentation has been recognized as an important digital tool in the instruction. In this study, 20 middle school students in Northeast region of Thailand were recruited to interact with a physical science lesson through model-based inquiry learning with computer-simulated experimentation of light refraction. After experiencing with the model-based inquiry with the computer-simulated experimentation, they were administered a 21 items of 5-points rating scale questionnaire to examine their perceptions toward such experimentation. The results showed that the highest percentage of their perception was perceive of satisfaction, enjoyment, perceive learning, perceive ease of use, perceive of usefulness, and flow, respectively. Moreover, ten students volunteered to interview with a series of perceptual open-ended question and the results indicated their positive perceptions on the model-based inquiry learning experience with the computer-simulated experimentation of light refraction. This implied that the use of the computer-simulated experimentation for the model-based inquiry learning could be considered as a value learning experience for promoting minds-on science learning of middle school students.

Keywords: Simulation, inquiry, modeling, physical science, experiment

1. Introduction

Physics is a branch of science that is difficult to understand. Due to the learning difficulty of physics concepts, the way in which a physics course is taught, and physics problems which are sometimes very vague students (Redish, 1994). Computer simulation, which is a visualization-based technology, can imitate dynamic systems of objects in a real supporting to the quality of making sense by vision. It has been used extensively as a visual representation tool to simplify dynamic theoretical models of real world phenomena or processes (Suits and Srisawasdi, 2013). When the computer simulation coupled with reform-based teaching practices, it has been an effective way to support student learning of science. The quality of the technology itself, as well as how it is used, impacts how much students learn. Interactive simulations are dynamic virtual environments that are used to provide implicit scaffolding and targeted feedback (Hensberry, Moore and Perkins, 2015). In recent years, research has been revealed that the computer simulation could be used for supporting science learning. However, many researchers suggested that the computer simulation is important pedagogical tool for motivating students and making relevant science leaning (Suits and Srisawasdi, 2013).

Moreover, the modeling that aims to make the practice accessible and meaningful for learners is specified as scientific modeling as including the elements of the practice. It has been developed increasingly in sophisticated views of the explanatory nature of models by shifting from correct or incorrect models to encompassing explanations for multiple aspects of a target phenomenon (Schwarz et al., 2009). However, this view is challenged by recent data showing that the computer simulation with model-based inquiry has not been studied yet. The question remains computer simulation with model-based inquiry promotes science learning.

Consequently, this study has been proposed a computer simulation with model-based inquiry approach implemented on the refraction light topic. Such that, in this study, we have attempted to provide a novel approach to promote science learning by using the computer simulation with model-based inquiry to help students increase science learning performance. Before having that implementation, this paper as the first-phase study aims to investigate students' perceptions toward the proposed computer simulation with model-based inquiry.

2. Literature Review

2.1 Computer Simulation

Computer simulation is new technologies have made rich and dynamic visual representations possible on common personal computers. Previously, the power of typical computers is available in schools severely limited by the range of computer-based educational experiences of students. Educational simulations of this prior era were often based on simple line drawings, and the degree of interactivity was usually limited to setting one or two parameters and then watching a resulting animation. Modern computational power allows much complex models, higher visual representations, and gives users of educational simulations with control and flexibility to make changes and see the effects in real time. With these advances, simulations can provide students with opportunities to rich and dynamic educational experiences as well as instantaneous feedback on the results of a virtual experiment. In particular, the activities engaging students with modern computer simulations differ from those in traditional educational environments. The computer simulation provides students by accessing to questions and methods of inquiry, which are well aligned with the ways scientists use experiments for exploration and discovery. Prior work has been shown that children could be engaged in productive inquiry and exploration along these lines with computer simulations (Podolefsky, Perkins and Adams, 2010). Computer simulation has been widely used to enhance teaching and learning for last decades and researchers mentioned that the use of computer simulation experimentation could actively engage and enhance student's meaningful learning in subject contents. Concurrent with the progressive development in science education community, contemporary technology-based approaches to science learning offers computer simulations with ample opportunities for students' inquiry-related learning environments in science (Srisawasdi and Panjaburee, 2015). Researchers indicated that the computer simulation could facilitate students by reducing alternative conceptions, and improving conceptual understanding of science concepts (Suits and Srisawasdi, 2013).

2.2 Model-based Inquiry Learning with Simulation

Modeling is a core practice in science and a central part of scientific literacy. Researchers presented theoretical and empirical motivation to a learning progression of scientific modeling that aims to make the practice accessible and meaningful for learners. The sciatic modeling was included the elements of the practice, such as constructing, using, evaluating, and revising sciatic models and the meta-knowledge that guides and motivates the practice, such as understanding the nature and purpose of models. The learning progression of scientific modeling included two dimensions that combine meta-knowledge and elements of practice scientific models as tools for predicting and explaining, and models change as understanding improves (Schwarz et al., 2009). Modeling Designs for Learning Science has been developing a learning progression to represent successively in sophisticated levels of engagement and knowledge of scientific modeling practices. It is to make the core scientific practice accessible and meaningful for learners in the upper elementary and middle grades. A scientific model is an abstract, simplified, representation of phenomena that makes central features explicit and visible. It can be used to generate explanations and predictions (Harrison and Treagust, 2000). Model-based inquiry is a core component of science and a central part of scientific literacy. It is critical to reform-based science education efforts that emphasize students' participation in scientific practices. The model-based inquiry is an instructional approach in which learners are engaged in scientific inquiry and are sked to focus on the creation, evaluation, and revision of scientific models that can be applied to explain and predict the natural world (Duschl, Schwingruber and Shouse, 2007).

Moreover, simulation-based learning environments are considered as appropriate learning tools for manifesting conditions of conceptual change in science learning (Chen et al. 2013). Inquiry-based learning with simulations is a promising area for science-based instruction to foster learners' mental interaction with the physical and social world in order to develop scientific understanding, explanation, and communication among science ideas. Researchers have found that simulation-based inquiry learning works as a remedial process by producing change in the alternative conceptions held by learners (Srisawasdi and Panjaburee, 2015).

3. Method

3.1 Participants

The 20 eighth-grade students in a local public school at the northeastern region of Thailand were recruited to participate in this study. They came from the same class and ages between 13-14 years old. They have informal experience with the use of computer simulation with model-based inquiry in classroom

3.2 Learning Material and Activity

The computer simulation was designed on refraction of light, named Bending Light, obtained from Physics Education Technology (PhET). Many physical situations of light wave refraction are unusually observed, and it makes discrepant events bothering human common senses. Therefore, the design of conceptual learning events on light refraction with computer simulation supports students with visualizations of the refraction of light phenomenon and helps them build more scientific views of light refraction concepts. It was implicated to content of lights properties. The simulation defines situation to student for the exploratory phase. The student was asked to interact with computer simulation. Figure 1 shows examples of computer simulation and Figure 2 presents overall learning activities through the computer simulation with model-based inquiry. Moreover, Figure 3 shows middle school students' mental model showing how the About the phenomenon of refraction of light.

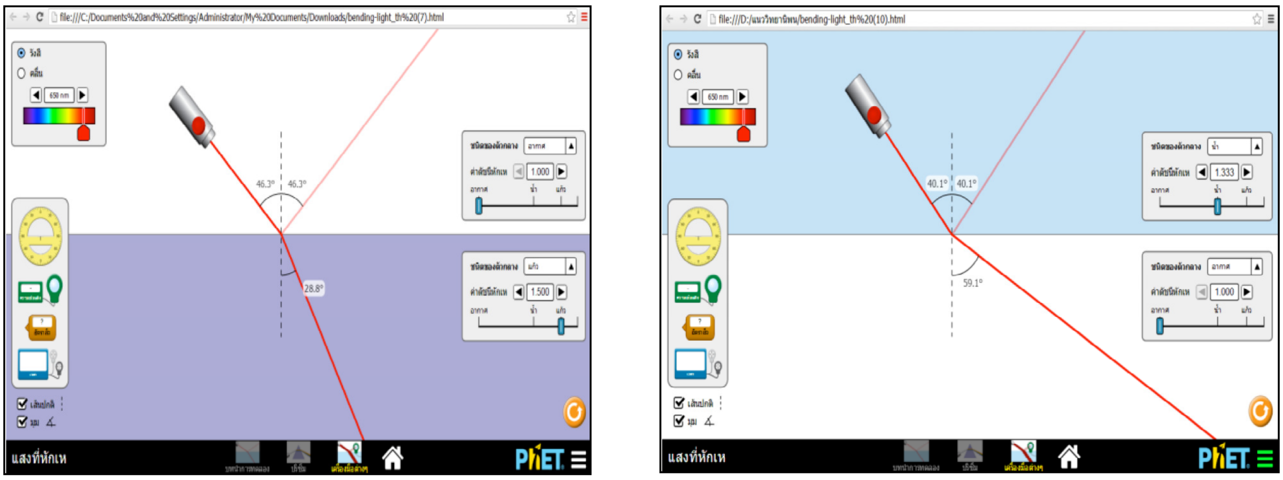


Figure1. Examples of computer simulation from Physics Education Technology (PhET) named Bending Light representing: boundary behavior of light refraction (left) and angle of refraction (right)

To enhance students' understanding of science concepts on refraction light, computer simulation obtained from PhET was utilized as visual aid of unobservable phenomena in the class. In an addition, the model based-inquiry strategy was used as an intervention for students' learning activities across light refraction concepts.

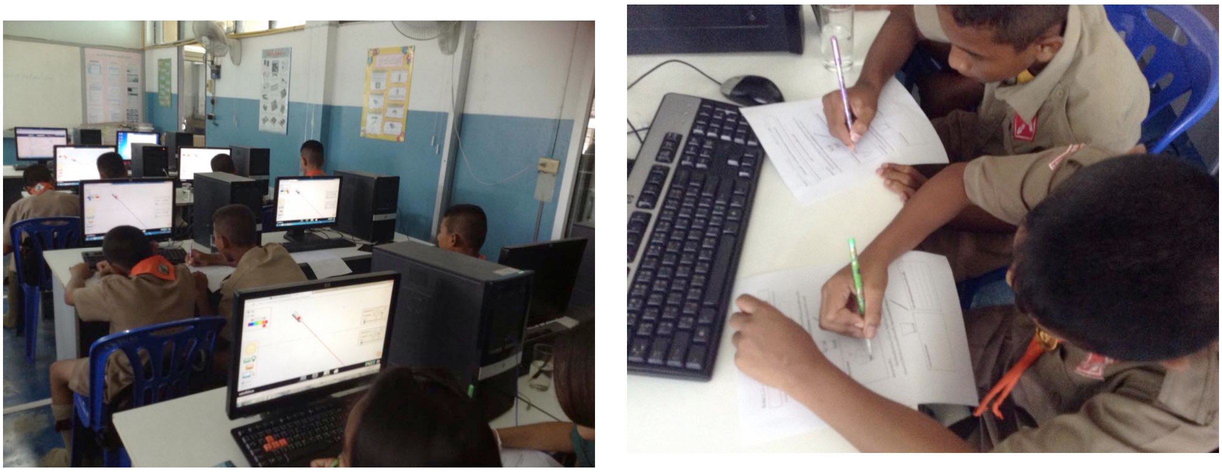
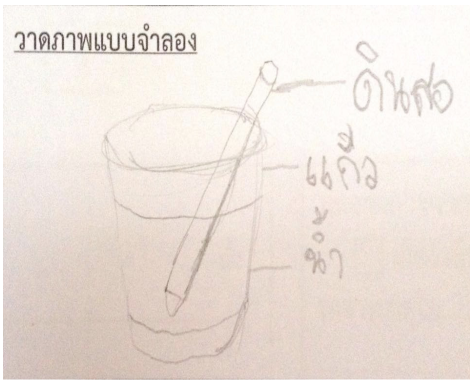
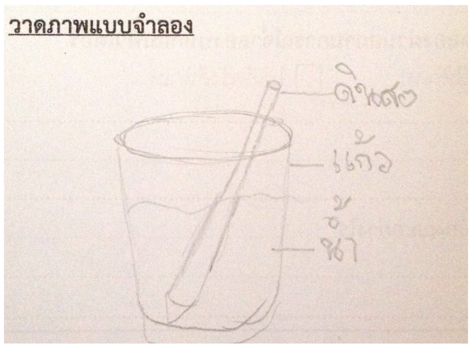


Figure2. Students' interaction with computer simulation (left) and their mental modelling within the model-based inquiry learning activity (right)

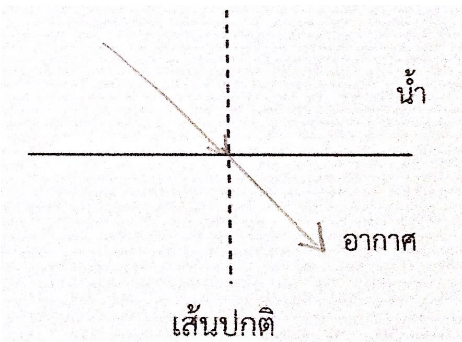
3.3 Research Instrument

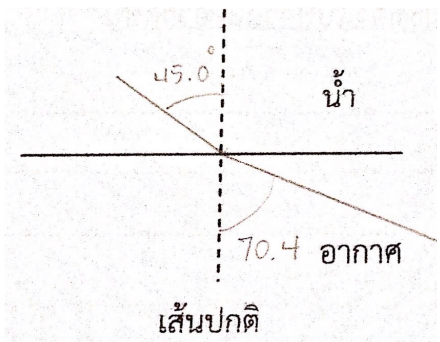
This study employed a questionnaire for exploring students' perceptions toward computer simulation with model-based inquiry about topic refraction. A 21-item perception questionnaire was used to collect data in this study. There are six components, such as perceive learning (PL) consisting of four items, flow of learning (FL) consisting of five items, enjoyment (E) consisting of three items, perceive ease of use (PEU) consisting of three items, perceive of usefulness (PU) consisting of three items, and perceive of satisfaction (PS) consisting of three items.





(a)





(c) (d)

Figure 3. Students' construction of mental model before (a and c) and after (b and d) interacting with simulation

3.4 Data Collection and Analysis

The participants consist of 20 8th grade students. The students interacted with computer simulation regarding model-based inquiry learning activity in 50 minutes. After finishing the learning activity, each student was asked to complete the perception questionnaire. The data was analyzed by mean, standard deviation, and percentage of students' perception scores.

4. Results and Discussion

To investigate the students' perceptions toward model-based inquiry with computer simulation, Figure 4 reports the percentage of their perception scores. The statistical analyses of the data suggest that there were some differences between the perception scores for each perceptual constructs.

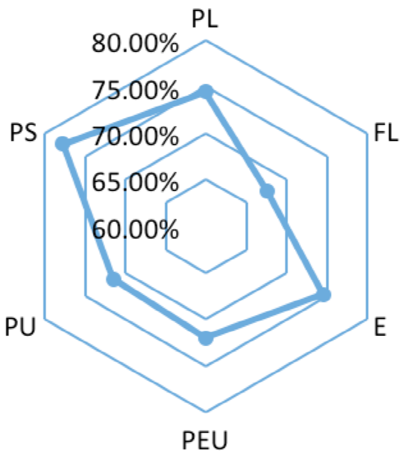
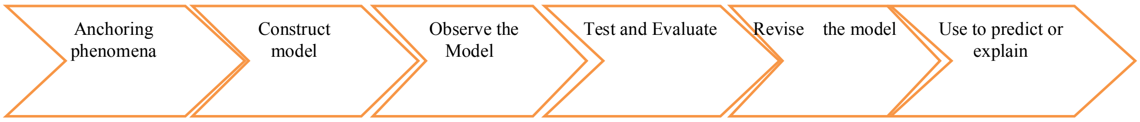


Figure 4. Mean difference in perceptual characteristics scores by attitude level

In a summative evaluation, the highest percent of PS is 77.67%, E is 74.67%, PL is 74.50%, PEU is 72.00%, PU is 71.33%, and FL is 67.60%, respectively. These pilot study reports students' perception scores toward the computer simulation with model-based inquiry. These results consistent with findings that the computer simulation could be used to promote students' physics learning experience in which the perception of student was increased. The computer simulation was digital technology to promote perceptions of students (Udomrat and Srisawasdi, 2015). That simulation could enhance students' perceptions. Moreover, it confirms with previous studies of Buyai and Srisawasdi (2014). The findings from previous studies never revealed the perceptions toward the computer simulation with model-based inquiry. However, researchers revealed the effect perceptions with technology (Dorji et.al, 2015). That is the finding from this study could confirm that the students' perceptions through learning material could improve their perceptions toward computer simulation with model-based inquiry.

5. The Design of Computer Simulation with Model-based Inquiry for Light Refraction

The computer simulation is able to promote learning science and is important pedagogical tool for motivating students in phenomena having dynamic visual and abstract as the refraction light. Students cannot see that the way of light is refracted and difficult to understand. The computer simulation could be used to solve this issue. Moreover, the model-based inquiry could be served as teaching method. That is teacher provides students strategy to make science accessible by empirical evidence that is observable phenomena and lead them to distinguish macroscopic explanation. The students are asked to further conducting an investigation of unobservable phenomena. When they gain knowledge by related concepts, they are asked to link three explanations together and result in knowledge integration for becoming the conceptual understanding, as shown in Figure 5



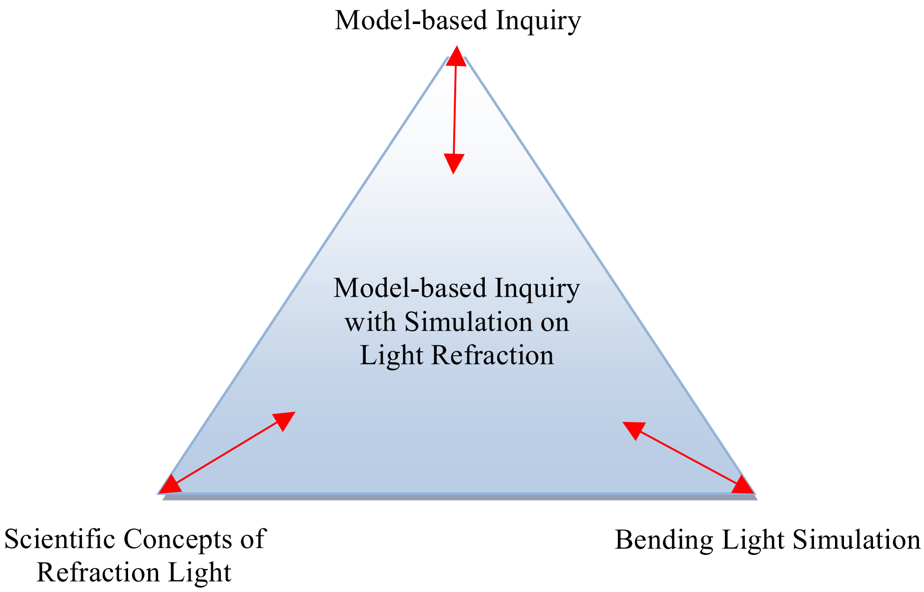
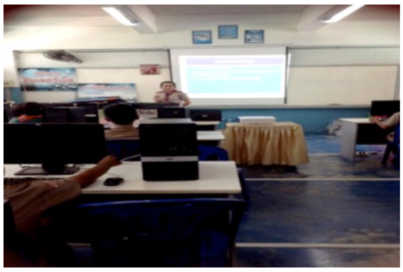


Figure 5. A conceptual model of model-based inquiry with simulation facilitated students' conceptual development in science

5.1 An Example of Model-based Inquiry with Simulation on Refraction of Light

In this part, the researchers use computer simulation with model-based inquiry to provide instruction. It could help students to visualize the material. After investing the phenomena, they are asked to discuss in class that is an important component of their understanding of the subject. In this method, the students are asked to predict the outcome of phenomena and drawing models of their prediction and use models, evaluate models, revise models to increase their explanatory and predictive power by taking into account additional evidence or aspects of a phenomenon from observing the situation with computer simulation as shown in Table 1.

Table 1: An example of learning process in computer simulation with model based inquiry

Components	*Description of learning process*	*Examples of learning activity*
1. Anchoring phenomena	Introduce driving questions and phenomena for a particular concept. Use a phenomenon that may necessitate using a model to figure it out.	
2. Construct model	Create an initial model expressing an idea or hypothesis. Discuss purpose and nature of models.	
3. Observe the model	Investigate the phenomena predicted and explained by the model	
4. Test and Evaluate	Return to the model and compare with empirical findings. Discuss qualities for evaluation and revision. Test the model against other theories, laws.	
5. Revise the model	Change the model to fit new evidence. Compare competing models, and construct a consensus model.	

Components	*Description of learning process*	*Examples of learning activity*
6. Use to predict or explain	Apply model to predict and explain other phenomena.	

6. Conclusion and Further Work

This study reported impacts of computer simulation on students' perceptions. The findings of students' perceptions towards learning of science with computer simulation clearly revealed increasing perceived learning, perceived ease of use, perceived usefulness, enjoyment, perceived satisfaction, and flow after interacting with the proposed learning environment in physics course. The results from this study could lead us to conclude that the learning environment combining with the educational computer simulation with model-based inquiry could be an alternative way for promoting science learning and students' perceptions in school science. In further study, the computer simulation with model-based inquiry will be used to enhance eleventh-grade students' conceptual understanding about properties of light including the reflection of light refraction of light and to promote students' scientific motivation. The participants will be students in the middle school level. The instruction will be designed based on knowledge integration framework by taking the questions before and after using computer simulation with model-based inquiry within class period. The pre-test, post-test and embedded questions will be analyzed and interpreted to answer whether computer simulation with model-based inquiry learning effect eight-grade students on conceptual understanding and knowledge integration of properties of light and on scientific motivation.

Acknowledgement

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Exploring Elementary School Students' Perceptions toward Simulation-based Mobile Learning based on Predict-Observe-Explain Approach

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Abstract: With a mobile device in hands, mobile learning serves to provide new learning opportunities to individuals and it fits with many learning environments, both in classroom setting and in informal learning environments. Recently, researchers have an interest in using mobile technologies and simulations to deliver more effective learning experience to students. This paper presents an exploration of elementary school students' perceptions toward simulation-based mobile learning based on predict-observe-explain (POE) instructional sequence in a physical science lesson of light refraction. A total of ten 4th grade students was recruited to participate in this study. They were administered with 21 items of 5-points Likert scale perception questionnaire regarding six perceptual constructs, i.e. perceived learning (PL), perceived ease of use (PEU), flow (FL), perceived usefulness (PU), enjoyment (E), and perceived satisfaction (PS), after interacting with the approach. The result indicated that there was some high degree of positive perceptions toward the approach, and the highest percentage of their perceptions were PU, E, PS, FL, PL, and PEU, respectively. Based on the finding, the simulation-based mobile learning based on POE approach will be redesigned for enhancing students' learning performance in the next study.

Keywords: Unobservable, Computer simulation, Mobile phone, POE strategy

1. Introduction

Recently, there has been wide interest in applications of mobile technology for teaching and learning. Mobile learning has been defined as learning facilitated by mobile devices such as mobile phones, tablet PCs, and personal media players (Herrington and Herrington, 2007; Valk, Rashid and Elder, 2010). In addition, mobile learning has become widespread as the development of mobile devices with advanced wireless communication technology has encouraged learning "on the move," using mobile devices in educational settings. Following this feature, it allows students to access learning content from various locations and times (Garcia-Cabot, de-Marcos and Garcia-Lopez, 2015; Hyman, Moser and Segala, 2014; Jones, Scanlon and Clough, 2013), and share learning contents with others (Woodill, 2011). As such, the learning with mobile devices could be used to deliver several contents in a manner of anywhere, anytime, and anyone learning.

According to the development of science education in 21st century, computers simulations have been recognized worldwide by educators and researchers as pedagogic tool for science teaching and learning. Computer simulations can make unobservable phenomena being visible representation and they could support students' conceptual development and their learning motivation (Srisawasdi et al, 2016). Several researchers indicated that computer animation and simulation can help student in reducing alternative- or misconceptions, and revising and improving conceptual understanding of scientific concepts (Srisawasdi and Kroothkeaw, 2014; Suits and Srisawasdi, 2013). Moreover, Suits and Srisawasdi (2013) mentioned that instructional computer simulation could support students' development of mental model through visualizing scientific phenomena both macroscopic, microscopic, and symbolic levels of chemistry representation. To extend the benefits of simulation for learning, the utilizing of mobile devices for delivering simulation could be an alternative way for engaging students in interacting with real-world modelling on screen. For science learning, mobile learning activities should support the active cognitive engagement of individuals by visualizing dynamic models of real-world components, phenomena, or processes at an unobservable level (Srisawasdi et al., 2016). Moreover, effective teaching strategy should be considered for successful learning and inquiry-oriented predict–observe–explain (POE) procedure is one strategy that could foster and enhance students' cognitive evolution by themselves.

POE learning approach has been recognized by educators and researchers for promoting students' science learning in classroom. The POE procedure was developed at the University of Pittsburgh, and it was used to induce students' conceptual change in science learning for many past decades (Champagne, Klopfer and Anderson, 1980). White and Gunstone (1992) have promoted the predict–observe–explain (POE) procedure as an efficient strategy for eliciting students' ideas and also promoting student discussion about their ideas. The POE procedure is based on the classic model of research where a hypothesis is stated and reasons are given for why this may be true, relevant data is gathered and results are discussed (White, 1988). It involves students predicting the result of a demonstration and discussing the reasons for their predictions; observing the demonstration and finally explaining any discrepancies between their predictions and observations. However, this view is challenge by recent data showing mobile and POE had not address in the use of simulation for mobile learning yet.

Consequently, in this paper, the researchers attempt to design and development simulation-based mobile learning approach with regarding POE sequence. This is a pilot study, which aims to investigate students' perceptions toward the simulation-based mobile learning approach with regarding POE in students learning of light refraction.

2. Literature Review

Computer Simulation

Computer simulations represent the real world by using a computer program, and rely heavily on visual representations of the phenomena they model. The simulations can be a valuable tool in today science classroom by exemplifying scientific concepts and situations to students, and allowing students to explore the nature of things. Currently, computer simulations are powerful tools which can make unobservable phenomena being visible representation and they could support students' conceptual learning performance in science. Regarding the use of computer simulations, learners can formulate hypotheses about the simulated environment and test these hypotheses by changing parameters in the simulation and observing the way in which the simulation responds to these changes (Lee, Plass and Homer, 2006). Concurrent with the progressive development in science education community, contemporary technology-based approaches to science learning offers computer simulations with ample opportunities for students' inquiry-related learning environments in science (Srisawasdi and Panjaburee, 2015). Researches indicated that computer simulations can facilitate student reducing alternative conceptions, and improving conceptual understanding of science concepts (Srisawasdi and Kroothkeaw, 2014; Srisawasdi and Sornkhatha, 2014).

Inquiry-based Learning with Predict-Observe-Explain *(*POE*)* Strategy

Inquiry-based learning is an important form of learning process in science-based education, as seen from the goals of the national science curriculum in many countries around the world. Currently, inquiry-based learning is one of fundamental pedagogy in science education focused on encouraging students to explore the world through investigative activity. Moreover, the inquiry pedagogy served as the benchmark in Thailand science education for the past decades (Srisawasdi, 2016). By the process of investigation and collection of scientific data, inquiry activities provide a valuable context for learners to acquire, clarify, and apply an understanding of science concepts (Edelson, Gordin and Pea, 1999). Regarding the inquiry-based instructional sequence, Predict-Observe-Explain (POE) strategy is a constructivist-oriented pedagogy that provides an important way to structure students' engagement in learning task, elicit and enhance their understanding of important scientific ideas, and promote discussion of students' science conceptions (Hong et al., 2014). Following the POE strategy, students were assigned to predict the outcome of a demonstration, committing themselves to a possible reason for their prediction, observing the demonstration, and finally explaining any discrepancies between their prediction and observation (Kearney and Treagust, 2001; Kearney, 2004). In the past decades, the POE strategy has been used for eliciting students' understanding (Kearney, 2004), determining students' alternative conceptions (Champagne, Klopher and Anderson, 1980), and promoting conceptual understanding (Tao and Gunstone, 1999). Due to the advancement of learning technologies, researchers reported that the incorporation of POE strategy into digital learning environment affected students' self-efficacy and perceived ease of use in biology learning activity (Nasaro and Srisawasdi, 2014). In addition, Srisawasdi et al. (2016) mentioned that students in the special designed ubiquitous learning outperformed others in development of scientific understanding about sound, and they have better inquiry learning performance. With the support of computer-simulated visualization, Chen et al. (2013) incorporates the POE strategy into a computer simulation learning environment to facilitate the change of alternative conceptions in science and they found that students could correct misconceptions effectively by constructing scenarios that conflict with existing knowledge structures, after interacting with the intervention. Moreover, Monaghan and Clement (1999) implemented collaborative POE activity using computer simulation to foster students' problem solving skills in physics and the results suggested that students used dynamic imagery in mental simulations during the intervention, and the POE strategy can facilitate student's appropriate mental simulations off-line in related physics problems.

3. Method

Study Participants

To conduct this pilot study, ten of 4th grade students, aged ranging 9-11 years old, in an elementary school at northeastern region of Thailand were recruited in this study. The participants never have formal science class on the topic of light refraction and any learning experience with computer simulation in science classroom before. This implied that their backgrounds had been heterogeneous before interacting with the simulation-based learning in this study.

Learning Materials and Activity

To implement the simulation-based mobile learning regarding POE approach in this study, a bending light simulation obtained from the Physics Education Technology (PhET) research group was used as an inquiry-supported tool for students. Figure 1 illustrates an example of the PhET bending light simulation used in this study.

Figure 1. Illustrative screens of bending light simulation from Physics Education Technology (PhET): the light travels through the same medium (left) and different mediums (right)

For the learning activity in this study, students were assigned to interact with simulation-based mobile learning regarding POE approach. In the lesson, the students used mobile phone for investigating the refraction of light, as display in Figure 2.

Figure 2. An illustration of the simulation-based inquiry learning activity in classroom: teacher introduced students how to use computer simulation (left) and allowed them to interact individually with computer simulation via mobile phone (right).

The Learning Experience of Simulation-based Inquiry Learning regarding POE approach

In this study, the researchers used mobile devices as a learning tool for simulation-based inquiry learning regarding POE approach. Figure 3 displays a conceptual framework for the simulation-based mobile learning experience.

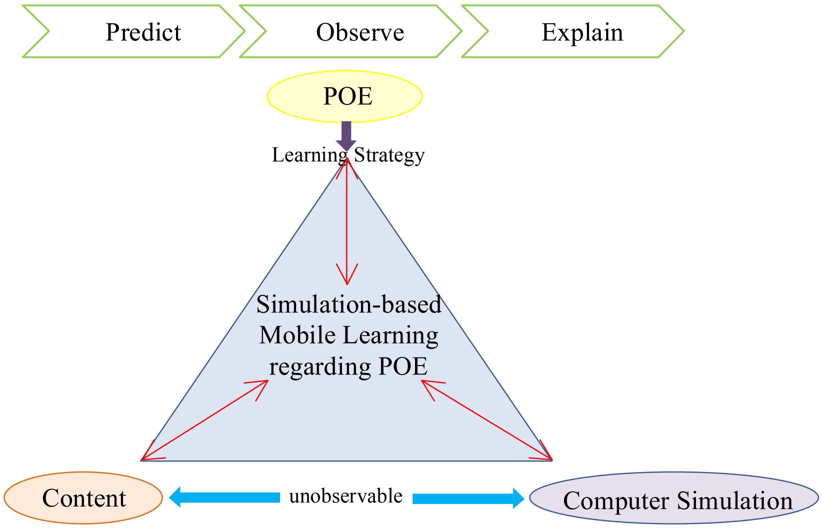
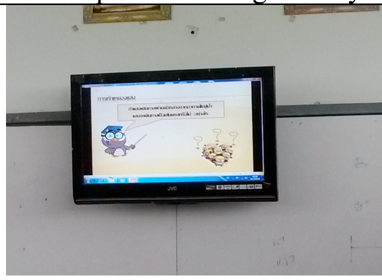
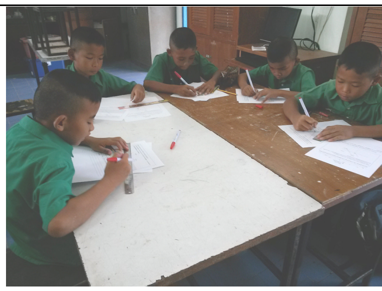
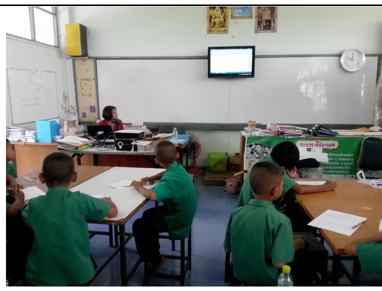


Figure 3. Feature of mobile learning with computer simulation through POE instructional sequence

To promote students' learning with interactive simulation on mobile device, the elementary students took a 2-hours lesson for interacting with the simulation through POE sequence. In this lesson, the teacher began with an introduction of the bending light simulation visualized via a projector. Then, they followed the learning activity as illustrated in Table 1.

Table 1 : An example of simulation-based mobile learning process regarded POE sequence

Sequence	Description of learning process	Example of learning activity
Prediction	Teacher provided relevant demonstrations about the phenomena of light refraction. The students were required to give some examples of the light refraction phenomena that happen in daily lives and then to discuss them with the whole class. After, teacher induced students to predict the result of a situation, based on their prior knowledge.	
	Teacher induced students to predict the result of a series of scientific situation, based on their prior knowledge: what would happen when light travel from air to air, air to water, and water to air. Then, they wrote their prediction on a worksheet individually with red ink pen.	
Observation	Teacher instructed students how to use mobile phone for accessing the PhET simulation and also engaged students to interact with the simulation via mobile device by themselves.	
	Teacher allowed students to conduct the light refraction experiments with PhET simulation, and they were assigned to write down evidence obtained from the simulation on their worksheet with blue ink pen.	
Explanation	Teacher engaged student to compare a similarity and/or difference on the prediction and observation. Teacher also engaged them to discuss on the similarity/difference. After, teacher encouraged students to explain another physical phenomenon based on the light refraction concept.	

Research Instrument and Data Analysis

In this study, 21-item Likert-scale perception questionnaire (Pinatuwong and Srisawasdi, 2014) has been used for examining students. The questionnaire was used to collect data of perceived learning (4 items), flow (5 items), enjoyment (3 items), perceive ease of use (3 items), perceive of usefulness (3 items), and perceive of satisfaction (3 items). The respondents were assigned to complete the questionnaire after interacting with the simulation-based inquiry learning. In this study, the researchers have analyzed and interpreted the respondents' answers into on each item, respondents were assigned to rate how much the respondent agree with into five scale form 1-strongly disagree to 5-stongly agree. In addition, after the learning activity in classroom, the researcher had interviewed students in order to explore their perceptual aspects of the simulation-based learning. To probe how much students can learn from the learning activity, a POE worksheet was used to measure their conceptual progression along the intervention and their learning performance base on the worksheet were evaluated with the maximum score of 10 points each activity. Figure 4 is an example of students' worksheet illustrated their learning performance.

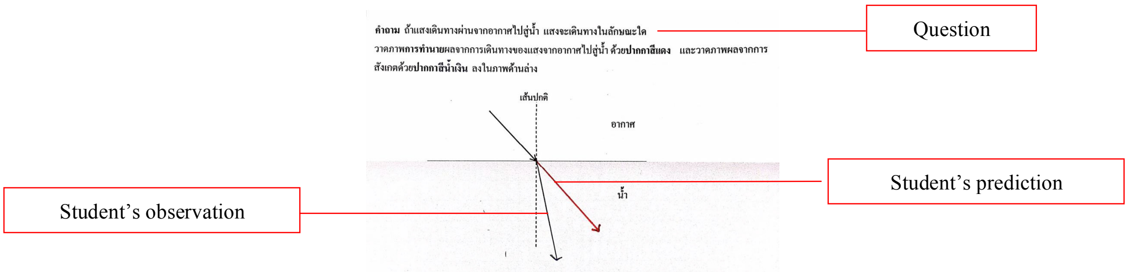


Figure 4. An example of POE worksheet used in this study and student's response

4. Result and Discussion

The results of this study is presented in Figure 5. There is the percentage of students' perceptions towards simulation-based mobile learning in science. Figure 5 shows the percentage of their perceptions on perceived learning (PL), flow (FL), enjoyment (E), perceived ease of use (PEU), perceive of usefulness (PU), and perceive of satisfaction (PS).

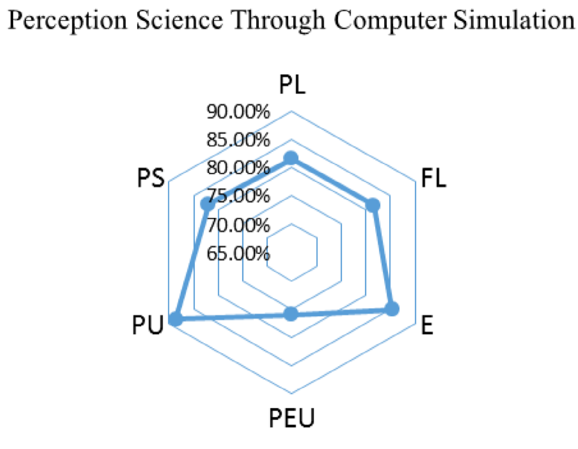


Figure 5. An illustration of elementary school students' perception scores

As seen in Figure 5, the highest score of students' perceptions were perceived usefulness (PU) (88.67%), enjoyment (E) (85.33%), perceived satisfaction (PS) (82.00%), flow (FL) (81.60%), perceived learning (PL) (81.50%), and perceived ease of use (PEU) (76.00%), respectively. The results implied that elementary school students relatively have positive perceptions toward the simulation-based mobile learning on refraction of light. This result is consistent with the research findings that students positively perceived benefits of simulation-based learning and they performed better achievements with learning from computer simulation (Buyai and Srisawasdi, 2014; Kaeosueptrakul and Srisawasdi, 2015; Pinatuwong and Srisawasdi, 2014; Udomrat and Srisawasdi, 2015).

5. Further Study

According to the result of this study, the researchers have a plan to conduct a further study for investigating elementary school students' conceptual understanding, scientific explanation performance, and their science motivation. In the next study, the POE sequence was implemented in a series for probing and fostering students' conceptual understanding about light refraction and for increasing the students' motivations to learn science by participating in the simulation-based mobile learning process. Particularly, the reconciling of any conflict between their predictions and observations was focused as the key for probing the students' scientific understanding of light refraction through the POE learning activities. The design of the simulation-based mobile learning activities through POE strategy consisted of four learning targets and a weekly learning target, including reflection of light, refraction of light, spectrum of light, and the visible light. A brief explanation of a series of POE-based mobile inquiry learning activities is displayed in Figure 6.

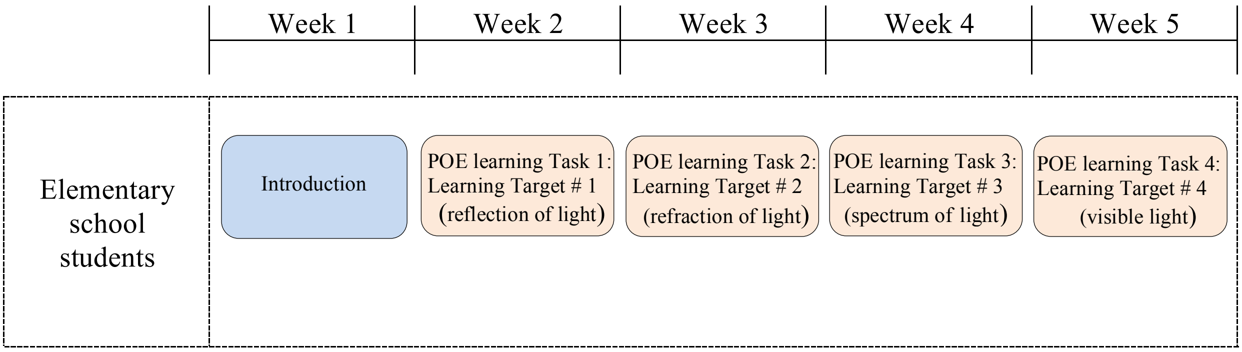


Figure 6. A series of POE-based mobile learning with computer simulation for the next study

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Exploring Preservice Teachers' Perception of Simulation-based Learning in Physics Education: A Preliminary Study of Lao People's Democratic Republic

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Abstract: With the importance of understanding physics concepts of sound wave and learning physics perception and of preservice teacher education in preparing student teachers before they have undertaken teaching the concept, it would be better to know the status of their conceptual understanding of the topic and their learning physics perception. Consequently, there are two phases in this study as follows: (1) investing understanding of the topic and perception after learning in the conventional learning activities by using conceptual understanding test and questionnaire, respectively; and (2) exploring understanding of the topic during learning in the proposed computer simulation-based inquiry learning and the perception toward the proposed learning. The results from the 3rd year student teachers from Teachers College in Dongkhamxang, Lao PDR, showed that most of the preservice physics teachers held misunderstanding of sound, such as reflection, refraction, interference, and speed of sound in the different mediums and temperature. Moreover, all of them held misunderstanding of sound diffraction concept. Interestingly, after finishing in the proposed computer simulation-based inquiry learning, they reflected that the highest score relied on enjoyment, perceived of usefulness, perceived learning, perceived satisfaction, perceived ease of use, and flow, respectively. It leads to rethinking of pedagogy used for teaching physics of sound wave in order to improving the preservice physics teachers' conceptual understanding and fostering their perception in Laos.

Keywords: Teacher education, preservice, perception, physics education, sound wave.

1. Introduction

In the past decade, several researchers revealed that many students had difficulty in learning science course due to their misconceptions in several science contents, especially properties of sound wave (Pirakra and Srisawasdi, 2014; Singh, Singh, Kumari and Kumar, 2011; Lee, Hairston, Thames, Lawrence and Herron, 2002). By the nature of content, the properties of sound wave involve reflection, interference, reflection, diffraction, and propagation of sound wave. Meanwhile, sound wave interference is invisible, complicated, and boring content (Piraksa and Srisawasdi, 2014). Transforming ideas and correcting defects of students' knowledge in physics is beyond the reach of the traditional teaching approaches. Because they tend to ignore the possibility that the perception of students is possibly different much than that of the teacher (Jimoyiannis and Komis, 2001). Computer simulation, therefore, serves as an educational tool for science learning activities, especially, in activity-based scientific inquiry and in conceptual development in physics sound wave (Srisawasdi and Kroothkeaw, 2014).

In learning physics, there are several scientific activities, which cannot be conducted using real laboratory experiments in a classroom setting. Because the experiment is either impossible to conduct, too dangerous, too complex or take too long. In contrast, where there is limited classroom time, computer simulation plays an important role in the physics classroom by providing students opportunity to study different kinds of scientific phenomena in a variety of circumstances (Srisawasdi and Kroothkeaw, 2014; Jimoyiannis and Komis, 2001; La Velle, McFarlane and Brawn, 2003). More importantly, the computer simulations offer an easy way of controlling experimental variables, opening up the possibility of exploration and hypothesizing. An additional advantage of simulations is presenting a variety of representational formats including diagrams, graphics, animations, sound and video that can facilitate understanding (Blake and Scanlon, 2007). Normally, teachers' teaching in a regular classroom can encourage students to succeed in school and unable to motivation to learn as interact in complex ways to lead learning (Schunk, 2005). Several researchers revealed that such teaching approach might depress motivation of students and decrease students' learning performance science (Hamzah and Mdzain, 2010). Recently, although, most researchers have been concentrated on the scientific conceptions. However, the issues of motivation to learn science has been becoming in respect of science achievement and scientific conceptions (Glynn et al., 2011). It is difficult to achieve this ultimate goal because many learners are treated with less motivation to learn science (Pirakra and Srisawasdi, 2014). In the meantime, the teaching of physics student teachers in Laos has been not currently satisfied to potential learning. The teaching method most provides the textbook by taking the form of lectures; the student teachers just read notes of explanation, memorization, and do exercises based on the teacher as narrator.

As mentioned above, the concept of sound wave is a basic and yet important one in physics education. The student teachers are need to prepare acquiring the scientific concept properly in order to understand the advanced concepts in the future. Possible misunderstanding about sound wave, therefore, must be identified and remedied (Srisawasdi and Kroothkeaw, 2014). The computer simulation might provide them opportunity to visualize the refraction of light when it passes from a fast medium to a slow medium, bending the light rays toward the boundary between the two medium, in order to confront their misunderstanding. However, computer simulation alone was not enough to promote students' understanding (Srisawasdi, 2012). It is needed to incorporate with an effective learning process. Consequently, this study has proposed simulation-based inquiry for learning sound wave of physics. In this vein, this paper aims to separate into two folds as follows: (1) investigating the status of understanding of the topic and perception toward the conventional teaching method; and (2) exploring understanding of the topic during learning in the proposed teaching method and perception toward the method.

2. Relevant Research

According to the rapid growth of computers and technologies in the practice and progression of physics education community, computer simulation offers students to learning physics through inquiry-based process (Rutten, 2012; Srisawasdi and Panjaburee, 2015; Vreman-de Olde, 2013; Kaeosueptrakul and Srisawasdi, 2015). Simulation is a computer-based visualization technology, which can imitate dynamic systems of objects in a real supporting to the quality of making sense by vision. Computer simulation has been used extensively as a visual representation tool to simplify dynamic theoretical models of real world phenomena or processes. It works with remedial by producing change to student's misconceptions (Bell, and Trundle, 2008). Computer simulation also improves scientific process skills and the performance of gaining more qualitative knowledge more coherent understanding of the concepts and more advanced mental model. Conclusively, the computer simulation is mentioned widely that it could be used to facilitate the construction of mental model and the development of conceptual understanding (Suits and Srisawasdi, 2013).

To address conceptual learning problems in physics outlined in the previous section, the simulation-based inquiry learning has been becoming a pedagogical approach for enhancing students' conceptual learning and development in school science (Srisawasdi and Kroothkeaw 2014; Srisawasdi and Sornkhatha, 2014). Researchers found that simulation-based inquiry learning worked with remedial by producing change to the alternative conceptions held by learners, improving the performance of gaining intuitive domain knowledge, promoting more qualitative knowledge than formalized knowledge, and achieving a more theoretical focus and coherent understanding of the concepts (Srisawasdi and Panjaburee, 2015).

3. Methods

Participants

The 3rd year student teachers from Teachers College in Dongkhamxang, Lao People's Democratic Republic were recruited to participate in this study. There were two phases of this study. The first and the second phase were conducted in the first semester and in the second semester, respectively, in 2015 academic year. There were 33 and 30 student teachers participating in the first phase and the second phase, respectively. In the first phase, the student teachers participated in the conventional learning activities of the sound wave topic. After that, they were asked to take a conceptual understanding physics of sound wave test in 20 minutes followed by the motivation questionnaire about physics learning. While, in the second phase, the student teachers participated in the proposed simulation-based inquiry learning. During learning, they were asked to reflect their understanding of the topic in the activity sheet. After fishing the learning activities, they were asked to response the perception questionnaire toward the simulation-based inquiry learning.

Research Instruments

In this study, there are two research instruments as measuring tools of conceptual understanding and perception. The first tool is a conceptual test involving conception of physics learning in pitch of sound wave. The test is designed basing on the four-choice question to measure the ability of understanding on the topic. Totally, it consists of 12 test items covering the concepts of pitch of sound wave. Each question requires the student teachers to clarify and provide the reasons for their understanding. The second tool is a questionnaire. It is 5-points Likert-scale questionnaire to investigate the student teachers' perception. Totally, it consists of 21 items covering Perceived learning (PL) (4 items), Flow (EL) (5 items), Enjoyment (E) (3 items), Perceived ease of use (PEU) (3 items), Perceived usefulness (PU) (3 items), and Perceived satisfaction (PS) (3 items) aspects. The questionnaire was obtained from Chang's (2014) and Barzilai and Blau's (2004) studies. We translated the questionnaire from English version to an identical version in Thai; one expert was recruited to identify communication validity of the items. The student teachers were required to consider each possible reason for simulation-based inquiry learning how much they agree with into five scale (1-strongly disagree; 2-disagree; 3-neutral; 4-agree; 5- strongly agree). The reliability for the overall questionnaire was 0.88.

The Design of Simulation-based Inquiry Learning for Sound Wave

With the benefits of computer simulation in being able to promote learning science and motivate the student teachers in phenomena having dynamic visual and abstract as the sound wave. The student teachers cannot see that the way of sound wave, which is difficult to understand. The computer simulation could be used to solve this issue. Moreover, the inquiry-based learning approach could be served as teaching method. It could provide student teachers strategy to make science accessible by empirical evidence that is observable phenomena. The students are asked to further conducting an investigation of unobservable phenomena. When they gain knowledge by related concepts, they are asked to link three explanations together and result in knowledge construction for becoming the conceptual understanding, as shown in Figure 1.

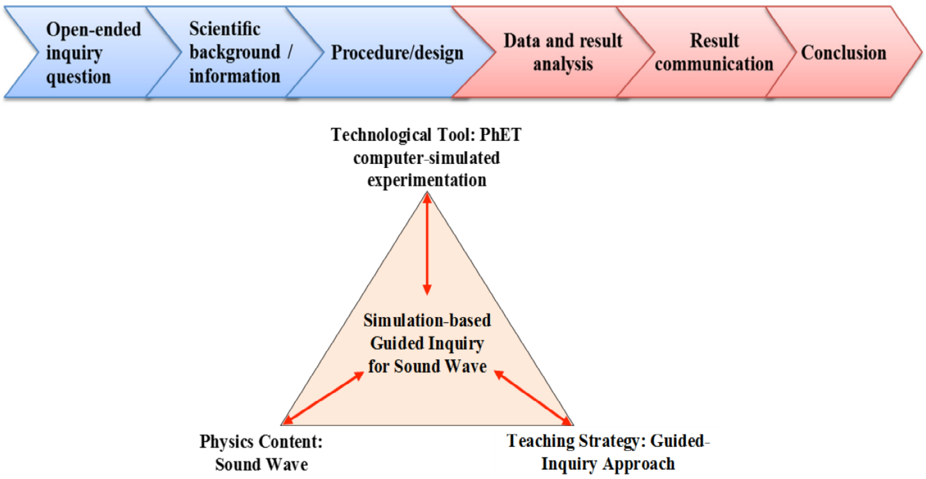

Figure 1. Computer Simulation-based Inquiry

According to Buck, Bretz and Towns (2008)'s idea, the learning process of inquiry-based physics learning with computer simulation could possibly be proposed in a combination of inquiry components and computer-based inquiry activities, in order to creating a unique learning environments of inquiry learning with computer simulation technology in this study as depicted in Table 1.

Table 1: Components of simulation-based inquiry for sound wave

Components of simulation-based guided-inquiry learning		Description of learning process	Example of learning activity
Pre-lab	Open-ended inquiry question	Teachers brought into the lesson by asking students how sound wave caused by anything.	
	Information	The teacher explained the process conducted by the computer simulation of the sound wave.	
Laboratory	Procedure/design	Students design their own scientific experiments and then interact with sound simulation for collecting the experimental data.	
	Data and result analysis	Students group analyzed data gathered in groups to create their own conclusions from the data.	

Components of simulation-based guided-inquiry learning		Description of learning process	Example of learning activity
Post-lab	Result communication	Student representatives of each group to present findings to the class.	
	Conclusion	Students share the results of experiments using computer simulations.	

4. Results

4.1 Phase 1: Results of Understanding and Motivation to Learn in Conventional Teaching Method

This phase was conducted in the first semester in 2015 academic year. There were 33 student teachers participating in this phase. The student teachers participated in the conventional learning activities (lecture with reading, writing, and memorizing) of the sound wave topic. After that, they were measured whether they had understanding or misunderstanding of sound wave by using the conceptual test, followed by the motivation questionnaire about physics learning. The results of conceptual understanding and motivation to learning physics were shown as following sections.

4.1.1 Conceptual Understanding of Sound Wave

The results from the conceptual test covering six concepts of sound wave including Reflection, Diffraction, Refraction, Interference, Speed of sound in the different medium, and Speed of sound at the different temperature show that all of the student teachers had misunderstanding of the Diffraction concept (100%). Most of them had scientific understanding of Speed of sound at the different temperatures concept (31.82%), as shown in Table 2 and Figure 2.

Table 2: Percentage of the student teachers' conceptual understanding scores of sound wave

Concept	Scientific understanding	Misunderstanding
C1: Reflection	13.64%	86.36%
C2: Diffraction	0%	100%
C3: Refraction	9.09%	90.91%
C4: Interference	15.15%	84.85%
C5: Speed of sound in the different medium	6.06%	93.94%
C6: Speed of sound at the different temperatures	31.82%	68.18%

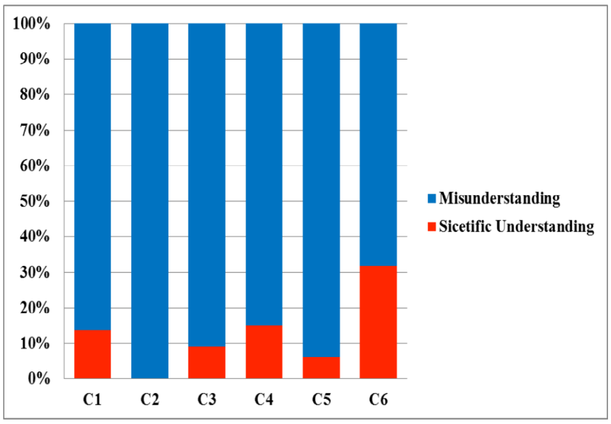

Figure 2. An illustration of percentage of student teachers' conceptual understanding scores of sound wave

4.1.2 Physics Motivation

When analyzing the motivation to learn physics, we found that the student teachers were motivated to learn physics at low levels in Intrinsic Motivation, Career Motivation, Self-efficacy, Self-determination, and Grade Motivation as shown in Table 3 and Figure 3. It implies that the teaching and learning based on the teacher-centered could not motivate the student teachers to learning physics course.

Table 3: Percentage of the student teachers' physics motivation scores

Motivation toward physics learning	Average
Intrinsic Motivation (IM)	20.06
Career Motivation (CM)	19.55
Self-efficacy (SEC)	17.03
Self-determination (SDT)	14.88
Grade Motivation (GM)	18.06

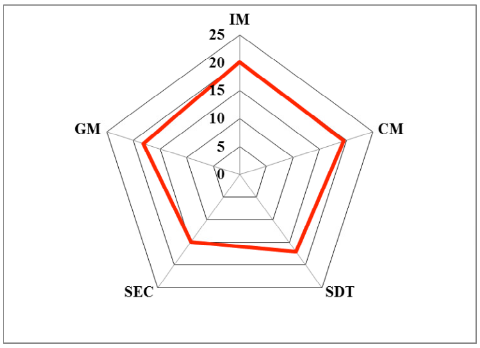

Figure 3. An illustration of the student teachers' physics motivation scores

4.2 Phase 2: Results of Understanding and Motivation to Learn in Simulation-based Inquiry Learning

This phase was conducted in the second semester in 2015 academic year. There were 30 student teachers participating in this phase. The student teachers participated in the simulation-based inquiry of the sound wave topic. After that, they were asked to reflect concept of sound wave by using the activity sheet during participating in the simulation-based inquiry, followed by the motivation questionnaire about the learning. The results of conceptual understanding and motivation to learning physics were shown as following sections.

4.2.1 Conceptual Understanding of sound wave during the computer simulation

For exploring student teachers' understanding about sound wave through the computer simulation, six of them were asked to draw a picture concerning wave. We found that 76.11% of them could draw pictures of waves during learning with the simulation-based inquiry learning as shown in Figure 4.

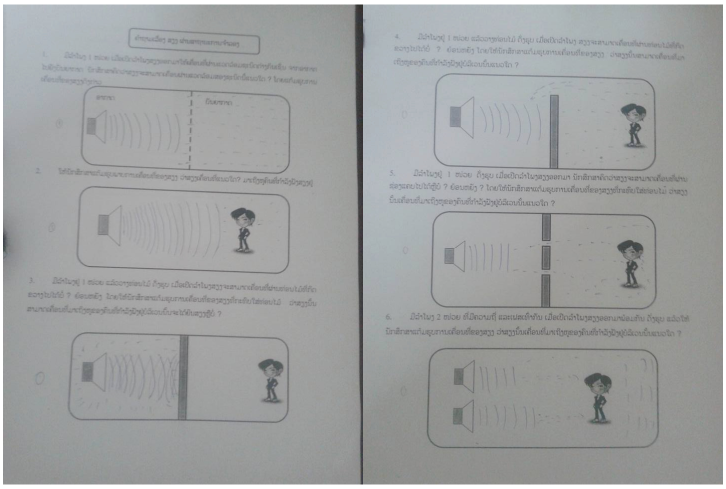

Figure 4. An example of student teachers' conceptual understanding of sound wave

4.2.2 Perceptions towards learning science through the simulation-based inquiry learning

Table 4 and Figure 5 shows that the student teachers reflected the highest score on Enjoyment, Perceived of usefulness, Perceived learning, Perceived satisfaction, Perceived ease of use, and Flow, respectively.

Table 4: Percentage of the student teachers' perception scores

Dimension	Sample items	Percentage
Perceived learning (PL)	- The simulation added to my knowledge. - I learned new things from the simulation. - The simulation will help me remember the things I learned. - I have learned so much from the simulation on a computer. -	85.17%
Flow (FL)	- I lost track of time when I played. - I really got into the simulation. - Playing the simulation was pleasant. - I fully concentrated on learning science through hands on computer simulation. - Learn through scientific scenarios on the computer. I cannot think of anything else that is not related at all.	82.93%
Enjoyment (E)	- I enjoyed the simulation. - I had fun playing the game. - Playing the simulation was pleasant. -	89.33%
Perceived ease of use (PEU)	- It is easy for me to learn how to use simulation. - The user interface of simulation is easy to use. - I can easily accomplish what I need to do in simulation. -	84.22%

Dimension	Sample items	Percentage
Perceived of usefulness (PU)	- Simulation can help me learn more effectively. - Simulation can improve my course performance. - It is useful to study the course content with simulation. -	87.33%
Perceived satisfaction (PS)	- I feel comfortable to use simulation. - I enjoy the experience of using simulation. - I am willing to continue using simulation for learning in other courses.	84.89%

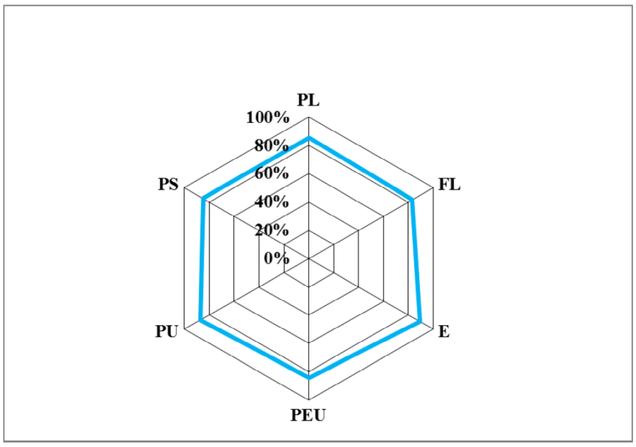

Figure 5. An illustration of the student teachers' perception scores

5. Conclusion and Future Work

The results from two phases in this study clearly revealed that the conventional teaching method, such as lecture with reading, writing, and memorizing of the sound wave topic, led student teachers held misconception of the topic and less motivation to learning the topic. Interestingly, the proposed simulation-based inquiry learning, such as using open-ended questioning, providing science basic knowledge about sound wave, asking them to inquire sound wave phenomena from the computer simulation, collecting evidence from the phenomena, discussing the evidence, and constructing their own knowledge, could promote their conceptual understanding reflected by drawing of the wave in the activity sheet. Moreover, the student teachers shoed positive perceptions toward the simulation-based inquiry learning. Because this learning environment provide student teachers opportunity to visualize the sound wave phenomenon and to help them view properties of sound wave and speed of sound wave concepts. These finding lead us to carefully rethinking of planning using the computer simulation with an effective pedagogy as inquiry-based learning in Laos's classroom of physics for preservice teachers. The success of further implementation plays an important role in enhancing preservice teachers understanding physics concepts and encouraging them to learn.

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Course Knowledge Assessment Tool Using Python

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Abstract: For teaching faculty, the current trend is to use revised blooms' taxonomy for setting question papers. It's beneficial for both students and faculty on equal levels. For students, a fair assessment is facilitated, whereas for the teachers it's helpful in detailed testing. Different levels of knowledge can be assessed using the verbs of blooms' taxonomy which is used while framing the questions. The tool is designed using Python script. It works on the concept of accepting the students' marks, maximum marks and the revised blooms' taxonomy level for each question. All of these elements are entered as an input, in the form of an excel sheet. The tool processes these values and provides the best skill level as an output. This value is then used to assess a particular student's knowledge level for a particular question, on the basis of overall performance.

Keywords: Computing methodologies, Knowledge representation and reasoning, tool using python

1. Introduction

For educationalist, revised blooms' taxonomy helps in classifying the thinking. It specifies 6 cognitive levels of complexity which helps in writing and revising the course objectives, planning curriculum, and identifying the different skills of knowledge. Revised blooms' taxonomy helps in aligning the assessment techniques. It incorporates different knowledge dimensions and the cognitive process to learn. It facilitates better assessment of the students. The Six categories in revised blooms taxonomy are create, evaluate, analyze, apply, understand and remember. Taxonomy reflects various forms of thinking verbs which describes actions. Blooms' taxonomy is an authentic tool to plan curriculum, instructional delivery and assessment methods. It can be easily applied to any level of education (Weili, Klotzkin, Myers, Wagoner, White, 2015) (Chung, Khor, 2015) (Llamas, Mikic, 2014) (Qinran , Fangxing, Chien, 2015).

The different levels that help assess different dimension of knowledge assessment are as follows:

ANALYSING KNOWLEDGE LEVEL: The knowledge retention level is assessed based on how students recall, restate and remember learned information.

UNDERSTANDING KNOWLEDGE LEVEL: Faculty can test how well the students have grasped the meaning of information based on their interpretation and translation of knowledge.

APPLYING KNOWLEDGE LEVEL: Their practical knowledge can be judged based on how students use the learnt information in a different, yet applicable context.

ANALYSING KNOWLEDGE LEVEL: Faculty can assess the students' capability of breaking down the learned information into parts of best understandable information.

EVALUATION KNOWLEDGE LEVEL: Faculty can assess the decision making capability of the students based on in-depth reflection, criticism and assessment.

CREATING KNOWLEDGE LEVEL: Faculty can assess the creative instincts and ability to leverage the knowledge, in order to form new ideas.

In this paper, authors describe the tool they have developed to assess the knowledge level of students based on their performance in the internal assessment of a course(Liisa , Taina , 2015) (Sousa, Antao, Germano, 2013) (Edmundo, 2013) .

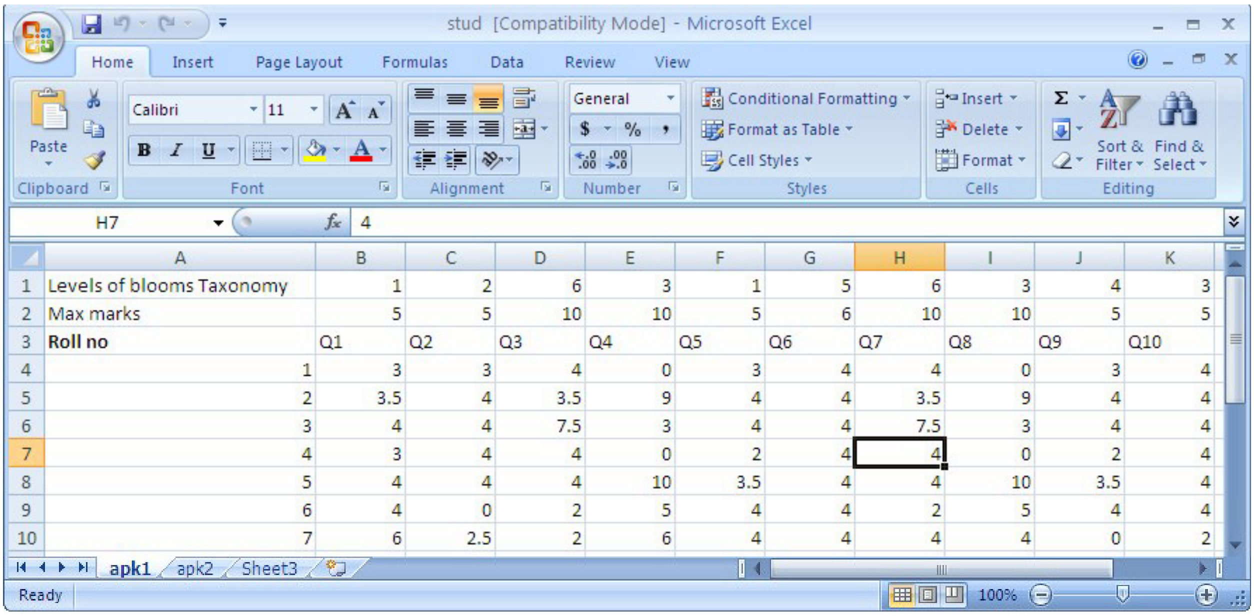
2. Related work

There are plenty of software tools available to analyze outcome based education. There are software tools which help the educationalist to manage learning, content and improvement analysis. The OBE software tools provide different roles such as content delivery, measuring outcome attainment level and OBE analysis. These OBE software tools include eLumen, canvas, Waypoint outcomes, moodle, desire2learn and Livetext.

eLumen focuses on comprehensive assessment, analytics and report the outcome analysis. Canvas is a web based open source OBE tool which helps to manage learning. Moodle is an open source tool which helps to manage content in educational environments. Waypoint outcomes is a tool which helps in assessment and reporting student performance. Desire2learn is a software tool which is helpful in content management and helps in improving the program. Livetext is a tool which helps in program improvement by different strategic planning (Hugh, Gillian, 2013) (Phillip, Wan, 2014) (Zeng, Zhang, Huang, Dong, 2014).

3. Methodology to Identify students' knowledge level Data Collection

The authors have designed a tool using python programming language. The tool accepts an excel file which collates students' performance details in terms of marks. The marks of students in each question is gathered in the excel file. The maximum marks for each question is specified along with the blooms' taxonomy level. This excel file is provided as an input to the tool. The tool processes the input and finds out the knowledge level and excellence of each student (Robert, 2015) (Raman, Achuthan, Nedungadi, Diwakar, Bose, 2014).



	A	B	C	D	E	F	G	H	I	J	K
1	Levels of blooms Taxonomy	1	2	6	3	1	5	6	3	4	3
2	Max marks	5	5	10	10	5	6	10	10	5	5
3	**Roll no**	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
4	1	3	3	4	0	3	4	4	0	3	4
5	2	3.5	4	3.5	9	4	4	3.5	9	4	4
6	3	4	4	7.5	3	4	4	7.5	3	4	4
7	4	3	4	4	0	2	4	4	0	2	4
8	5	4	4	4	10	3.5	4	4	10	3.5	4
9	6	4	0	2	5	4	4	2	5	4	4
10	7	6	2.5	2	6	4	4	4	4	0	2

Figure 1. Students' performance in excel file

This will serve as a tangible output for the faculty. This parameter of a student's excellence and knowledge level will assist the faculty in forming groups for subsequent study activities. Such group activities will ensure collaborative work amongst students of comparable skill set. Each group will have students excelling in creative, analytical, application, recollecting, understanding and evaluation. In this manner, the outcome of each group in active learning will be better compared to groups formed randomly.In Figure 1. Student performance details are shown. The excel file should have the blooms taxonomy for each question in the first row. In the second row, the maximum marks for each question has to be entered. In the remaining rows, students' marks need to be entered

(Samuel , Christian , Richard , 2014))(Hemingway, Angell, Hartwell, Richard, 2011) (Ching, Gwo, Chien, Chih, 2012) (Ros, Rodriguez, Diaz , 2014).

4. Algorithm to find best knowledge level of student

1. Read each row from the excel file
2. Then count how many questions are from each blooms taxonomy level and maintain in tot_tax[ ] array.
3. Blooms' Taxonomy level for each question is stored in tax[ ] array.
4. Then read the maximum marks for each question, store it in max[ ] array
5. For each student perform the following
    a. Initialize skills[ ] array to zero.
    b. Read marks scored by student in each question one by one from each column
    c. Do the following for each mark from a cell in excel sheet of row rx and column cx
        i. Check among the 6 revised blooms taxonomy, which taxonomy the question belong to. i is the blooms level, where 1≤i≤6
            1. Find out the percentage of mark scored in each question as following and add it to the skills[i] skills[i]=skills[i]+mark *100/max[cx]
    d. After calculating skills of each student based on marks scored in each question, find out the average skill of student in each knowledge level as following.
        i. For each revised blooms level, k from 1 to 6 do the following for each student:
            1. Skills[k]=skills[k]/total_tax[k] ii. To identify best_skill of each student, do the following:
        iii. Initialize top_percentage as 0.
            1. For each blooms level k from 1 to 6, do the following for each student:
    a. If top_percentage<=skills[k]
                i. Top_percentage=skills[k]
                ii. Best_skill=k
    e. Display/store the students best skill identified as the following:
        i. If best_Skill==1 ,then student is good in remembering skill
        ii. If best_skill==2 , then student is good in understanding skill
        iii. If best_skill==3, then student is good in applying skill iv. If best_skill==4, then student is good in analyzing skill
        v. If best_skill==5 then student is good in evaluating skill
        vi. If best_skill==6, then student is good in creative skill

5. Discussion and Results

In Figure 1, students' performance in each question is shown. Questions 1 and 5 are mapped to blooms taxonomy level 1. Question 2 is mapped to blooms level 2. Questions 4, 8 and 10 are mapped to blooms level 3. Question 9 is mapped to blooms level 4. Question 6 is mapped to blooms level 5 Questions 3 and 7 are mapped to blooms taxonomy level 6. As per the algorithm given in this paper, first the total number of questions mapped for each blooms taxonomy level will be calculated. There are two mapped to blooms level 1, one question mapped to level 2, three questions mapped to level 3, one question mapped to level 4, one question mapped to level 5 and two questions mapped to level 6.

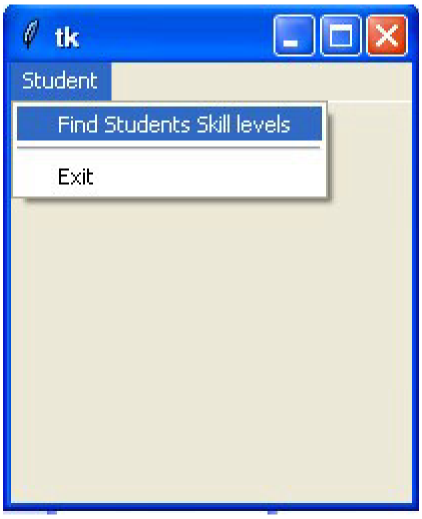
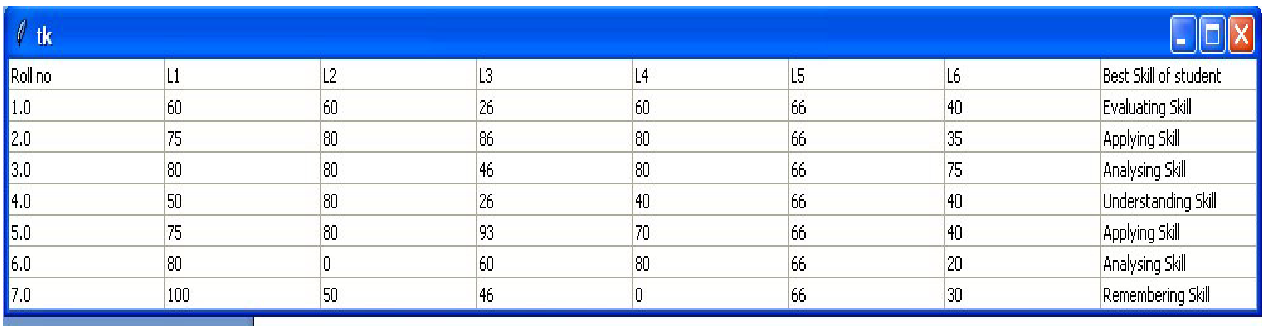


Figure 2. Opening file in tool developed using Python

For the student 1, the skills [1] for blooms level 1 is measured as following: Initially Skills[1]=0 ;Skills [1] =skills [1] + (3*100/5) // 3 marks in Q1, Q1 is mapped to Blooms level 1. Now skills[1]=60; Skills[1]=skills[1]+(3*100/5) // 3 marks in Q5, Q5 is mapped to Blooms level 5.Now skills[1]=60+60=120 .Finally the average skill of student in blooms' knowledge level needs to be calculated. It will be calculated using dividing skills [1] by total_tax[1] which is 120/2. Similarly, the percentage skill of each student, at each knowledge level is measured. For student with roll number 1, percentage of knowledge levels is calculated and their values are, skills[1] is 60, skills[2] is 60, skills[3] is 0, skills[4] is 60, skills[5] is 66 and skills[6] is 40. By comparing all average values, the tool identifies that the student possesses the highest skill value in blooms knowledge level 5. Thus the tool determines that Student-1 is good at 'evaluating' skill. Similarly for all the students, their skill excellence is calculated. This list is given as a recommendation to students and faculty, so that they can form the group which comprises of students with all skill set. In figure 2. The tool developed using python programming language is shown. The faculty can select the excel file which consists of students performance details for each question.



Roll no	L1	L2	L3	L4	L5	L6	Best Skill of student
1.0	60	60	26	60	66	40	Evaluating Skill
2.0	75	80	86	80	66	35	Applying Skill
3.0	80	80	46	80	66	75	Analysing Skill
4.0	50	80	26	40	66	40	Understanding Skill
5.0	75	80	93	70	66	40	Applying Skill
6.0	80	0	60	80	66	20	Analysing Skill
7.0	100	50	46	0	66	30	Remembering Skill

Figure 3. Result Analysis tool developed using python

In figure 3. Result Analysis tool is shown. For each student their skill set calculations are shown. First student has got the highest average percentage skill in L5 of blooms level and so he is identified for 'evaluating' skill. Second student has highest average percentage skill in L3 of blooms level, so he is identified for 'applying' skill. Similarly, other students' skills are calculated. The authors designed the tool in a manner such that, if the skill score is equal for more than one blooms level, the higher blooms level will be considered. For example, the student 3 has a skill score of 80 in L1, L2 and L5. However, the tool will consider L5 as the students' knowledge level.

6. Conclusion

Identifying the students' knowledge level helps in forming collaborative working groups. These student groups can be involved in technical paper writing, mini projects and assignments. The knowledge level identified for each student can be recommended to the students and faculty in forming groups, so that each group can be formed with students of all knowledge level. With this, the outcome of their work will be appreciable and effective, as students of all knowledge domains are involved in the collaborative work.

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VidhyaSangam : A Cost-Effective Video Learning Solution for Class-Room and Students Personal Use

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Abstract: Advancements in the technologies are changing the class-room set-up. The affordability of the technology is enabling the teachers to use the ICT in the class rooms to deliver the knowledge. Additionally, the penetration on internet is helping to bring new solutions to the learning process. It is also a well known fact that the usage of diverse knowledge delivery methods aids in the better learning outcomes. The video learning solutions from various solution providers have been in use but not adopted in the middle tier schools on a larger scale due to cost implications and lesser content relevancy. Our present effort is to develop and deliver a cost-effective cloud based video leaning solutions to the vast majority of middle tier schools in India. The solution also allows the teachers and the students to easily access the relevant digital content from within the context of the electronic textbook with a single click. The solution is ready for Science and Social subjects for Karnataka State Board Curriculum and is being used by around 25 schools in Bangalore and other parts in Karnataka from the VidhyaSangam (www.vidhyasangam.com) portal.

Keywords: e-learning, video learning solutions, cloud based learning, content curation

1. Introduction

Using technology in the class room is not new e.g Robert (2000) and Clayton et,al(2008). Many of the early solution providers such as Educomp, Edurite and Extramarks have been providing end to end solutions, which includes smart board, dedicated server with content hosted within the school premises. But these solutions are expensive for majority of the schools for adoption. Additionally, content of many of these solutions is aligned with the NCERT syllabus making these solutions unfavorable for adoption by schools following different curriculum (e.g Karnataka State board syllabus) as the content is not relevant.

Secondly, it is becoming very evident in the education psychology research findings (Savita ,2012) and (Prakash, 2013), that the current approach to the teaching and knowledge delivery in the majority of the schools need to be enhanced and augmented with additional methods like using smart boards with video content and images etc. This can help to get the children more engaged in the class room and also improve the learning outcomes.

2. Video Learning Solutions

There have been many players in the market place providing e-learning solutions. E.g. Educomp, Edurite, Extramarks, Tata Class Edge etc. Most of these solutions are focused on CBSE/NCERT curriculum for obvious market penetration reasons. Also, these solutions are very much hardware centric with their own central servers deployed at the schools premises and many times to be purchased with display boards and computers. This caused problem to the schools for quick adoption due cost factors. Also the content was bundled independent of the text-books which causes inconvenience to the teachers in terms of understanding the video context. Also due to nature of solution deployment, it was not easy to update the content. A dedicated staff will have to visit each school and do content updation on regular basis whenever there is change in the syllabus.

Hence there is an obvious cost implication in the updating the content. All these issues caused difficulties to the solution developers as well as to the schools. This resulted in slower adoption of technology based learning in the schools. Out of millions of school in India, only small fraction of the schools have adopted the technology based learning in the class room. The vast amount of content is freely available on the internet in the form of Videos, Images and presentations. However, getting the right digital content is a very painful process as there is lot of searching and selection is involved, to get the content which is highly relevant, high quality and authentic and this leads to precious time been wasted. This presents an "abundance" problem where the user is bombarded with too many choices having more noise than the signal(Figure 1).

Figure 1. Content Abundance Problem

2.1 Internet Technologies and Penetration

With vast penetration mobile phones in the country as well as mobile internet usage (Telecom pguerformance indicator report, 2015) the exposure to technology is exponentially increasing and newer ways of using the technology for improving productivity are being deployed. Mobile and broad-band penetration are continuously increasing. Additionally, Government of India initiatives such as digital India and Start-up India are paving ways for more and more technology based solutions being developed and deployed.

3. VidhyaSangam e-Learning Solution

With the above background, there was a need to develop a cost-effective video learning solution for vast majority of the schools that allows the teachers to easily access the relevant content from within the context of the electronic textbook with a single click for in-class room learning. www.vidhyasangam.com is an effort in this direction. Vidhyasangam is an internet based e-Learning solution. This solution is built on Kaybus (www.kaybus.com) knowledge automation platform. Since there was a gap sensed in the market place for the content for the State Board based curriculum, the first version of the solution was developed for Karnataka State Board curriculum.

The initial version focused only on Science and Social subjects. It was very easy to get the videos on the internet which match the curriculum. The text-books were scanned since the corresponding PDF files were not available. For each of the chapters, important keywords, concepts and activities were identified and corresponding videos were shortlisted. The videos were double checked to ensure that they match exactly with the keyword/activity under focus. Once that is checked, the URL of the video was inserted into the scanned PDF document at the exact location of the keyword inside the text book. To quickly identify the URL, depending on the content type appropriate visual icon such as video icon( ) (Figure 2) or image icon( ) was inserted with the keyword highlighted in pink color as shown in the figure below. This contextualization process helps the teacher to access the relevant video at the right place and time using a single click.

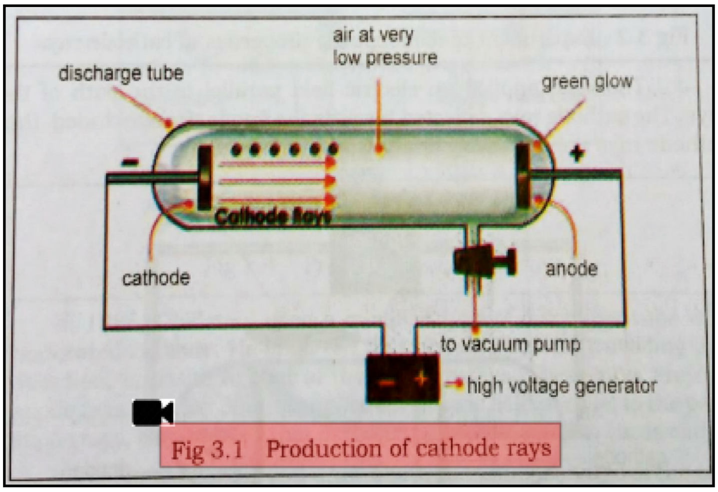

Figure 2. Videos linked contextually into the text book

The Kaybus knowledge automation platform provides the necessary features to manage the content library (PDF files with the inserted video links). Additionally it provides mechanism for user administration (user registration and login, access management and group management). Content can be selectively assigned to schools and students. It also provides analytics to track and monitor the content usage pattern at individual user level.

3.1 Content Harvesting and Curation

As mentioned earlier, there is a vast amount free content available on the internet. The current problem is of "abundance" .Hence,major activity undertaken by Vidhyasangam team was to harvest the relevant content from the Internet and linking the content in the text-books. Around 4000 plus videos are harvested for Karnataka state board Science and Social subjects. Wherever relevant video was not available in-house production of videos was done. Additional care was taken to ensure that:

- The content matches exactly whatever is needed to augment/support the text book content.
- The accent of the narrator is understandable by the students of non-English speaking population.
- The video time was limited to 3-5 minutes to ensure that the class time is not engulfed in videos.
- More focus was given on real life videos rather than animated videos.
- Each textbook page has at least one video linked to an important keyword.

3.2 User Interface

Given below are some of the User Experience flows.

3.2.1 Registration (Figure 3) **:**

Users goes to www.vidhyasangam.com portal(Home Screen) and click on **"Register"** button. User then enters the details (Register Screen) and clicks on the "**Submit Request**" button. Upon receiving the user information an account is created for the user and a welcome email is sent along with the login details.

Figure 3. Registration Screens

3.2.2 User Login (Figure 4):

Users goes to www.vidhyasangam.com portal (Home Screen) and click on the Login button (Login Screen). Upon Login, user is presented by list of content organized by class and subjects (Content List Screen).

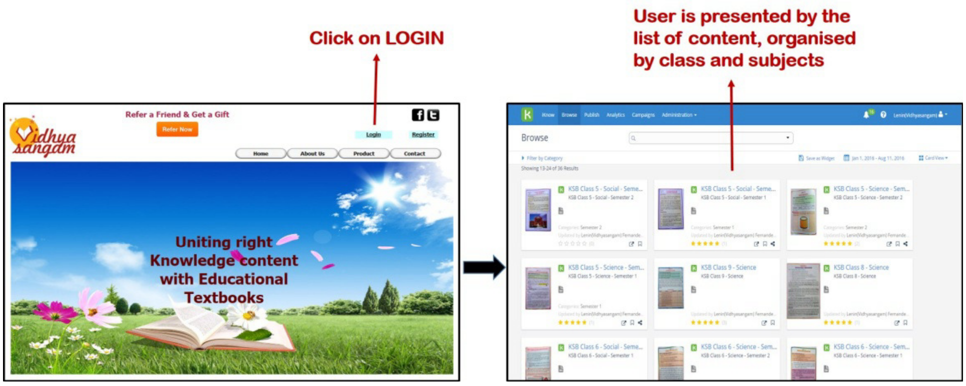

Figure 4. Login and Content Screens

3.2.3 User Clicks on a Subject (Figure 5):

The user can select the subject and the chapter of interest. Respective chapter shall be displayed containing the video links highlighted in pink color along with the video icon near it.

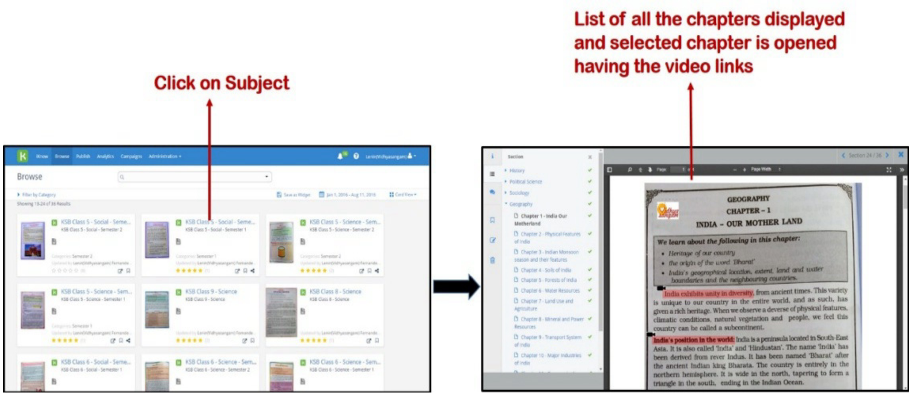

Figure 5.   Subjects and Chapter display with Video links

3.2.4 User Clicks on a Video (Figure 6):

User clicks on the video link and the video starts playing in the full screen mode in a new browser tab. After finished watching the video the user can close the browser tab to return back to the chapter.

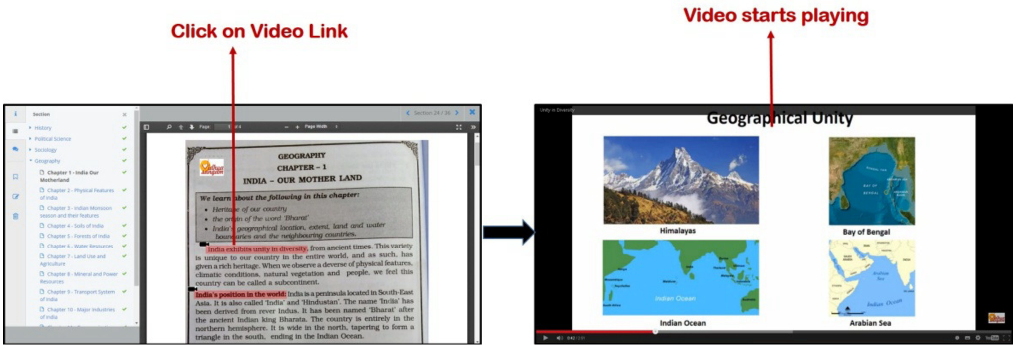

Figure 6. Click on the Video link and Play the video

4. Pilot Experiments

Once initial proto-type was available, there was pilot experiment done at two schools. Modern Public School at RT Nagar, Bangalore and St Johns School at Nagarbhavi, Bangalore. The feedback from both the schools was positive.

5. Customer adoption

After getting positive feedback during the pilot studies, VidhyaSangam launched the solution to the market place after having the content for Science and Social subjects for Class 5 to 10 - Karnataka State Syllabus. The response from the schools was overwhelming. Each of the school which was ready for technology adoption but had not started to use, quickly decided to use VidhyaSangam solution. Around 25 schools in Bangalore have registered and made it a regular practice to incorporate VidhyaSangam sessions in the classroom.

6. Conclusion

Usage of ICT technologies to augment the class room teaching is growing continuously. There is an urgent need of cost-effective solutions to meet this growing need. VidhyaSangam attempts to meet the need of some of the segments in this market place and has been successful. VidhyaSangam plans to expand its offering in other subjects for Karnataka State Curriculum (Maths, English etc) and also produce solutions to the CBSE Board Schools with NCERT textbook based content.

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The design study of inquiry-based learning space for cultivating k-12 student's scientific literacy

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Abstract: Traditional K-12 class have a limitation of training self-inquiry ability which is very important in today's society. This research attribute to offer a unique solution towards this question by designing and constructing a learning space which could truly support the inquiry-based teaching and learning, matching K-12 student's characteristic and having a positive effect on student's scientific literacy. The new space is a combination of formal and informal space where we could teach in both traditional and novel ways which may promote the cooperation and communication among students. And with the full consideration of the flexibility, comfort, convenience and safety, students may connect the each other more easily and freely choose different approaches and resources to solve problems by their own.

Keywords: Scientific literacy, inquiry, active, learning space, design

1. Introduction

The demand for student's scientific quality has been more and more frequently mentioned since 21st century, and it is also a significant part of the Skills of 21st Century. Cultivating scientific quality is not just only improving student's own ability, but also having a great effect on the development and consummation of the whole society. At present, school is an important place for student's growth, and the science courses like physics, biology and chemistry play a key role to cultivating scientific quality. However, teachers in these classes pay a great attention to knowledge delivery especially in middle school where they should pass the test. Even in the experimental class, students are always asked to following the experiment recipe instead of thinking creatively which would lead to surface understanding toward what they are doing (Huang, 2014).

Comparing with the lecture mode of knowledge delivery, inquiry-based teaching method has enough advantages in developing scientific attainment (Li, 2006). In order to compensating the drawback of the lecture mode of teaching, more and more classes in k-12 are beginning to try inquiry-based teaching method to guide students exploring science issues. Whereas, outcomes of new teaching and learning method are limited by the traditional classroom with inflexible desk, unpleasant atmosphere and so on, so there is an urgent need of a brand new space for new teaching and learning method (Huang, 2014).

Hardware device, educational resources, media material, cognitive tools and management service should be included in a learning space to support learning activities. Learning space can be divided in two aspects ——physical space and virtual space. The word of "Learning Space" came out to public since 2006 when the book of Learning Space was published by EDUCAUSE. In 2011, University of North Carolina established the Journal of Learning Space focusing on the topic of space research (Xu, Yin & Zhang, 2014). Numerous investigations and project constructions have been done by many researchers what typically include SCALE-UP project in North Carolina State University, the TEAL project in MIT, the TILE project in University of Iowa, the ALCs project in University of Minnesota, and the ALTC transformation university learning space project in Australian Teaching Committee. It is worth noting that all those successful practice cases were taken place in colleges with a focus on informal learning space design like library instead of middle and primary schools (Zhang, Liang, Sun. & Chiang, 2015).

Based on the consideration of scientific literacy cultivating, inquiry-based teaching for K-12 students, we blend the proper basic design theory into the specific procedures, and fix our design by evaluating whether it is rational and scientific through scales and interviews, and then complete the space design. This is an attempt to design an exploring-style learning space for cultivating K-12 student's scientific quality and accumulating more experience.

2. Research Design

2.1 Research Procedure

There are three steps of our research: preliminary investigation, space design and post evaluation. The preliminary investigation includes field investigation, interview with teachers and literature research through which we could accumulate space-designing experience, find out what teachers and pedagogy need. Space design includes drawing sketch, drawing two-dimensional blueprint and drawing three-dimensional blueprint. Before the construction we do the evaluation one more time to ensure that everything is on board. The flow chart is as follow.

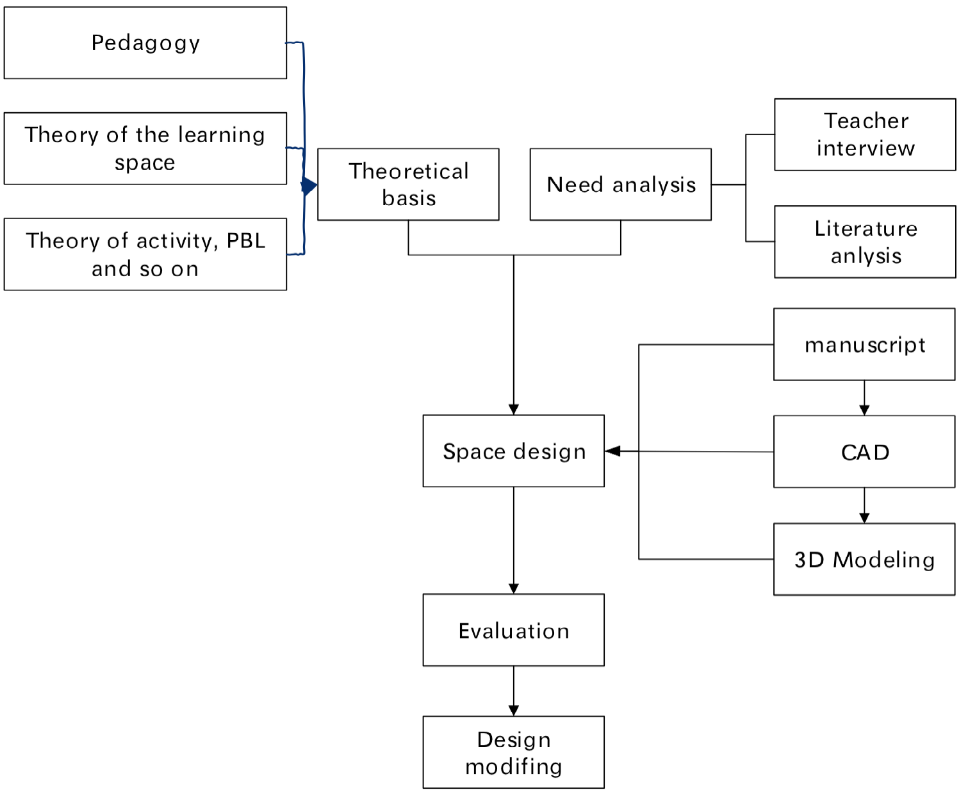

Figure 1 Research Procedure

2.2 Preliminary Investigation Result

Table 1 Investigation Result

Method	Result
Field investigation (School, Museum, Exhibition Hall)	1. the design and the characteristics of students are matched 2. The flowing design are more dynamic and positive to draw students' attention. 3. Students may feel more comfortable. 4. The traditional space are not flexible

Teacher's interview	1. Students prefer flexible place. 2.students are limited by unmovable desks and chairs, so we reduce the desks and chairs and in some space there are even no desks and chairs. 3. Students follow the menu to do experiment and have little innovation. 4. Students are difficult to communicate and express to each other with the unmovable sequence of computers.
Literature Research	1. The inside establishment of science laboratory (Lu Q., Yu B., 2010)0. 2. It is not easy to team-work with the unmovable desks and chairs. 3. The water tank and electric power are not effectively and efficiently used, so we set up those equipments around the classroom and we do not want to limit the movement of the desks and chairs. (Li Y., 2006) 4. The display desk which could move up and down is very effective. 5. The display zone could inspire students to learn. 6. Make the classroom colorful, set up some bookshelves and biology corner. 7. Set up material zone, students could collect daily resources.

3. Space DesignIllustrations

The Yanjiao learning space covers an area of one thousand and two hundred square kilometers. We co-work on the basic theory and design experience summary from home and abroad learning-space studies, analyze the current situation of the laboratories, and set up the Yanjiao learning-space construction goal to design the model of learning-space by using Sketchup 2015, Phtotoshop CS6.

Radcliffe referred to the Pedagogy-Space-Technology (PST) design frame, and he thought space design, pedagogy and technology connect and effect to each other, and there is an iteration circle among them in which one of them definitely effect the other two. (Cheng, Wu & Zhang 2010)

3.1 Design Purpose

This design of learning-space is a place where teachers could use exploring-style pedagogies and students could cooperate to each other, so it could drive students to positively learn and critically think, and then reach the accomplishment-cultivating goal.

3.2 Design Principles

- **Integration of formal and informal space.** Our new learning-space could support various styles of learning actives, besides the normal class-teaching and self-supporting study discussion and exploration. There are many specific zone (formal) for different majors teaching. On the other hand, we would like to provide a cozy and open learning space to promote the informal learning on the basis of ensuring less noise.
- **Compatible between lecture-based class and inquiry-based class.** We will ensure the flexibility of the desks and chairs in the teaching zone, to make the panel discussion, group work and traditional teaching-style class convenient.
- **Interdisciplinary integration.** In middle school, science class is separated into three parts: physics, biology and chemistry, but they all belong to science field that means they are kind of integration. Considering the cultivation of students interdisciplinary thinking ability, we integrate the interdisciplinary theory into our design.
- **Flexibility**. The flexibility of the new style space reflects in different aspects: different sections could merge and split flexibly; desks and chairs could do the puzzle based on different requirement and adjust the height of desks and chairs according to the age of students. (Zhang Y., Liang A. A., Sun H. P. & Chiang F. K., 2015)
- **Comfort, convenience and safety.** The design of new-style learning space need to cater the demands of users and to make them feel more comfortable and convenient.

3.3 Function Needs according to inquiry-based learning

There are six processes of exploring-style learning: discovering, analyzing problems, assuming, collecting evidence, solving problems, communicating and sharing. The function of the space is designed as follows:

Table 2 Function Needs

Inquiry-based Learning process	Requirement of Function	Space Function	Related Space
Discover	Collect plenty of science	Lecture/ Read/ Teaching	Multimedia hall, hallway, Peaceful room
Analyze and Assume	/	/	/
Collect Data and Solve problems	Explore experiences and Surf the internet	Experimental zone, discussion zone and surfing zone	Experimental zone, discussion zone, surfing zone and hallway
Communicating and sharing	Expression and lecture	Expression and lecture	Multifunction room, hallway and wall

We think teacher play an important role in Analyze and Assume period while physical classroom has a very limited effect on it. Therefore, we will not take it in to our design.

3.4 Design Elements and Functions

There are chemistry classroom, biology classroom, physics classroom, STEAM classroom, multimedia hall and a peaceful room. The main shape of our design is hexagon, and almost every classroom is a hexagon, and so do the decorations, the honeycomb inspires us about this design: students may feel more connective to the real nature, and we would like to cultivate their multiple intelligence.

3.4.1 Integrated classroom

The integrated classroom integrates the teaching zone, discussing zone, activity zone and exploring zone together, and it reflects the interdisciplinary integration characteristics.
Teaching zone and the activity zone are separated with other rooms in case the interference of noise and people steam. In the discussing zone and exploring zone, the exhibits and tools are not classified by different majors, aiming to make it convenient for students to choose what they need. In the discussing zone and experimental zone, there is a movable whiteboard for expression, and the movable desks and chairs are easy to carry out the group works.

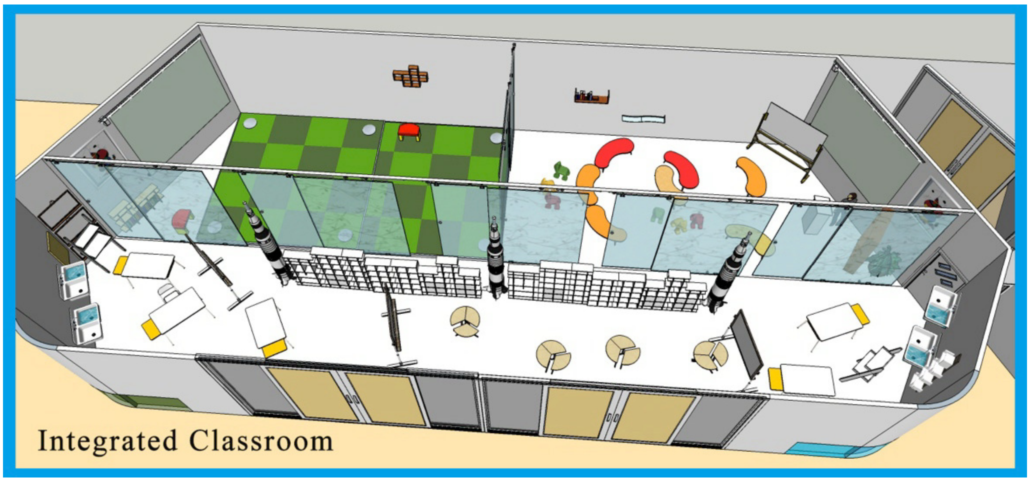

Figure 2 Integrated Classroom

3.4.2 Major classrooms

Each classroom integrates the teaching zone, discussing zone, expressing zone together, and it reflects the step by step progress. And each classroom has its special characteristics. Chemistry classroom emphasizes the convenience for conducting an experiment. Triangle tables in teaching area are easily for cooperation and sharing experimental materials. Discussion area and special experimentation area where contain a storage rack for material storage are adjacent to teaching area.

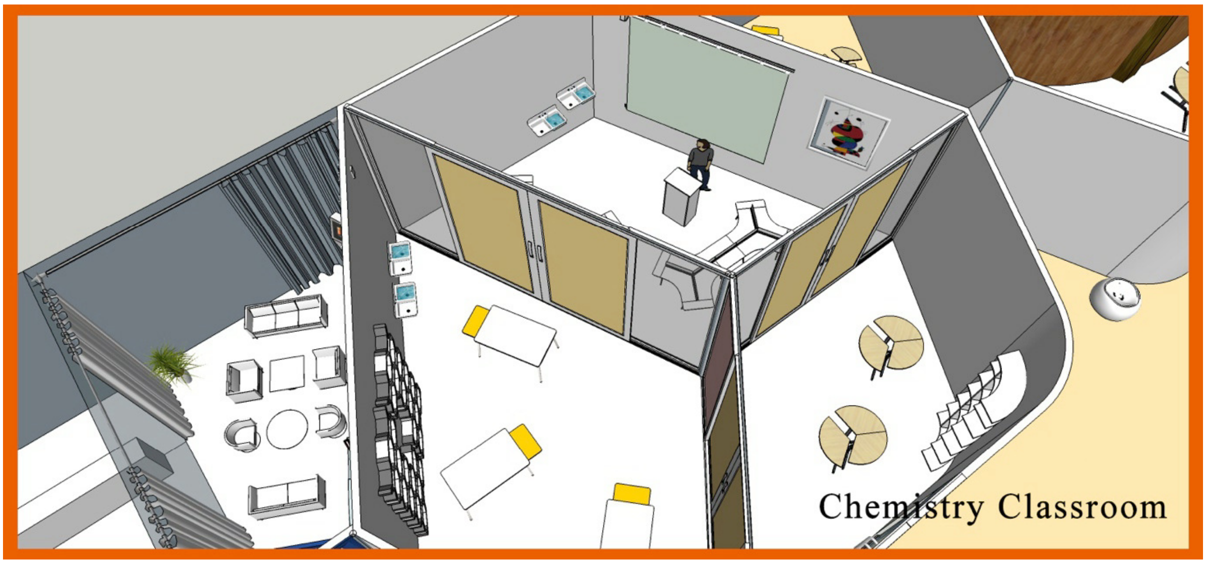

Figure 3 Chemistry Classroom

Biology classroom is trying to be more natural looking. Big tree, some cell model and etc. are used to achieve this propose. An ecological zone used for planting, observing and recording at the corner in this room. And student can easily do some inquiry or discussion at green lawn. Chairs in this room are mushroom look like.

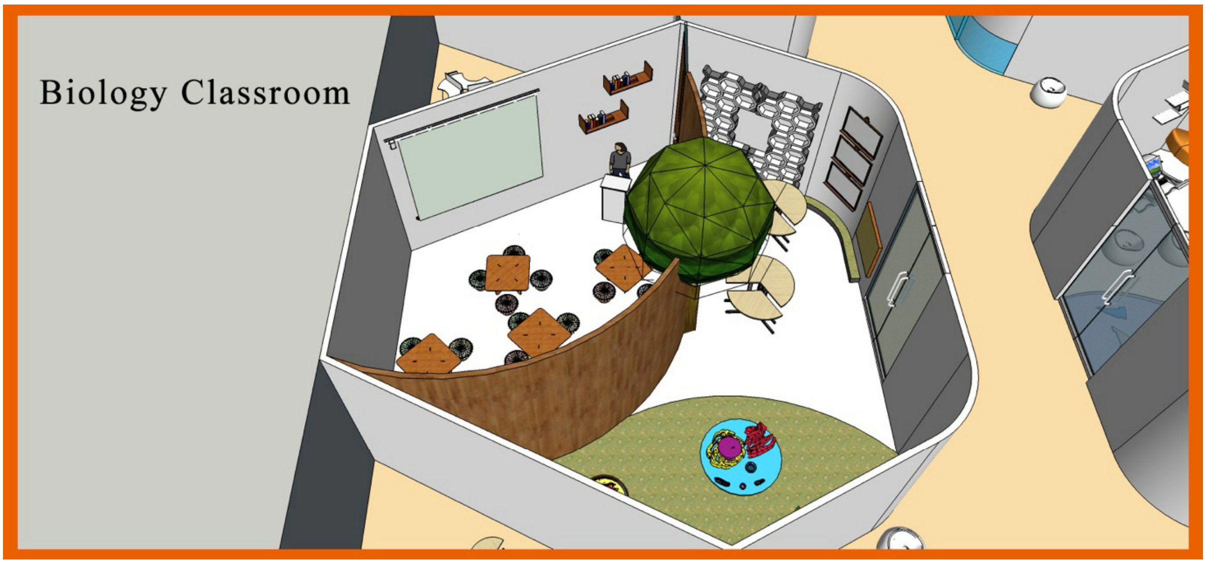

Figure 4 Biology Classroom

Physics classroom have a special demand of electricity result in low flexibility of desk in this room, and each desk have an electric outlet with a small storage rack for material saving.

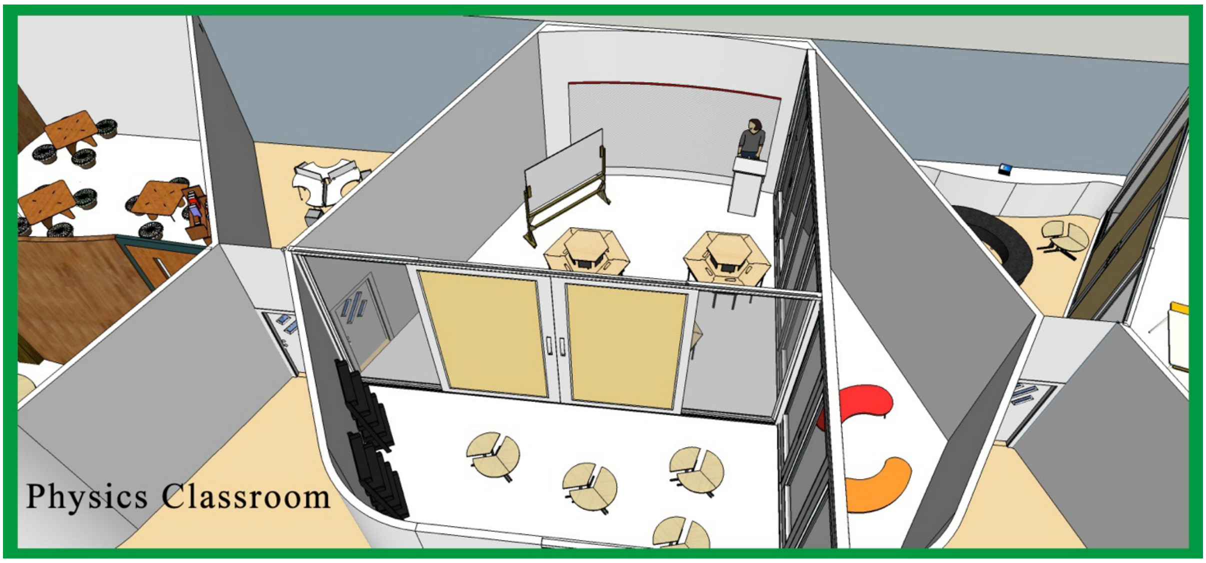

Figure 5 Physics Classroom

STEAM classroom emphasizes to learn step by step. Three area are consisted in this room. First area covered by ground mat with some soft low desk. Student can do some model build at this area which is designed for younger kids. Second area contains some big table and movable desk for model design and discussion respectively. The last area has more computers than other. This area focuses on model programming.

Figure 6 STEAM Classroom

3.4.3 Computer classroom

The location of computer classroom is suffering zone and computer teaching. This classroom is separated into two parts: teaching zone and suffering zone. We set up the high level configuration computers at the red zone for specific professional demands. And the red circles are soft sofa and movable desks and chairs which are used for information searching and discussion.

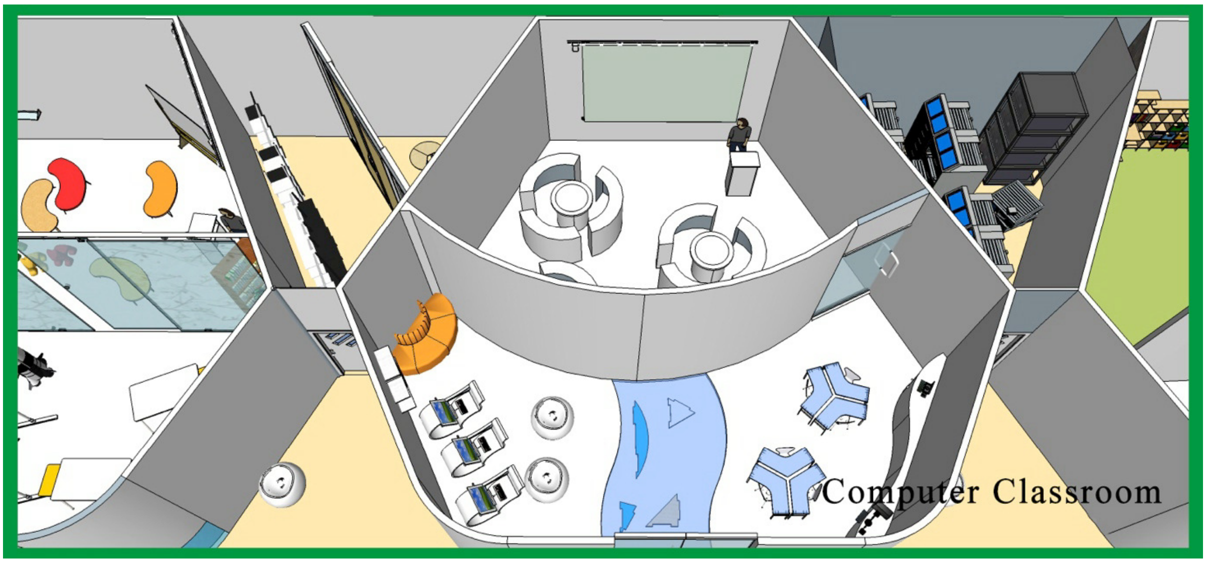

Figure 7 Computer Classroom

It is worthy to note that we design a new desk used in this classroom as follow.
Computers are laid on the round desks, and students could turn around for discussion and at the same place they also could turn back and communicate with teachers.

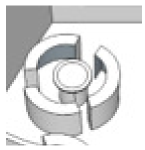

Figure 8 Unique Desk

3.4.4 Multimedia hall and a peaceful room

The main function of this room is self-learning and reading, we would like to offer students a quiet zone for thinking. In this classroom, there are also the movable desks and chairs
Multimedia classroom, in which students could watch demoes, express their works and teachers could have a workshop. This classroom is adjacent to the Peaceful room， and they could connect into a huge classroom meanwhile it also could be separated by sliding door.

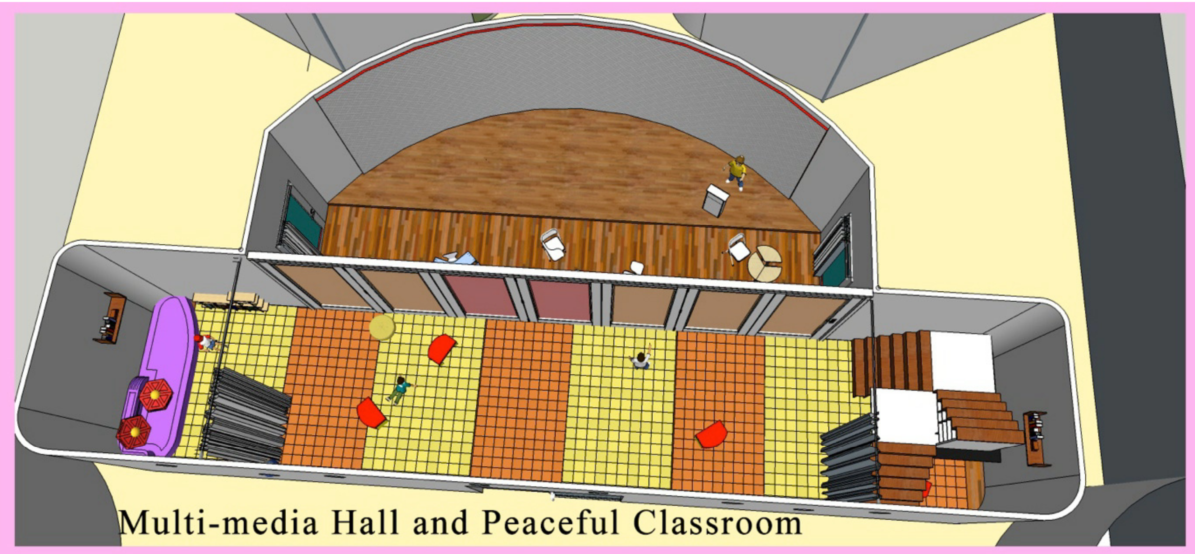

Figure 9 Multi-media Hall and Peaceful Classroom

3.5 Three-dimensional Modeling

Figure 10 3D Modeling

3.6 Evaluation Principle

Inquiry learning space design aims to improve student development and scientific literacy. In order to testing the quality of the design model, this research invites relating person, including one expert in the field of Educational Technology, one interior design specialist and eight k-12 school teachers, to evaluate this design, following the principles of direction, comprehension and feasibility.

1) *Directional principles*: as developing scientific development, in order to promote the all-round development of students.

2) *Comprehensive principles*: Educational environment is a system, which might contain a variety of related factor that would influence education outcomes, like space, equipment, activities, interaction, parents, teachers and so on. Therefore, we can't ignore the relationship between every factors, and take it in to consideration while doing a design job.
3) *Feasibility*: Educational environment is created to conduct educational activities, so it's important to take educational purpose, learning needs and local education development level in order to ensure the education can be implemented smoothly Headings, or heads, are organizational devices that guide the reader through your paper. There are two types: component heads and text heads.

3.7 Evaluation results

Evaluations are made by 10 expects though three field including a professor of Educational Technology, an interior design specialist and 8 K-12 school teachers.
Based on the feedback of professors, the current model may already meet the requirement of inquiry-based learning space for cultivating k-12 student's scientific literacy, every score evaluated by expert in Educational Technology and interior design specialist are over 4. Every average score of each items are also over 4, especially the creativity which is the highest 4.9.

Table 3 Evaluation Result

Evaluate dimension		Expert in Educational Technology	Interior design specialist	Mean
General arrangement	Rationality	5	4	4.1
	Utilization rate	5	4	4.1
	Practicability	5	4	4.2
Plastic	Multi-media	5	5	4.5
	Aesthetic and comfort	4	5	4.0
	Flexibility	5	5	4.7
	Safety	4	5	4.4
	Participation	5	4	4.4
Function	Integrity	5	5	4.5
	Situationality	5	5	4.3
	Diversity	5	5	4.7
	Easy Operation	5	5	4.5
	Humanization	4	4	4.5
Educational application	Pedagogy flexibility	5	5	4.8
	Initiative	5	5	4.6
	Enthusiasm	5	5	4.5
	creativity	5	5	4.9

* Mean represent the average score of 10 expects though three field.

4. Summary

This study is the first try for accomplishment-cultivating of K-12 students, which is supposed to integrate the K-12 students, accomplishment and learning –space efficiently. This is a new method to research, and the outcome enriches the theory of learning-space in China, and support the accomplishment-cultivating in a brand new way. We are not just doing the analysis and theory study, but also apply those for real. So that our study is more convinced after the test of practice and other researchers could use for reference.

Space design is complicated, and it is based on the theoretical attainments and artistic attainments, but it is a pity that we did not pay more attention to the artistic of space design, so what we learn from this study is that we should blend multi-major members to cooperate for the learning-space design. Furthermore, more evaluation and empirical research is need in the future to find the influence on student learning and teacher teaching and how does it work.

Acknowledgements

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Establishing the Educational Evaluation System of Academic Advising for Sino-foreign College

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Abstract: The paper is to establish an evaluation index system on academic advising for sino-foreign college students in Chinese universities. Because there is almost no formal academic advising system for sino-foreign college students in China, the researchers made some investigations and looked for some authoritative articles to establish the indexes. Then through mathematical methods, the rationality of data was checked and the weights of the indexes were determined. Finally we got the equation to evaluate the final score and then got the comprehensive evaluation.

Keywords: Educational evaluation system, academic advising, sino-foreign college

1. Introduction

Nowadays, as education is more and more emphasized, various educational patterns appear. Sino-foreign education becomes an important part among the new patterns. According to the information from Chinese Ministry of Education, until 2014, there were 12 regions having sino-foreign schools in mainland China and 54 of them were allowed to run (Wu, 2016). This educational pattern has been more and more common during these years.However, sino-foreign education is not mature enough in China. As for academic advising institution which seems a relatively new concept in Chinese universities, we have searched online for all the sino-foreign colleges in mainland China and found that there is none of them having formal academic advising institution. Though it seems that some have websites for students to ask for guidance, after we investigated further, we found these websites are just deceptions and are not really useful.

For the concept "academic advising", American universities have a long history on it. Harvard University is known as the pioneer of academic advising. As time goes, until 2011, about 70% American universities have academic advisory body and it is designed to solve students' problems on study and future plan (Wang & Zeng, 2015). Learning from them, a few Chinese universities also established academic advisory institutions for students' future development. To catch up with the preeminent education and improve the quality of sino-foreign education, an academic advising institution is necessary. When we establish the institution, it is important to ensure the quality of the institution. Only when the quality of the institution is high, we can help the students effectively. Hence, we build an evaluation system to test the quality of academic advising for sino-foreign colleges.

2. The Concept of Evaluation System and Design of Evaluation Indexes

2.1 The Concept of Evaluation System

The evaluation system is the key to judge the quality of academic advising. It plays a guiding role for advisors in advising. It contains evaluation object, evaluation index, weight of index and evaluation criterion (Zheng, 2012).

First, evaluation object is something or someone we evaluate to. Here the object includes the advisor, counselor, course, etc. Therefore, to let them all included, we make the quality of academic advising as our evaluation object. Second, evaluation index is a specific standard for the object. In an evaluation system, there are always many indexes since we need to judge the object from different perspectives. Generally speaking, the indexes are often decomposed to 3 levels at most. Here we decompose the indexes to 2 levels, because the second-level indexes are concrete and clear enough.

Third, weight of index is a constituent ratio, which can measure the relative importance that each index accounts for in the evaluation index system. There are many methods of determining the weight. We can divide them into two types: subjective method and objective method. Subjective method, like AHP and Delphi's method, needs experts to determine the weights. However, it is easily influenced by individual. Objective method, such as PCA, CA and FA, determines the weights according to the original data. However, it often has complex calculations and is easily influenced by random error. In conclusion, these two types both have weakness and we need to select an appropriate method due to our situation to minimize the error.Last, evaluation criterion is a measurement to each index and to the whole object. It is often represented by grade (A, B, C, D etc.) or quantitative score (1, 2, 3, 4, 5 etc.). Here we choose quantitative score as evaluation criterion to make it easy for us to calculate.

2.2 Design of Evaluation Indexes

To establish the indexes, we visited some universities which have a long history of academic advising, like Tsinghua University and Beijing Jiaotong University. In addition, we also did interviews to some foreign professors who teach in the sino-foreign college of China Agricultural University and have academic advising institution in their alma maters. Given the evaluation systems of those universities, the interviews, some literal research papers and our own ideas, we created the indexes as shown in Table 1 and Table 2.

Table 1: Academic advising evaluation index-1.

First-level Index	Second-level Index
I_1= advisor's attitude and the quality of content provided by advisor	X_1=patience X_2=reliability of information provided X_3=passion X_4=respecting student privacy X_5= coordinating the relationship between instructors and students X_6=conveying students' suggestions to college X_7=contributing to improve study environment X_8=timely informing internship and social practice opportunities X_9=providing accessory services (such as language help, simulate interview and resume revising)
I_2= professional ability of advisor	X_{10}=qualification of advisor X_{11}=professional ethics of advisor X_{12}=current situations of students who have consulted the advisor X_{13}=academic record of counsellor (as an advisor) X_{14}=attitude of counsellor (as an advisor) X_{15}=attendance of counsellor (as an advisor)

Table 2: Academic advising evaluation index-2.

First-level Index	Second-level Index
I_3= academic advising as a course	X_{16}=clarity of syllabus X_{17}=quality of course X_{18}=zest of course X_{19}=rationality of examination X_{20}=rationality of time management X_{21}=punctuality of the instructor X_{22}=appearance of the instructor X_{23}=responsibility of the instructor X_{24}=seriousness of recording attendance X_{25}=ability of controlling classroom discipline X_{26}=consistency between teaching process and syllabus X_{27}=accessibility of the course
I_4= the effectiveness of advising (the amount of information students accept)	X_{28}=student's understanding of current job market X_{29}=student's understanding of future development X_{30}=student's understanding of his/her objective occupation requirements X_{31}=student's understanding of the process of applying higher education (including undergraduate and postgraduate application) X_{32}=skills that student acquires from accessory services X_{33}=skills that student acquires from relative lectures X_{34}=skills that student acquires from relative research programs provided by advisors (including programs with foreign universities) X_{35}=skills that student acquires from internship and social practice opportunities provided by advisors

For convenience, we use I_1-I_4 to represent four first-level indexes and use x_1-x_{35} to represent 35 second-level indexes. When we designed the indexes, we mainly considered four principles. First, the purpose of academic advising is to serve for students, so the indexes focus on whether the students do get benefit from the advising. The demand of students for advisors is the most important thing for indexes. Second, the problems reflected by the indexes can be solved or improved. The purpose of the evaluation system is to find the weakness of academic advising and to improve the quality of advising. An index will make no sense if the advisor or college is unable to improve the problem reflected by it.Third, the indexes should be accessible to measure. The final evaluation is quantitative, so the indexes have to be available for statistic analysis.

Last, pertinence of sino-foreign college is important. Because the evaluation system is for sino-foreign college, we designed the indexes, such as x_9, x_{13}, x_{14}, x_{15}, x_{16}, x_{26}, x_{31}, x_{32} and x_{34}, for these special students. Because sino-foreign colleges have a relatively high requirement of language level, x_9 and x_{32} are to help the students with their language problems. In some sino-foreign colleges, due to that most undergraduate students need to go abroad after they studied at home for 2 or 3 years, the counselors are also undergraduate students who stay in China. These counselors are suitable for being an advisor, which is also a good way for students to consult. Hence x_{13}, x_{14} and x_{15} are for counselors as advisors. x_{16} and x_{26} are only useful in sino-foreign colleges because general courses in Chinese universities do not have syllabus. x_{31} and x_{34} are very important because students in sino-foreign colleges need to know many information about foreign universities, including courses, programs and applications. However, Chinese Internet makes students hard to get the information. Hence they need advisors to give them efficient messages.

3. Design of Questionnaire and Investigation among Students

To check the rationality of our indexes and to determine the weight of each index, we made a questionnaire and collected students' views.

3.1 Design of Questionnaire

In the first section of our questionnaire, we designed six questions to get the basic information of the participants. Due to that the evaluation system is for sino-foreign college students we asked that whether the participant is full-time sino-foreign college student to rule out those who are not studying in this kind of college. Then we brought the respondents to the topic by asking whether their colleges have academic advising department. We also asked about the content and form that academic advising should have to let the students who do not know academic advising well have a basic impression about it. After answering these questions, they could understand the following questions easily and make rational answers.

In the second section, we asked the respondents to grade for the indexes according to the importance of the indexes. Full score is 5, which also means the index is very important. 1 means the index is least important. There are five levels (1, 2, 3, 4, 5, from least important to most important) in total. Combined with students' views, we can check the rationality of our indexes and determine the weights of the indexes.

3.2 Distribution and Collection of Questionnaire

Because the questionnaire is for sino-foreign college students, we mainly disseminated the questionnaires in some universities that have this kind of college, such as China Agricultural University, Hefei University, University of Science & Technology of Anhui and Changchun University of Technology. These universities were randomly picked and most feedbacks we got are effective.

The questionnaire was published via Sojump (www.sojump.com), an on-line survey website that is commonly used by college students to do research. The questionnaire was distributed and collected from April 11, 2016 to April 27, 2016. During the roughly 2 weeks, 332 questionnaires were collected in total. Due to the filtering question, the real sample volume is 311. Among the participants, over 70 percents students are sophomores or with higher grade. That means most students are very familiar and experienced with the study in university, which improves the credibility of the result.

3.3 The Reliability Analysis of Questionnaire

In order to test the reliability of our survey, we made the reliability analysis. We observed that some students graded the lowest point for all the indexes, so these data is not reliable. However, if we regard these samples as invalid samples, some effective information may be missed. Hence we still retain this part of the result.

Under normal circumstance, if the Cronbach's Alpha of the data is greater than or equal to 0.6, it means that the data is reliable. By means of SPSS, we got that the Cronbach's Alpha for all the data reaches 0.982; and the alphas for each four indexes are all higher than 0.9. Therefore, the questionnaire has a good internal consistency and is strongly reliable as shown in Table 3. Furthermore, it also shows that each index is independent, and the content and the evaluation standard are clear (Zheng, 2012; Wang, Guo, Xing, Wang, Li, Zhang, et al. 2013).

Table 3: Reliability statistics.

Index	Cronbach's Alpha
I_1	0.942
I_2	0.919
I_3	0.966
I_4	0.952
total	0.982

3.4 The Validity Analysis of Questionnaire

Because the content validity is difficult to quantitatively measure, we use factor analysis to measure its construct validity. Via construct validity, we can know the degree of coherence between the index and the measurement results. As shown in Table 4, Bartlett's Test of Sphericity shows that the significant probability is 0.000, which is less than 0.05. Therefore it rejects the null hypothesis, which demonstrates that factor analysis is suitable for it. In Kaiser-Meyer-Olkin Measure of Sampling Adequacy, the KMO value is 0.969. According to the criteria given by the statistician Kaiser, if KMO is greater than 0.9, it shows that the data is fit for factor analysis.

Table 4: Statistics of Bartlett's Test of Sphericity and KMO Measure.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.969
Bartlett's Test of Sphericity	Approx. Chi-Square	12289.335
	df.	595
	Sig.	0.000

Then, we used the principal component analysis method to extract the common factor of the 35 items, and 4 common factors were extracted after maximum variance skew rotation. The cumulative contribution rate of the 4 common factors is 74.5%, and each second-level index has a relatively high load value (greater than 0.4) on one of the common factors while has a relatively low load value on the other common factors. Hence it has good structure validity. It also shows that we well understand the actual situation and make a fair design of the index (Wang, Guo, Xing, Wang, Li, Zhang, et al. 2013).

4. Determination of Indexes and Weights

4.1 Index Screening

To screen some irrational indexes, we take the three series 75% as the screening index (Ji, 2011). If the average score of an index is less than 3.75, the index is not qualified. However, we can observe that the average score of each index is more than 3.75, so we regard them all qualified and retain all the indexes.

4.2 Determination of Indexes

There are many methods to determine weights. Many people use AHP to determine weight of evaluation indexes, which needs experts' opinion and is subjective. In addition, because our evaluation indexes are for sino-foreign college and there are few experts in this field, we fail to obtain sufficient experts' opinion. Hence we do not use such methods that need experts' opinion of weight.

Here we use two objective methods--variation coefficient method and principle component analysis to determine weight. In the end, the comprehensive weight is the arithmetic mean of two results calculated by two methods.

4.2.1 Determination by Variation Coefficient Method

Variation coefficient method can eliminate the error caused by different means. In variation coefficient method, we take standard deviation coefficient which is most commonly used as the indicator of weight. Standard deviation coefficient is the standard deviation per unit of mean. The weight of each index is the percentage of its standard deviation coefficient accounting for in the sum of standard deviation coefficients of all the indexes (Men & Liang, 2005; Wu, Liang, & Li, 2013).

4.2.2 Determination by Principal Component Analysis

Principal Component Analysis can determine the weight by describing the relationship between each original index. The eigenvalues of extracted principal components should be larger than 1. In addition, the total cumulative of the extracted principal components should be larger than 50%. Here there are 4 extracted components and the total cumulative is 74.525%, which meets the requirement. It also means the 4 components can basically reflect the information of the original indexes. The details are shown in Table 5.

Table 5: Total variance explained.

Component	Extraction Sums of Squared Loadings		
	Total	*% of Variance*	*Cumulative %*
1	21.761	62.173	62.173
2	1.594	4.555	66.728
3	1.561	4.459	71.187
4	1.168	3.338	74.525

Then to get the index vector of each original index, we make the numbers in component matrix divided by the square root of the eigenvalues of corresponding principal components.

In this method, the indicator of weight we use is the coefficients in the comprehensive score model. The coefficients are the sums of the index vector of each original index multiplied by the corresponding percentage of variance contribution rate of the principal component accounting for in the total cumulative.

Finally, the weights are the percentages of each coefficient accounting for in the sum of the coefficients (Zhang, 2006).

4.2.3 Comprehensive Weight

The comprehensive weight is the arithmetic mean of two results calculated by the two methods. Table 6 shows the weights calculated by the two methods and the comprehensive weight. W_1 is the weight calculated by variation coefficient method. W_2 is the weight calculated by principal component analysis. W_3 is the comprehensive weight.

Table 6: Academic advising evaluation index weight.

Index	W_1	W_2	W_3	Index	W_1	W_2	W_3
X_1	0.027	0.031	0.029	X_{19}	0.020	0.030	0.025
X_2	0.027	0.031	0.029	X_{20}	0.020	0.029	0.025
X_3	0.033	0.030	0.032	X_{21}	0.021	0.026	0.023
X_4	0.027	0.030	0.028	X_{22}	0.022	0.024	0.023
X_5	0.031	0.033	0.032	X_{23}	0.019	0.027	0.023
X_6	0.030	0.033	0.031	X_{24}	0.024	0.025	0.024
X_7	0.029	0.034	0.031	X_{25}	0.021	0.028	0.024
X_8	0.031	0.032	0.031	X_{26}	0.020	0.028	0.024
X_9	0.031	0.033	0.032	X_{27}	0.020	0.028	0.024
X_{10}	0.045	0.026	0.035	X_{28}	0.030	0.024	0.027
X_{11}	0.037	0.029	0.033	X_{29}	0.020	0.024	0.027
X_{12}	0.040	0.029	0.035	X_{30}	0.029	0.025	0.027
X_{13}	0.042	0.029	0.035	X_{31}	0.028	0.023	0.026
X_{14}	0.042	0.031	0.036	X_{32}	0.030	0.025	0.027
X_{15}	0.045	0.027	0.036	X_{33}	0.033	0.028	0.030
X_{16}	0.020	0.031	0.025	X_{34}	0.033	0.029	0.030
X_{17}	0.020	0.030	0.025	X_{35}	0.031	0.028	0.030
X_{18}	0.022	0.030	0.026				

5. Synthetic Evaluation

When students finally make evaluation, only second-level indexes could be scored. The maximum score is 5 points, and students can only score positive integral points in the evaluation. To get the final evaluation score, we can multiply the score of each index that a student gives with their respective weight (here is the comprehensive weight on table 6) and then add them up. The sum is the final score that a student evaluates to the academic advising. In the end, the arithmetic mean of the final scores from all students is the comprehensive score for the academic advising (Song, Lv, & Su, 2014). The formula below shows how to calculate the final score. Y is the final score. n is the amount of indexes, so here n is 35. x_i is the point a student scores for the ith index. $W3_i$ is the comprehensive weight of the ith index.

$$Y = \sum_{i=1}^{n} x_i W3_i \quad (1)$$

6. The Reflection and Conclusion about the Evaluation System

Due to that few universities have sino-foreign college and there is almost no formal academic advising for this type of college in China, we have no academic advising evaluation system to refer to. Hence the system we build may not be very reasonable or comprehensive. In order to compensate for the potential drawback, we hope that after the two-year practice of the system, we could make a more reasonable questionnaire to test the rationality of our system again. We will also continue to seek the experts in this field to improve the evaluation system.

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A Simulation based learning for Computer Organization Education

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Abstract: Computer Organization is a course for undergraduate computer science students that comprises of aspects of functional units of a computer. In this course, students learn designing the CPU, ALU, RAM, Pipelining, ARM and MIPS programmingusing Open Source tools and also they simulate the working of Single data path bus and Intercommunication between the CPU and Memory and the working of ARM instruction in ARM Processor using Open Source Tools. In this paper, we investigated Simulation based learning for Computer Organization through Open Source Tools.

Keywords: Computer Organization, Open source tools, ARMSim, MarieSim, Logisim, QTSpim, CPU-OS Sim

1. Introduction

The computer organization deals with the structure and behavior of digital computers (Petterson, Hennessy 2010). The main objective of this subject to understand the overall principles of computer organization, including its hardware structure and communication among the functional units (Hamacher,Vranesic, Zaky, 2011).Like any other systems, a computer system also consists of an inter-related set of components known as functional units.

Depending upon the organization of these functional units i.e the way in which they are interconnected and how they function as a individual component, the system can be characterized as a best system. In this subject we are simulating each functional unit including the working of a processor, using open source tools like MarieSim, ARMSim andLogisim. The paper is further organized as follows. Section 2 discusses about a brief introduction to the different functional units of a computer that we simulated. Section 3 describes about course overview, tasks carried out in each week and the tools used, section 4 discusses about survey conducted for the curriculum and its results based on the course outcomes of the introduction of a Simulation based teaching Computer Organization using open source tools and section 5 focus on conclusion.

Simulation based learning (SA notes 2013) helps in linking theory with the practice of teaching. It is an effective means of teaching/demonstrating concepts to the students. In our curriculum, we have used different simulators to simulate the working of different functional units of a computer and also allow the designer to study the problem at different levels of abstraction. We have used simulators to design ALU, CPU and Memory system which are very difficult to represent it in theory, so it has helped us to examine and confirm theoretical models which may be too difficult to grasp from a purely conceptual level.

2.Functional Units of a Computer

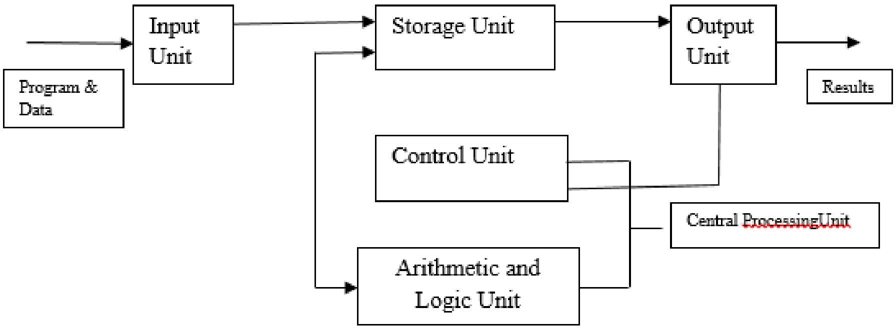

Figure1. Functional units of Computer

Figure 1: represents the functional units of Computer, they are as follows:
1. Input Unit
2. Output Unit
3. Central Processing Unit

The simulations have been done for the following concepts to teach the Computer organization and Architecture in a better way.

- In Central Processing Unit, the basic functions of an Arithmetic and Logical Unit.
- The working of Memory system in executing the data transfer instructions.
- Execution of the ARM instructions.
- Execution of an instruction using single data path bus architecture for the 8086 instructions.
- The advantages of using Pipelining technique.
- Execution of MIPS Instructions.

3. Course Overview

MarieSim(Linda, Julia 2016) is a computer architecture simulator based on the MARIE architecture and it is mainly used to teach the execution phases of an instruction to the beginners of computer organization and architecture effectively. It provides users with interactive tools and simulations to help them to expand their understanding of the operation of a simple computer. During the execution of assembly language instructions, students can see the execution datapath by observing the changes in CPU's registers and system'smemory. Java Swing is used to design the GUI of MarieSim.

Figure1 represents some of the samples the students they have worked out to understand the interaction between the CPU and the Memory and the single datapath Simulation.

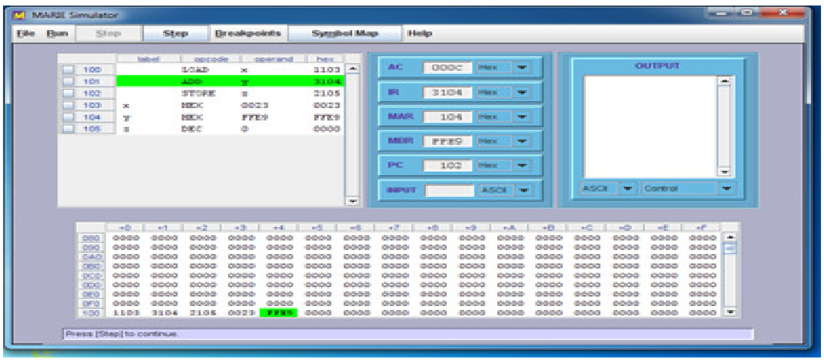

Figure1: The content of MAR, MDR, PC, IR and Accumulatorwith respect to the code got executed.

Logisim (Sourceforge.net 2016) is a simulation tool developed for educational purpose.It helps the instructor to teach thelogical circuit subject effectively showing the designing and simulation of digital logic circuits. With its trouble free and rich set of logical entities available ina self explanatorytoolbar, a student can easily build the required circuits, it is simple enough to facilitate the students to learn the most basic concepts related to logic circuits. Using those logic circuits, we are able to build the ALU and SRAM. Figure 2 represents the design of ALU using different gates to perform Arithmetic and Logical operations(IITKGP, 2010).

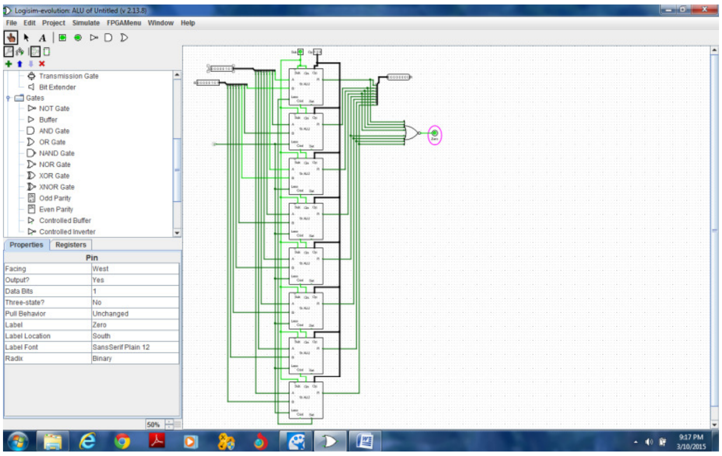

Figure 2: Design of Complete ALU Operations

Figure 3 represents the design of RAM (IITKGP, 2010) using different gates to perform Reading and Writing of data on to the memory.

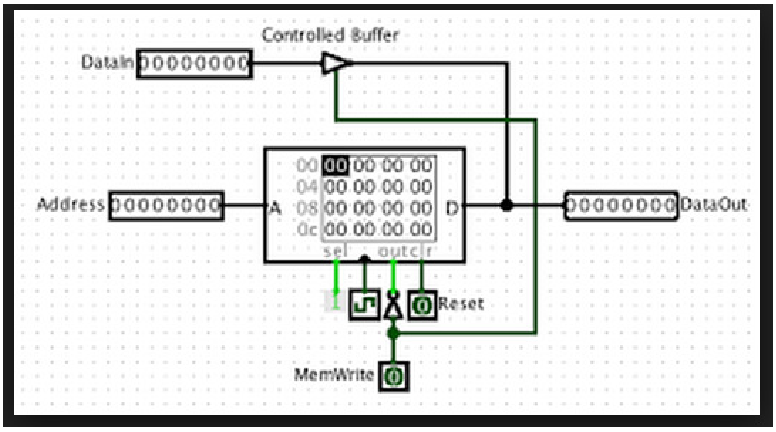

Figure 3: RAM Operations

ARMSim(University of Victoria) is an open source desktop application running on a Windows environment. It allows users to enter an ARM program (simple basic programs to lightly complex programs including loops and subroutines). Once the program is run, students can clearly observe the contents of registers and memory locations after the execution of each instruction.With the help of this simulator students can also understand different ARM addressing modes. Figure 4 represents the ARMSim editor for the program execution and with the register contents and memory location.

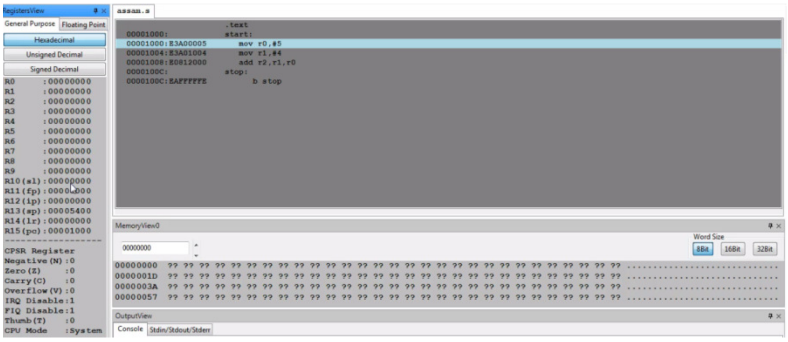

Figure 4. ARMSim editor for a simple program

One of the key important and advanced topic in Computer Organization is pipeline technique which affects the CPU performance. We have used CPU-OS Simulator(Informer Technologies, 2016) to demonstrate advantages of using pipelining over sequential execution. The students in addition can also analyze the causes of different pipeline hazards likeData hazard, Control hazard and Branch hazard.

Figure 5 represents the Pipelinined stages for a simple program of adding 2 numbers with the data hazard (highlighted in Red). It will even demonstrate the number of clock cycles required and the runtime for that program in 3 different stages

1. Instruction execution without pipelining

2. Instruction execution without pipelining

3. Instruction execution by inserting bubble(delay)

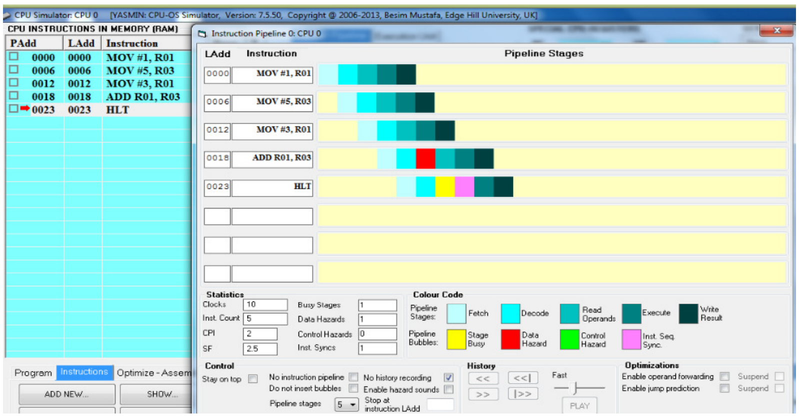

Figure 5. Pipelining with data Hazard

In this tool we will demonstrate

1. The data hazard and how it can handled after inserting the bubble, and

2. The Control hazard and how it can handled after inserting the bubble

   MIPS(Microprocessor without Interlocked Pipeline Stages) programs can be better demonstrated by QtSpim(Jorgensen 2016) software that will help the students to simulate the execution of MIPS assembly programs. Just like ARMSim students upload their MIPS program. Once they run, they can see the execution of each MIPS instruction by observing the changes in register set and memory locations.

Figure 6 represents a snapshot of QTSpim editor with the string reverse function and its output on the console

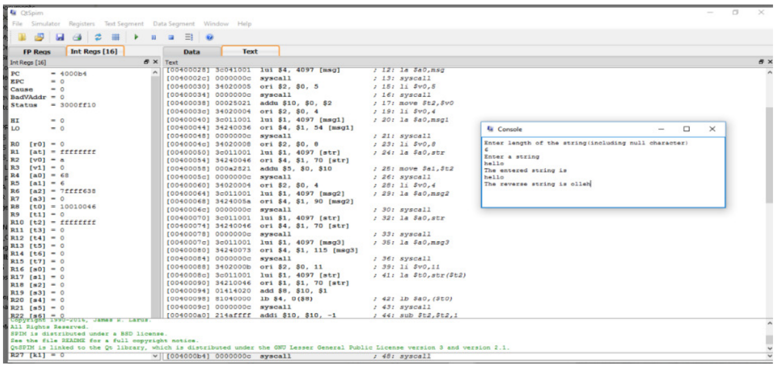

Figure 6. MIPS Program Execution and its output using QTSpim

In this course, the students are able to work with many open source tools for simulating different functional units of computer. The below table1 represents the simulation, tools used and corresponding information

Table 1: Free and open source tools used for simulation for understanding Computer organization concepts

Simulation conducted	Free and Open Source Tools used	Information
Simulate the execution stages of an instruction. **Students are able to understand theinterconnection between processor and memory and the data path.**	Mariesim	The usage of the tool and the conduction is been demonstrated in the college website https://sites.google.com/a/msrit.edu/computer-organization/simulation4
Simulating the design of SRAM using counter, controlled buffer, clock, Random generator and tty **to write and read the data onto the memory.**	Logisim	https://sites.google.com/a/msrit.edu/computer-organization/simulation-5
Simulating the design of ALU and its working using AND, OR, X-OR gates to perform **Arithmetic and Logical Operations.**	Logisim	https://sites.google.com/a/msrit.edu/computer-organization/simulation1
Simulating the execution of an Assembly instructions. Comparing the performance of the CPU without and with pipelining. **Students are able to identify the Data Hazard.**	CPU-OS simulator	https://sites.google.com/a/msrit.edu/computer-organization/simulation-6
Simulation of execution of Assembly instructions without and with pipelining and inserting bubble and also **students can demonstrate the Control Hazard.**	CPU-OS simulator	https://sites.google.com/a/msrit.edu/computer-organization/simulation-7
Simulation of ARM Instruction Execution. **Students can understand the ARM Architecture** through simulation.	ARMSim	https://sites.google.com/a/msrit.edu/computer-organization/simulation-8
Simulation of MIPS Instruction execution. **Students can understand the MIPS Architecture** through simulation.	QTSpim	https://sites.google.com/a/msrit.edu/computer-organization/simulation-3

3. Course Surveys and Results

In this course of Computer Organization, we conducted surveys by designing course outcomes that can be satisfied by the students after learning this course. The main aim of these surveys is to improve the curriculum of Computer Organization course using the feedback from the students. The analysis and the results are as shown in the table 2 and table 3. Table 2 lists the course outcomes and their results. Table 3 lists the survey questions formed and its results. From these survey results and feedback from the students we infer the following results.

- Ability to design a CPU using the Basic gates and to verify the proper working of CPU.
- Ability to design ALU using the basic gates and verify all the Arithmetic and Logical Operations.
- Ability to design RAM using basic gates and simulate the movement of data in memory.
- Analyzing the working of Processor, Memory and Single Datapath.
- Analyze the working of ARM Processor.
- Analyzing the working of MIPS Instruction using QTSpim
- Demonstration of Pipelining and different hazards using CPU-OS Simulator

We have taken a survey on Computer organization course outcomes and we are appreciable for the attainment of all 5 CO's. Totally 114 responses we got from the students. Here we are representing that attainment of CO's graphically. Around 50% of the students have rated the attainment of CO's are very good.

Table 2: Course outcomes and its attainment

No	Course Outcome	Results of Survey(Attainment Level)	
1	Understand the operations & operands of the computer, representing instruction and ARM addressing modes.	Rating Criteria Excellent Very good Good Satisfactory	Percentage of Attainment 26% 51% 22% 3%
2	Implement different algorithms used to perform fast multiplication and division also represent the floating-point number in IEEE format	Rating Criteria Excellent Very good Good Satisfactory	Percentage of Attainment 26% 45% 24% 4%
3	Analyze the logic design convention, datapath elements and understand the importance of pipelining	Rating Criteria Excellent Very good Good Satisfactory	Percentage of Attainment 26% 46% 26% 4%
4	Learn how to measure and improve the cache memory performance and also recognize the advantages of using virtual memory technique	Rating Criteria Excellent Very good Good Satisfactory	Percentage of Attainment 25% 44% 27% 5%
5	Evaluate I/O system also demonstrate the connection and interfacing of I/O devices with the system.	Rating Criteria Excellent Very good Good Satisfactory	Percentage of Attainment 26% 37% 33% 3%

We have also taken the survey of simulation tools whatever the students explored in the lab. In that survey 85% of students felt that the simulation has helped the students in understanding the basic concepts of functional units of a computer. Around 50% of the students have felt very good in the attainment level of Logisim in designing the ALU and RAM. The survey on attainment level of MarieSim and ARMSim are appreciable. Where they rated Excellent in understanding the interactions between the processor and the Memory and Working of ARM Instructions in ARM processor.

Table 3: Attainment level of each simulation tool in the lab

Sl.no	Survey questions	Results
1	Use of Simulation and practical approach to understand the Computer Organization and Design	**Was the Simulation helpful in understanding the concepts of functional units of a Computer** Yes 84% No 15% **Attainment Level of tools explored in the LAB** Excellent 33% Very Good 36% Good 25% Satisfactory 6%
2	Design of ALU and RAM using Logisim	**Attainment Level of Logisim tool for designing CPU, ALU, RAM** Excellent 28% Very Good 43% Good 24% Satisfactory 4%
3	Understanding the concepts of Single data path Bus and Communication between Processor and Memory	**Attainment Level of MarieSim tool for Understanding of Interconnection between Processor and Memory** Excellent 28% Very Good 43% Good 24% Satisfactory 4%
4	Understanding the working of ARM processor in the execution of ARM instructions	**Attainment Level of ARMSim tool for Understanding of ARM Instruction and the Architecture** Excellent 29% Very Good 34% Good 26% Satisfactory 7%
5	Understanding the working of MIPS processor in the execution of MIPS instructions	**Attainment Level of QTSpim tool for Understanding of MIPS Instruction and the Architecture** Excellent 26% Very Good 37% Good 26% Satisfactory 7%

5. Conclusion

Computer Organization education plays a key role for the students to understand functional units of a Computer and also to design the functional units. The Simulation using open source tools based approach for Computer Organization helps the students to understand practically the processor and its operation. The approach we have introduced in the course is in par with virtual labs introduced in. The mapping of categories of the experiments followed in the virtual labs is same as the different tasks carried out in our approach. Initially, the course was designed with only lectures based on the contents in the syllabus. Based on the student's opinion to improve the course content through a practical approach, the course was modified with new syllabi and lab. The proposed Simulation based approach for Computer Organization made students aware of the course contents and the principles and techniques of the course.

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Matching Learning Styles with Digital Media Preference for Recommending SQL Instruction in a Database Management Course

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Abstract: With the benefits of online learning environment, digital media related to personalized information of individual students have been rapidly developed. For learning Structured Query Language (SQL) in a database management system, although, there were various online learning systems, which were developed based only on single-source of personalization information, such as learning style, cognitive style or learning achievement. In this study, an innovative approach has been proposed by basing upon two main sources of personalization information that is, learning styles and digital media preference. This paper, a pilot study was conducted to explore the relation between learning styles and preferred digital media for arranging the sequence of digital media to each student learning on SQL topic.

Keywords: Online learning, SQL, learning style, digital media, personalized learning

1. Introduction

In the past decade, Structured Query Language (SQL) has been one of necessary programming languages to retrieve and manipulate database systems (Mitrovic, 2003). Teaching and learning SQL has been normally need in part of computing/IT courses (Connolly, 2006; Soflano, 2015). Previous research showed several digital media types for supporting learning SQL, such as computer-aided instruction, web-based learning, and computer game-based learning (Piyayodilokchai, Panjaburee, Laosinchai, Ketpichainarong, and Ruenwongsa, 2013; Latham, 2012; Soflano, 2015).

In recent years, learning style models has been recognized as a different way of learning and processing in personalized information, such as Felder and Silverman's index of learning style, Kolb, Rancourt's, hemispheric, and VAK. As mentioned in previous study, individual students have different learning experience based on their background, learning goal, and learning style (Kolb, 1984). With the reason, we have considered that the learning style could be applied to serve proper instruction for each student. Although, several researchers combined four of learning style models, such as Kolb's, Rancourt's, hemispheric and VAK to find the relation of learning styles and different multimedia types, such as animations and video materials, document with color discrimination, well-structured learning materials, audio learning materials to present learning material for each student (Ocepek, Bosnić, Šerbec, and Rugelj, 2013). However, it still was not considered in any specific learning content.

With the benefits of online learning environment, learning materials related to personalized information of students have been rapidly developed. The recommend system that provides appropriate learning materials by considering personalized information aims to increase learning performance; in other hand fixed digital learning material without consideration technology preference reduced learning performance (Vogel-Walcutt, Gebrim, Bowers, Carper, and Nicholson, 2011). Consequently, it was implied that the low level of learning performance might be affected by digital media types that did not fit with the students' learning style. Therefore, for supporting SQL learning, we have faced with the research question as follows: what is the method for recommending SQL digital instruction by matching learning styles with digital media preference?

In this pilot study, we focused on Kolb's and Felder–Silverman's learning style models, which are frequently used in adaptive E-learning system (Truong, 2016). To cope with the research question, this paper revealed the method and relation between two learning style model and preferred digital media for arranging the sequence of digital instruction to individual students for learning SQL.

2. Related Research

2.1 Learning styles

Learning style is the way individuals prefer to learn, which students perceived, and processing information that are reflected in their learning behavior; how students learn, how students like to learn, how teacher teach, and how students interaction with the learning environment (Felder and Brent, 2005; Kolb, 1984; Keefe, 1991; Reiff, 1992; Filippidis ,and Tsoukalas, 2009).

In the past decade, there are various researchers proposed learning style model such as Kolb (1984), Keefe (1979) and Felder and Silverman (1988). Previous studies have represented the use learning styles as a one factor for recommending personalized learning content (Graf, Viola, Kinshuk and Leo, 2007; Papanikolaou, Mabbott, Bull and Grigoriadou, 2006; Tseng, Chu, Hwang, and Tsai, 2008). Among learning style models, Felder and Soloman (1997) created Index of Learning Styles (ILS) questionnaire and developed Felder–Silverman Learning Style Model (FSLSM) which is the most appropriate model for developing e-learning systems (Hwang, Sung, Hung and Huang, 2012; Akbulut ,and Cardk, 2012; Kuljis and Lui ,2005).

The four main dimensions of the learning styles in Felder–Silverman Learning Style Model (FSLSM) with subsequent updates (Felder and Spurlin, 2005) contain two sub-styles: perception dimension (sensitive-intuitive), input dimension (visual-verbal), processing dimension (active-reflective), and understanding dimension (sequential-global). Particularly, the perception dimension is the most important learning style considered in (Felder, Felder, and Dietz, 2002; McCaulley, 1990). According, Kolb's learning theory set four experience type of learner, he believes that learning styles are not fixed personality traits, but relatively stable patterns of behavior depend on their background and their experiences. The four stage are concrete experience (CE) that being involved in a new experience, reflective observation (RO) which watching others or developing observations about own experience, abstract conceptualization (AC) that creating theories to explain observations and active experimentation (AE) that using theories to solve problems and make decisions. Kolb's model differs from others because it offers both a way to understand individual learning styles, which he named the "Learning Styles Inventory-LSI", and an explanation of a cycle of experiential learning that applies to all learners.

In adaptive learning systems, learning style information has been used to provide opportunity for students to learn in preferred way. Many researchers interested in different parts of online learning such as e-learning environment, predict of learning style and application for automatic classification of learning style type (Truong, 2016). Truong (2016) had reviewed 51 articles and grouping themes of integration of learning styles theories applied in adaptive e-learning system. The results showed that used theories of Felder-Silverman Model was 70.6%, Honey and Mumford Model and Kolb Model was 3.9%, VAK Model was 9.8% and 11.8% for others. Consequently, it is challenge to use Felder-Silverman Model synergy with Kolb Model in SQL learning for university students in Thailand context.

2.2 Digital Media in SQL Learning

Several researchers studied many types of digital media used in various subjects. Piyayodilokchai, Panjaburee, Laosinchai, Ketpichainarong, and Ruenwongsa (2013) developed CAI multimedia based on the 5E learning cycle model for teaching second-year undergraduate students. The results showed that using the CAI could help students' learning achievement better than other instructions. For the web-based learning environment, Lister (2014) suggested that development of E-Learning and Online Learning has been rapidly growth of learning. Some web-based learning was developed for teaching SQL content, such as Latham (2012), Mitrovic (2003), and Allen (2000) developed tutoring system. Moreover, based on the content in database course, the game-based learning focusing on supporting learner's skills was proposed (Connolly, 2006). In recent years, SQL topic has popularity development in computer game-based learning based on learning styles, which helped students to complete task faster than the other instructions (Soflano, 2015). It is clearly that E-learning systems has been included various types of digital material to delivery SQL content, in this pilot study, we have reviewed from articles published from 2000 to 2015; and then categorized the similar attributed into three groups, such as Computer-assisted instruction, Web-based learning, and Game-based learning.

3. The Proposing Matching Learning Styles with Digital Media Preference Approach

In this study, we have developed a web page embed questionnaires in order to explore students' learning styles and their frequencies to use digital learning. This phase was conducted by randomly selected undergraduate students from universities in Thailand (North, South, East, and Northeast parts of Thailand). Totally, there were 190 students who registered in database course or course related to SQL. We collected data with three tools are Index of Learning Styles developed by Felder and Soloman (1997), Learning Style Inventory developed by Kolb's Learning Style (KLS) (1995), and the Digital Media Preference Questionnaires.

Based on literatures of the digital material delivering SQL content, in this pilot study, we have employed three types of digital material for presenting SQL content such as M1: CAI; M2: Web-based learning; and M3: Game-based learning. Therefore, the framework of exploring relation between learning styles and digital material preference for recommending SQL instruction was shown in Figure 1.

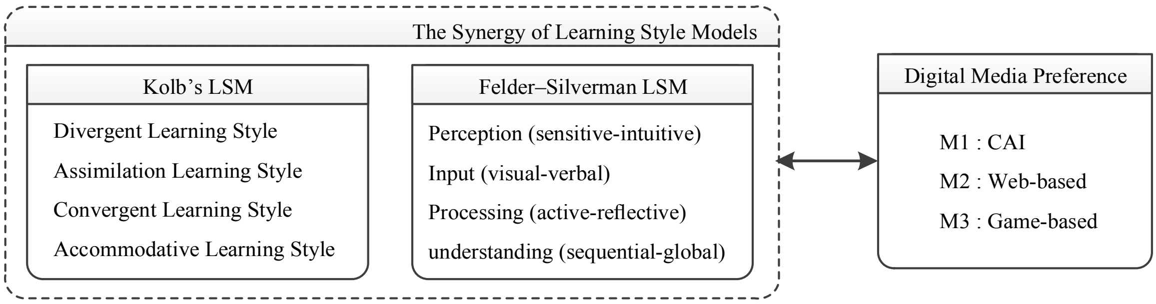

Figure 1. The synergy of learning style models and digital media preference

The participating students were asked to login to the web page to complete all questionnaires. After submitting learning style questionnaires, we exported data from the web page to excel format and then imported into Microsoft SQL Server for analyzing those data. We categorized student's learning style preference as shown in Figure 2.

Figure 2. Demographic of participants

The core of this pilot study is to combine two learning style models and find relation between learning style group and digital material preferences with Pearson's Correlation. Moreover, we analyzed by using Regression to find coefficient of determination (R square) and minimize the sum of squared errors of prediction (β) from equation $Y = a + \beta_1X_1 + \beta_2X_2 + \ldots + \beta_kX_k$ in which Y represents digital media types in four of Kolb Learning Style value from M1 to M3; "M1" represents CAI, "M2" represents Web-based learning and "M3" represents Game-based learning. For predictor variable X_i

represents Felder's learning styles as act, ref, sen, int, vis, vrb, seq and glo. If other X_1, X_2,.. and X_k are fixed, then for each change of 1 unit in X_i, Y changes β_i value. We observe a value of β_i, which Felder's learning styles (X_i) is most influence to digital material (Y). From this analysis, we can sort the sequence of digital learning which is suitable for each learning style group. In this phase, we proposed a mechanism to recommend the sequences of digital material for each student to learn SQL. The proposed idea to identify the sequential of Digital Media Mechanism Pseudocode following.

```
    Declare an array of string type variable called K_i
    Declare an array of string type variable called F_1
    Declare an array of string type variable called F_2
    Declare an array of string type variable called F_3
    Declare an array of string type variable called F_4
        For all Kolb learning type K_i = 1 to 4; K_i = [DIV  ASS  CON  ACC]do
        For all Felder learning type F_1 = 1 to 2; F_1 = [act; ref] do
        For all Felder learning type F_2 = 1 to 2; F_2 = [sen; int] do
        For all Felder learning type F_3 = 1 to 2; F_3 = [vis; vrb] do
        For all Felder learning type F_4 = 1 to 2; F_4 = [seq; glo] do
            For i = 1 to 3 do //all Digital Learning Types M ϵ {M_1, M_2, M_3}
                P_Mi = Min (P_MiF_1, P_MiF_2, P_MiF_3, P_MiF_4)
                Read β_Mi Value from P_Mi
            End for
            For i = 1 to 3 do //Find Each Sequence of Digital Learning Type
            If P_Mi is minimum and β_Mi >0 then
                S_Mi =1st
                Next P_Mi
                If P_Mi is minimum and β_Mi >0 then
                    S_Mi =2nd
                    Next P_Mi
                    S_Mi = 3rd
                Else
                    S_Mi = 3rd
                    Next P_Mi
                    S_Mi = 2nd
                End if
            Else
                S_Mi = 3rd
                Next P_Mi
                If P_Mi is minimum and B_Mi >0 then
                    S_Mi = 1st
                    Next P_Mi
                    S_Mi = 2nd
            Else
                S_Mi = 2 nd
                Next P_Mi
                S_Mi = 1st
            End if
        End if
        End for  //Sequence of  Digital Learning Type
    End for  // Felder learning type F_1
    End for  // Felder learning type F_2
    End for  // Felder learning type F_3
    End for  // Felder learning type F_4
End for  // Kolb
End for
```

4. Example of Results and Discussions

By using the proposed algorithm, we could categorize students learning style synergy group and sequence of digital material preference. The results of relation between Kolb's and Felder–Silverman's Learning Style models affected to Digital Material as shown in Figure 3.

Learning Style Cluster		Sequence of Digital Learning								
Kolb	Felder	M1			M2			M3		
		Seq.	Beta	sig	Seq.	Beta	sig	Seq.	Beta	sig
Diverger	INT	1st	0.123	0.200	2nd	0.024	0.803	3rd	-0.172	0.062
Diverger	VRB		0.094	0.320		0.026	0.786		-0.140	0.123
Assimilator	ACT		0.730	0.037*		-0.057	0.841		-0.457	0.119
Assimilator	GLO		0.426	0.194		0.120	0.717		-0.442	0.171
Assimilator	VRB		1.084	0.057		-0.379	0.456		-0.340	0.440
Converger	VRB		0.046	0.807		0.031	0.942		-0.113	0.852
Converger	GLO		0.370	0.163		-0.109	0.830		-0.247	0.732
Accomodator	SEQ		0.220	0.129		-0.078	0.588		-0.184	0.210
Accomodator	INT		0.183	0.210		-0.222	0.129		-0.010	0.946
Assimilator	INT	1st	-0.647	0.210	3rd	-0.559	0.317	2nd	1.107	0.059
Converger	ACT		0.678	0.045*		-0.394	0.466		-0.089	0.903
Converger	INT		0.497	0.074		-0.562	0.279		0.443	0.515
Accomodator	REF		0.074	0.596		-0.132	0.346		0.034	0.809
Accomodator	VRB		0.079	0.566		0.043	0.756		-0.131	0.353
Diverger	ACT	2nd	0.018	0.852	1st	0.095	0.332	3rd	-0.128	0.174
Diverger	GLO		0.026	0.791		0.203	0.035*		-0.257	0.006*
Assimilator	SEN		0.647	0.210		0.559	0.317		-1.107	0.059
Converger	SEN	3rd	-0.497	0.074	1st	0.562	0.279	2nd	-0.443	0.515
Converger	REF		-0.678	0.045*		0.394	0.466		0.089	0.903
Accomodator	ACT		-0.074	0.596		0.132	0.346		-0.034	0.809
Accomodator	SEN		-0.183	0.210		0.222	0.129		0.010	0.946
Diverger	SEQ	2nd	-0.026	0.791	3rd	-0.203	0.035*	1st	0.257	0.006*
Diverger	REF		-0.018	0.852		-0.095	0.332		0.128	0.174
Diverger	SEN	3rd	-0.123	0.200	2nd	-0.024	0.803	1st	0.172	0.062
Diverger	VIS		-0.094	0.320		-0.026	0.786		0.140	0.123
Assimilator	VIS		-1.084	0.057		0.379	0.456		0.340	0.440
Assimilator	SEQ		-0.426	0.194		-0.120	0.717		0.442	0.171
Assimilator	REF		-0.730	0.037*		0.057	0.841		0.457	0.119
Converger	VIS		-0.046	0.807		-0.031	0.942		0.113	0.852
Converger	SEQ		-0.370	0.163		0.109	0.830		0.247	0.732
Accomodator	VIS		-0.079	0.566		-0.043	0.756		0.131	0.353
Accomodator	GLO		-0.220	0.129		0.078	0.588		0.184	0.210

Figure 3. The results of relation between Kolb and Felder affected to Digital Learning

The results were analyzed by Liner Regression and using mechanism to arrange sequence of digital media. The results show that *p*-values and Coefficients (β) between each Kolb's Learning Style and one dimension of Felder–Silverman's Learning Style affecting to the first priority for arrangement. We had explained only a statistic significant (*p*-value < .05).

For discussion of significant data, the result of Assimilator mode and Active learner is M1 for being the first sequence. The group of students who had Assimilator mode learning based on experience related to Abstract Conceptualization (AC) and Reflective Observation (RO). They learn by readings, learning with lectures, need more time to think, and individual learning. For Active leaner of Felder learning style, they prefer to learn in-group and need the experimental practice. Because of CAI (M1) have properties to aim learning activities for this group such as drill and practice exercises, reading content, and individual interactive with system. But the reflective students with Assimilator group is need more time for process information before doing, then practice which is M1 is the last sequence.

For students who have Converging learning style with Active preference, the first sequence is M1. The Converger mode on experience related to Abstract Conceptualization (AC) and Active Experimentation (AE). They learn by a practical of idea, problem-solving approach, and do better in situation applications such as simulations that mostly exist in properties of CAI. Moreover, active leaner is experimentalist, which learns by doing. The opposite *p*-value of reflective with Assimilator group prefers to think more than doing, that is to say M1 is the last selected digital learning.

For students who have a Diverger mode with Global preference, the sequence are M2. This Diverger mode related to Concrete Experience (CE) and Reflective Observation (RO). Students had situated in Social, they learn by working in groups and need response their feedback such as Brainstorming. The students can chat or conference in their group, learning of web-based learning (M2) provided those properties. With the Global preference, the students can understand information by overview and when understand they jump to next step or next interested content, which include in web-based learning type. The *p*-value of Sequential contrast the global group, students prefer the understand information with increase each step-by-step and hard to grasp over picture. The reason of the game-based learning that created story line to students learns by increase small knowledge in each higher level is better media for Sequential group.

Each Kolb's Learning Styles and each of Felder's Learning Style had sequential results in Table 1, but it could not justify some conflict sequential like student who have Converger Mode with four Felder's learning style in ACT, INT, VRB, and SEQ. The Converger Mode with Active, Intuitive, and Verbal preferences provided M1 to be the first learning media, but the Sequential preference selected M3. Therefore, we proposed the mechanism for decision sequence of media, which using minimum *p*-value of four dimensions in each media type would most influence of selected sequence of digital learning.

In additions, we can categorize students learning style synergy group (Kolb's learning style model and Felder–Silverman's Learning Style Model) and sequence of digital learning preference. The correlations between three digital learning types are represented by circle and four of learning style synergy group represented by rectangles, and significant correlations represented by the arrows as shown in Figure 4. The solid line represents positive relation; the other dash line represents negative relation.

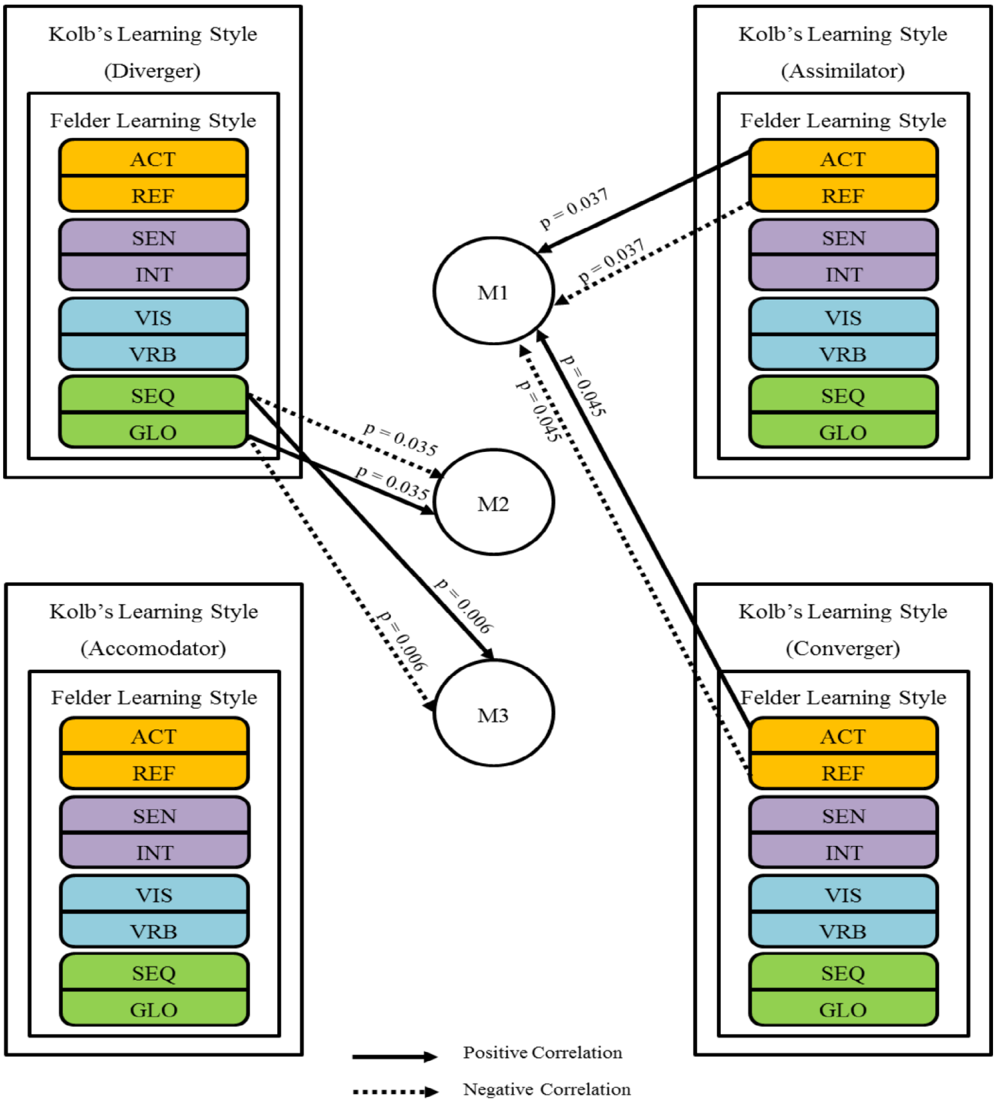

Figure 4. Relations of Synergy Learning Style Models and Digital Media Preference

To sum up, we could synergy the different learning style models in order to get information about student's learning preference. The results in Figure 4 show positive and negative correlation only significant values. For example, students who have the mode of Diverger experimentation (Kolb's learning style model) and a sequential preference (Felder–Silverman's Learning Style Model) seem to use Game-based learning (M3) as the positive correlation, but they avoid to using Web-based learning as the negative correlation. The reason is mode of Diverger like to gather information and need new experience that have properties matching in Games-based learning attribute normally created for challenge and gather data environment during playing a game. Otherwise, the reason is students who have a sequential preference learn in material step-by-step and increases small step when they understand, it similar to student playing in game each level will increase harder when they pass the level.

5. Conclusions

This paper presents an innovative approach for recommending sequence of digital material for learning SQL in university level by matching the Kolb's learning style model and the Felder–Silverman's Learning Style Model with the Digital Media preference to each student. Based on the proposed approach, an adaptive learning support system has been developing and implementing. To evaluate the performance of this innovative approach, an experiment on SQL in database management course of a university student will be conducted. 200 first year students will be recruited to compare the performance of the conventional web-based learning systems and our enhanced approach.

Figure 5 proposes the system architecture of the adaptive learning support system based on the proposed approach. We shall summarize the proposing system that the Registration of Learner module will provide opportunity for students to create their own profile for log into the system to complete questionnaires and learning activities. The students' data will be stored in Learner's Profile database. The system will calculate students' information in order to create digital learning sequences by using proposed mechanism and this information will be stored in Learning Sequence database. Recommendation Sequence of Digital Media module will provide sequence of digital media for each student. The students can select to confirm the recommended sequence or change digital learning sequence based on their preference before starting to learn in each unit of SQL in Confirm Recommendation module. If the students select the sequence of digital media by their own preference, the system will change sequence in Learning Sequence database. The Learning Content module connected with Learning Material database will provide SQL content for each student.

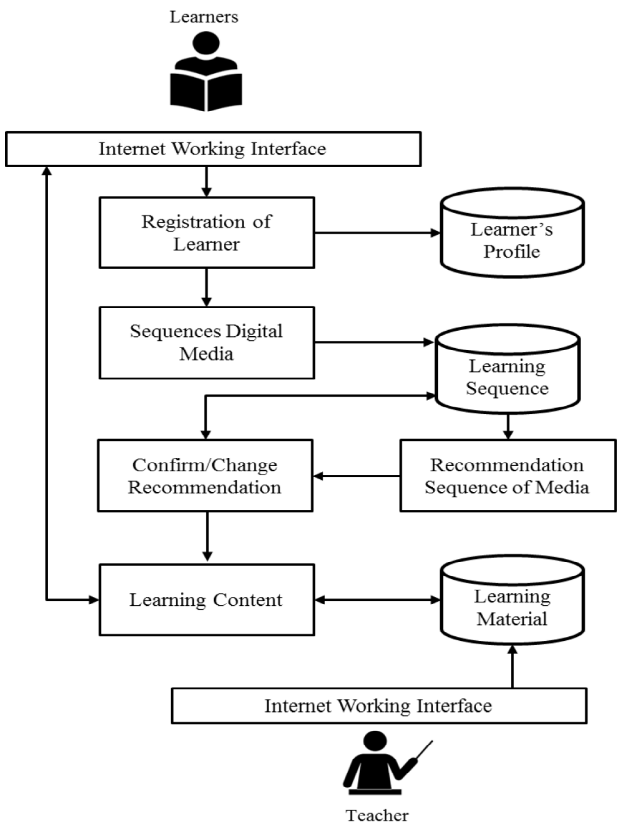

Figure 5. System Architecture of the Adaptive Learning Support System

The success of this study will plays an important role in enhancing the effectiveness of the entire adaptive web-based learning environment in SQL learning.

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A Process Model for Mapping Course Outcomes to Programme Outcomes

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Abstract: In recent past several higher education programmes are adopting outcomes based education (OBE) to address the technical developments and challenges effectively and efficiently. The essential element in OBE of any programme is Programme Outcomes (POs). Several courses are aggregated to address the POs of any programme. Many programmes in engineering education invariably concentrating on achieving outcomes prescribed by accreditation bodies. In this context Course Outcomes (COs) play major role as it is must for developing the assessment of student learning. To achieve this there is a need for proper mapping of courses to POs. Hence a methodology for mapping CO to PO based on key elements is provided in this paper highlighting the importance of each PO. In our methodology we evaluate the attainment of POs, which indeed based on the COs attainment considering the data from the results obtained by the students in various test items. The methodology is validated using the case study on the course taken from computer science. Further the methodology is highly useful in attainment of POs for improving POs which in turn improve the engineering programme vision and mission.

Keywords: Course Outcomes (COs), Educational Institutions, Outcomes Based Education (OBE), Programme Outcomes (POs)

1. Introduction

In this global scenario expectation of graduate engineers are addresses through various Accords, like Washington Accord, Sydney Accord, Dublin Accord addressing the knowledge, skill and attitude levels. The graduate engineers must have abilities according to the Washington Accord. Washington Accord essentially defines characteristics of a graduate engineer. These graduate attributes are taken into consideration while developing Programme outcomes (POs) by respective accreditation agencies like Accreditation Board for Engineering and Technology (ABET), National Board of Accreditation (NBA) etc. POs are essentially to be addressed by various courses and co-curricular activities of a Programme. The activities of the student are aggregated into attainment of POs. for this essentially a proper mapping of Course outcomes (COs) to POs is required. The PO attainment will be more accurate if understand the PO clearly. Proper care has to be taken in understanding POs with key elements and then mapping COs to POs.

In recent past, with the tremendous technical developments in the field of higher education, an effective and efficient education has always been a major challenge. The major challenges for many educational institutions have always been to improve the quality of the education they provide, the methods used, have always been the same (ABET, Curriculum Coordinating Council).

The increase in the numbers of engineering educational institutions, the healthy competitions among these institutions is also been raised. These competitions have let to the recognition of new ways of satisfying the stakeholders and providing international standards to imbibe quality education to the students making them more efficient in various fields of life. The standards of these organizations can be evaluated by the process of accreditations. These procedures will be within the Washington Accord and several other accords reflecting the graduate attributes. Several Institutions are establishing quality educational cells within the campus for the procedures adapted by accreditation.

The efficient assessment techniques both in internal and external quality has to be followed for evaluating the qualitative competence of the educational institutions in engineering and technology and related disciplines. Many of these institutions have invented their own methodologies for teaching and assessing the students. The major objective of these methodologies is to provide quality technical education to its students. To achieve this, the curriculum is to be developed into courses and each course has to be presented in the form teaching lesson plan consisting of topics and session outcome known as COs, that easily map into different POs. Those POs, which can be measured at the time of graduation must have a consistency in terms of course delivery and test items like internal and final exam, quiz, lab report, project report, assignment etc..

To achieve the profession and career accomplishments stated in the POs, the assessment of different courses is a strong way to measure the POs by considering a cohesive mapping of COs to POs. In general the faculty define the goals of the course i.e., COs, develop teaching lesson plan, develop POs that the course should address with respect to PO of the Programme.

Whenever a course is designed with some objectives, the teaching – learning process has to be defined appropriately. While designing the curriculum enough brainstorming sessions are done so that the COs and teaching – learning activities designed align with the POs and all these three fall in the same line so that this course would help in the attainment of the POs. It becomes very important that at the end of each course as to what level it helped in the attainment of POs. This is done in two methods called direct method which involved a semester end examination or by taking surveys from the various stakeholders of the organization (DILA).

The CO-PO mapping for a course based on the detailed weightages will be helpful in measuring the COs and also attainment of POs of the programme. Further it is more important to improve the successive curriculum development. The author in [6] developed a mathematical approach to generate indicators for the alignment of course content with CO and PO. Student performances were considered to derive these indicators and are hence used in assessing the CO and PO achievement. These results are used in realignment of the course content.

A framework that aligns the assessment of an outcome with the learning of the outcome is termed as 'Unit of learning' is proposed in (Forehand, 2009). This model takes into account only the learners, assessors and delivery methods, the assessment method and their relationships alone. It fails to provide an insight on how individual unit of learning can be consolidated to provide an assessment of achieving the POs.

An office automation system for assessment strategies important to improve the Programme design and delivery is developed by the faculty of engineering at Universiti Putra Malaysia (UPM). This system helped the faculty to monitor the OBE implementation.

Keeping the above discussion in view, we identified the importance of CO-PO mapping in the assessment of the Programme. Hence in this paper, the focus is on developing a methodology to well define the mapping of CO-PO. An illustrative case study is also presented in this paper

2. Basic Terminology

2.1 Accords

The Washington Accord is an international agreement responsible for accrediting engineering degree programs since 1989. The accord recognizes the substantial equivalency of programs accredited by those bodies and recommends that graduates of programs accredited by any of the signatory bodies be recognized by the other bodies as having met the academic requirements for entry to the practice of engineering. Flowing from the Washington Accord, a similar Agreement was developed for Engineering Technologists or Incorporated Engineers, called the Sydney Accord (SA), which was signed in June 2001.The Dublin Accord is an agreement for the international recognition of Engineering Technician qualifications signed in 2002 (International Engineering Alliance).

2.2 CO-PO Mapping

The procedure followed in mapping CO to PO as mentioned in Table 1 is done in a traditional way i.e. without allocating the weightage to the mapping. However our approach is addressing this limitation with the generic process model mentioned in section 3 and with the methodology mentioned in section 4.

Table 1 Sample Co-PO Mapping

CO-PO Mapping				
PO / CO	a	b	c	d
CO1	X	X		X
CO2		X	X	X
CO3	X	X	X	
CO4	X	X	X	X
CO5	X		X	X

3. Process Model

The generic process model used to obtain the CO to PO mapping matrix is shown in Figure 1 and the steps are explain in the methodology mentioned in section 4.

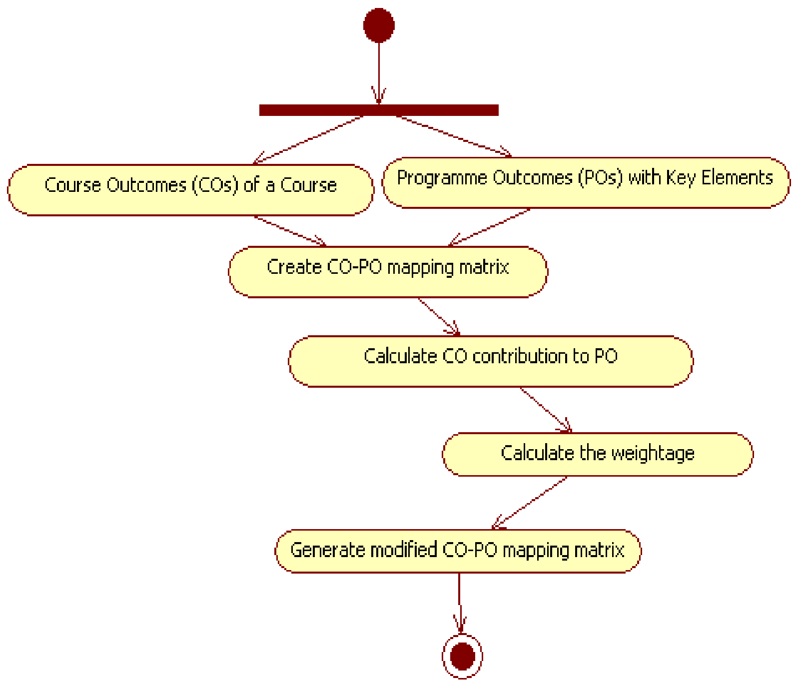

Figure 1. CO to PO Mapping Process Model

4. Methodology

To obtain the CO-PO mapping matrix, the steps described in the methodology are as follows

- Consider the POs (a) through (k) specified by ABET
- Generate a two column matrix Considering the POs along with their key elements given by (Besterfield-Sacre, M.E., et al , 2000)
- Consider the COs of a course and generate CO-PO mapping matrix for that course by

considering the POs key elements that are satisfied by each CO of a course

- Create a final CO-PO matrix based on the following 2 steps
  i. Calculate each CO contribution to PO as follows
     Contribution (C) = [(no. of key elements of a PO satisfied by the CO) / (no.of key elements
     belongs to the PO]*100
  ii. Calculate the weightage as follows
     If C is >=70 then assign grade '3' or if C is >=50 and <70 then assign grade '2' otherwise assign grade '1' to CO-PO mapping and obtain the final CO-PO mapping matrix

5. Methodology Illustration and Discussion

To illustrate the methodology consider a sample computer science course CA with course outcomes CO1 to CO5. Also consider the sample POs (*PO-a to PO-d)* related to the course CA along with their key elements as shown in Table 2.

Table 2: PO with key elements

Matrix1	
POs	No. of Key elements
a	3
b	4
c	14
d	15

The key elements pertaining to each PO as mentioned in Table 2 which are satisfied by an individual course outcome for the illustrated course are provided in Table 3.

Table 3: Key elements satisfied by each CO

No. of key elements each CO fulfills against the PO (Matrix2)				
PO / CO	a	b	c	d
CO1	2	1	0	10
CO2	0	2	10	12
CO3	3	3	7	0
CO4	3	4	5	9
CO5	1	0	8	5

From Table 3 it is observed that CO1 satisfies 2 key elements of PO-a, one key element of PO-b, no key elements of PO-c and 10 key elements of PO-d. Similarly CO2, CO3, CO4 and CO5 key elements list against the each PO can be observed in Table 3. Each CO contribution to PO is given a weightage based on the steps in the methodology. The results obtained are mentioned in Table 4.

Table 4: Final CO-PO mapping considering key elements

Resultant Matrix of CO-PO Mapping based on Key Elements (Matrix3)				
PO / CO	a	b	c	d
CO1	2	1	0	2
CO2	0	1	3	3
CO3	3	3	1	0
CO4	3	3	1	2
CO5	1	0	2	1

From Table 4 it is observed that the weightage acquired by CO1 against the PO-a to PO-d are 2,1,0,2 respectively. Similarly for other COs the list is also available in Table 3. This weightage is useful in assessing the contribution of a particular course in achieving the POs.

6. Conclusion

In educational accreditation process of several agencies, POs plays a major role. In designing curriculum understanding of key elements of POs is imperative. In this paper we developed a methodology that supports assessment of POs in the form of CO to PO mapping by considering the key elements supported by each PO. The methodology is validated with a case study on computer science course. This approach is useful in calculation of the attainment of POs which contains several courses of a programme. Further the approach is also useful in computing the PO attainment for improving the other engineering Programmes vision and mission

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Representative research on domain knowledge of students' environmental literacy for 21st Century Competencies Education

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Abstract: In order to investigate the relationship among the students' socio-demographic distribution, different scoring of environmental education objectives and various environmental educational objectives, the research directly quoted the Environmental Education Scale in environmental Literacy for high-level graders in elementary schools designed by Lin & Lin (2010) and Yang (2011), and did the questionnaire survey at an elementary school of Taoyuan District, Taoyuan City, Taiwan in May 2016, withdrew 266 copies of effective questionnaires. We analyzed questionnaire responses, and found that students' socio-demographic background just indicates the significant difference between different grades and whether ever been participated in on- or off-campus associations; nevertheless, students obtain the environment relative information mainly from their families, teachers and school education, and most favorable environmental education methods are outdoor experiential learning, peer discussion and teachers' instruction, etc.; various indicators in different value in environmental education objectives are positive attitude; finally, Pearson correlation coefficient tests that diverse environmental education objectives present significant difference, moreover respectively present low and medium level positive correlations, which could be provided as the reference data to evaluate the teaching process of environmental education curriculum for high-level graders in elementary schools.

Keywords: 21st century competencies education, environmental education, environmental literacy, high-level graders at elementary school

1. Introduction

In most educational contexts Environmental Education is not a compulsory subject. This is because it focuses on topics such as ecological conservation with a goal of influencing the wider public in caring about nature, rationally using natural resources, maintaining ecological balance, and in preventing and avoiding environmental problems. In addition, it has a kind of power which can produce reflection, feedback, propaganda and transfer for the environment (Wang, 2003). The tenet of environmental education is to prompt mankind to acquaint and be deeply concerned about the human and environment relevant problems, so as to make people have ability about environment knowledge, skills, attitude and action, work together to resolve existing environment problem and prevent generating new problems by individual or association (Yang, 1995). Yang (2007) pointed out that the purpose of education is to change human thought and behavior, so the key to resolve environment problems were to develop and promote the educational curriculum which conforms to the goal of environmental education. The Ministry of Education in Taiwan first established the Environmental Education Committee in Nov. 1992 in order to promote environmental education activities in Taiwan. It was accompanied by Executive Yuan's ministries, which have become the key part in school educational content in Taiwan. In order to cope with new trends of globalization, knowledge age and technological development, each country puts forward 21st century competencies education from different angles, in which environmental literacy becomes an emerging field (Shi *et al*., 2016). The ultimate goal of environmental education is to cultivate citizens having environmental literacy, but the development of environmental literacy must follow the principles of environmental education philosophy and objectives (Wang, 2003; Hsu, 2003; Lu & Hsu, 2011; Srbinovski *et al*., 2010). Regarding the concept of environmental literacy, Sia (1984) indicates that the person bearing responsible environmental behavior is same as the one having environmental literacy; Hungerford & Tomera (1985) considers that environmental literacy has 8 elements, namely ecological concept, environmental sensitivity, locus of control, knowledge of problem, belief, value, attitude and environmental action strategy, etc.; Roth (1992) believes that environmental literacy refers to environment cognition, environment relevant knowledge and attitude holding by individuals, having resolving problem' skills and incentives about environment, and having willingness to proactively maintain a dynamic balance between living and environmental quality. All of that are the core definitions adopted by environmental literacy researchers.

The environmental education implementation is essentially started from school education. About the knowledge contents of environmental education, research done by Frantz & Mayer (2014) and Sutton & Gyuris (2015) indicate that "environmental education teaches the environmental knowledge and experiences, and creates and changes people's belief, attitude and important behavior performance". In environmental education implementation process in Taiwan at present, environmental action practice, experience, examination and reflection about environmental issues are emphasized. But curriculum objectives of environmental education are to trigger the students' consciousness and sensitivities in educational activities, enrich students' relevant knowledge of sustainable environment, make students obtain correct value in the interaction between human and environment, possess improving and solving environmental problems' knowledge and skills when facing daily life and global environmental issues, in order to cultivate students' environmental action experiences, and ultimately objective is to make students have favorable environmental literacy. Furthermore, about research on environmental literacy in Taiwan, Hsu (2001) and Lang *et al*. (2011) showed that learning various environmental issues can promote the environmental literacy of the public and the purpose of environmental education is to cultivate the citizens who have environmental literacy and could adopt responsible environmental behavior. Lu & Hsu (2011) research the visitors' environmental literacy in Jinshan District, New Taipei City, the result reveals that the cognition of environmental literacy relates to recreation purpose, age, educational background, the number of visiting in Jinshan District; the affection of environmental literacy relates to age and the number of visiting in Jinshan District; in the end, the willingness of ecological conservation relates to recreation purpose, means of transportation and average monthly income, of which cognition, willingness, conservation of environmental literacy have positive correlation, but cognition has low correlation with conservation action willingness, which represents promotion of environmental literacy could not only just aim at the cognition dimension, but also enhance the dimension of willingness.

2. Research design and method

2.1 Research design

The research quoted the environmental education scale in environmental literacy for high-level graders in elementary schools designed by Lin & Lin (2010) and Yang (2011). The scale mainly includes two parts: first part is 7 socio-demographic item including gender, which grade students, parents' educational background, parents' occupation, source of environmental information, favorite environmental education methods, whether involved in on or off-campus association, of which parents' educational background, parents' occupation, career type and the most educated parent are check boxes; the second part is 5 environmental education objectives including "Environmental Awareness and Sensitivity", "Conceptual of Environmental Knowledge", "Environmental Ethics and Values", "Skill of Environmental Action" and "Experience of Environmental Action". The high-level graders in elementary schools in Taoyuan District, Taoyuan City are the research object. The grade 5 and grade 6 in the school has 11 classes respectively, average number of students in each class is 28, so the total number of high graders in the school is about 616. In order to make the sample conform to statistical inference, according to the sampling formula of Rea & Parker (1997) calculate that at least 237 student samples could fully reflect the parent population characteristics, the computation formula is as follow:

$$n = \frac{Za^2 \cdot [p(1-p)] \cdot N}{Za^2 \cdot [(1-p)] + (N-1) \cdot C_p^2}$$

"*n* showed the sample size, *N* showed the parent population, *Za* showed the confidence interval is 95% of the standard normal value (1.96), *Cp* showed the maximum admissible error (5%), *p* showed the parent ratio (0.25)".

2.2 Research method

2.2.1 Socio-demographic background information of high-level graders in an elementary school

Socio-demographic analysis uses descriptive statistics method, aiming at high-level graders' socio-demographic information to conduct frequency distribution statistics, and use Cramer's V value to explain the relationship strength between two categorical variables. In addition, in the socio-demographics of analysis of environmental information sources and favorite environmental education method, check boxes according to liking level in questionnaire design. The research just uses percentage distribution to represent the students' favorite sources of information or education methods.

2.2.2 Significance analysis in five key goals of environmental education

The objective of environmental education is to cultivate the citizen who has good environmental literacy. The research designs the questionnaire through the five key objectives of environmental education, then counts and orders the average values of various items to obtain the cognition degree of high-level graders in elementary school. After that, use one-way ANOVA of dependent samples to discuss. When the analysis results show significant difference ($p < 0.05$), use LSD（Least-Significant Difference）post hoc test to do difference analysis of significance of each item. Of which Conceptual of Environmental Knowledge should utilize choice question model to design the scale, therefore, the statistic results are presented in correct answer rate of various items.

2.2.3 Correlation of various items in environmental education

Analyzing correlation of various items in environmental education is to use Pearson correlation coefficient to test linear relationship in order to test the correlation among various item of environmental education. Of which, Pearson correlation coefficient is between 0~1, there is no or slight correlation when the coefficient is 0~0.25; there is medium level correlation when the coefficient is 0.51~0.75; there is high-level correlation when the coefficient is higher than 0.76 (Portney & Watkins, 2009).

3. Results and discussion

3.1 Socio-demographic background information of high-level graders in an elementary school

The researchers used "stratified random sampling" to select four or five classes in grade 5 and grade 6 as questionnaire samples, and authorized the teachers to distribute and recovery questionnaire in May, 2016. Through questionnaire filing, descriptive statistic results of socio-demographic background information are shown in table 1. First part is gender, female students is more than male in grade 5 and grade 6. In educational background of parents of grade 5, most graduates of senior high schools / higher vocational schools are 60, occupying 40.0%; the minimum of graduates is elementary schools / junior high schools (17 graduates, 11.3%). In educational background of parents of grade 6, most graduates of universities / junior colleges are 51, occupying 44.0%; the minimum of graduates is elementary schools / junior high schools (12 graduates, 10.3%). For parents' occupation, about 47 parents of grade 5 is in service industry, only 5 are soldiers & police and agriculture, forestry, fishery and animal husbandry; about 35 parents (30.2%) of grade 6 is in service industry, only 3 (2.6%) are soldiers & police and agriculture, forestry, fishery and animal husbandry: other percentages of parents' occupation in different occupation are a little bit different. For the item of whether participated in on- or off-campus association, 57.3% and 80.2% of students in grade 5 and grade 6 respectively did not do before, which are higher than the participators of 42.7% and 19.8%. Moreover, Cramer's V value explains the relationship strength of different socio-demographics; genders in different grades has weak relationship (Cramer's V=0.01), other socio-demographics in different grades show moderate relationship; whether participated in on- or off-campus association (Cramer's V=0.24) ＞ parents' occupation (Cramer's V=0.17) ＞parents' educational background (Cramer's V=0.11). The analytical results indicate that correlation of students' gender in environmental literacy is lowest one, and highest one is the item of whether participated in on- or off-campus association, which could be provided as the reference data to evaluate the teaching process of environmental education curriculum for high-level graders in elementary schools.

Table 1. Socio-demographic distributions of the students in study elementary school.

Socio-demographic	Item	Frequency (n) / percentage (％)				χ^2 （Cramer's V）
		Grade 5	％	Grade 6	％	
Gender	Male	73	48.7	56	48.3	0.01 （0.01）
	Female	77	51.3	60	51.7	
Parents' educational background (the higher）	Elementary school or junior high school	17	11.3	12	10.3	3.20 （0.11）
	Senior high school or vocational school	60	40.0	38	32.8	
	University or junior college	50	33.3	51	44.0	
	Institute and above	23	15.3	15	12.9	
Parent's occupation（the higher）	Soldier or police	5	3.3	3	2.6	7.33 （0.17）
	labor	23	15.3	9	7.8	
	Business	19	12.7	20	17.2	
	Agriculture, forestry, fishery and animal husbandry	5	3.3	3	2.6	
	Civil servant	18	12.0	10	8.6	
	Education personnel	8	5.3	7	6.0	
	Service industry	47	31.3	35	30.2	
	Others	25	16.7	29	25.0	
Whether participated in on- or off-campus association	Participated	64	42.7	23	19.8	15.50*** （0.24）
	Never participated	86	[illegible]	93	8	

Note：1. *** showed $p< 0.001$.

2. Cramer's V value of the scale of the strength of the relationship, in which Cramer's V<0.10 shoewd weaker relationship; 0.10≦Cramer's V＜0.30 showed moderate relationship; Cramer's V≧0.31 showed stronger relationship.

In the part of source acquired environmental related information by students, shown as table 2, highest proportion is 114 from families, occupying 42.9％, then is teachers (22.2％), computer network (10.9) in that order. From the analysis, information sourced from families and teachers occupies 65.1％, which reveals students acquire the environmental information from families and teachers. Besides, for the students' favorite environmental education method, the highest proportion is outdoor experiential learning (36.8％), then, in order, peer discussion (12.4％) and teachers' instruction (12.0％), so most favorable environmental education methods of students are outdoor experiential learning, peer discussion and teachers' instruction.

Table 2. Percentage of students on source of environmental information and favorite environmental education method.

Item	Source of environmental information		Item	Favorite environmental education method	
	Frequency (n)	%		Frequency (n)	%
Family	114	42.9	Outdoor experiential learning	98	36.8
School teachers	59	22.2	Discuss with classmates	33	12.4
Internet	29	10.9	Teacher in class	32	12.0
Television	21	7.9	Visit museum or conservation center	29	10.9
Outside reading	17	6.4	Doing experiments	24	9.0
School textbooks	13	4.9	Internet autonomous learning	23	8.6
Classmates or friends	11	4.1	Watching films or movies	16	6.0
Newspaper	2	0.8	Listening lectures	11	4.1

3.2 Significance analysis in five key goals of environmental education

In order to know the five key goals of environmental education for high-level graders in elementary schools (except dimension of "Conceptual of Environmental Knowledge"), analysis results are show in table 3. The average values of various items are between 3.72 to 4.78, and the total average value is 4.3 which is higher than the options (degree) of "Five-point Likert scale" which indicates that the attitude of students for environmental education goal scale is positive. In the ranking of cognition of various environmental education goals, the scores from high to low are "Environmental Ethics and Values" (4.49), "Environmental Awareness and Sensitivity" (4.31), "Skill of Environmental Action" (4.25) and "Experience of Environmental Action" (4.14). Among them, the average value of "Environmental Ethics and Values" is relatively higher, which presents that high-level graders have better attitude for environment. However, the values of "Skill of Environmental Action" and "Experience of Environmental Action" are lower than other dimension, which present there still has more efforts space in future environmental education in Taiwan.

Table 3. Mean and standard deviation for each item of key goals of environmental education

Key goals of environmental education	Item	Mean	S.D.
Environmental Awareness and Sensitivity	I think using the vehicle with gasoline engine will cause air pollution.	4.56 [a]	0.04
	I know using water and electricity is a good way to save energy and reduce environmental pollution.	4.52 [a]	0.04
	I know we should prepare shopping bags by ourselves which can reduce environmental pollution.	4.52 [a]	0.05
	I know joining in the activity of cleaning the school and neighborhood can improve the environment around us.	4.38 [b]	0.05
	I know our food comes from nature.	4.37 [b]	0.05
	I know the materials making clothes come from nature.	4.09 [c]	0.06
	I can notice the change of natural environment in school.	4.03 [c]	0.05
	I can notice the change of air quality around school.	4.02 [c]	0.06

Note：The same lower-case letters showed that there is no significant difference at the level of 5 %.

Continued table 3. Mean and standard deviation for each item of key goals of environmental education.

Key goals of environmental education	Item	Mean	S.D.
Environmental Ethic and Attitude	We should save water resources.	4.78 [a]	0.03
	I think humans should care for animals and plants equally, not destroying their homes.	4.69 [b]	0.04
	I will feel sympathetic if I see the stray animals abused.	4.59 [c]	0.04
	I can protect land from not being destroyed. (eg. Stop throwing away rubbish randomly.)	4.52 [c]	0.04
	I will respect primitive hunting culture and farming methods	4.45 [cd]	0.05
	I can understand and forgive different cultures.(some people eat meals using hands.)	4.37 [d]	0.05
	I should adopt reusable items (eg. environmental chopsticks and glass)to avoid throwing away after using.	4.33 [de]	0.07
	I am concerned about conditions of surrounding land usage.	4.20 [e]	0.05
Skill of Environmental Action	There are some jobs about trash classification and resource recycling in school.	4.72 [a]	0.03
	I will turn down the volume when I listen to music, because loud music will influence life of neighbors.	4.56 [b]	0.05
	I will turn off the light, electric fan and air conditioner.	4.55 [b]	0.04
	I think bathing in a tub will consume more water than showering.	4.20 [c]	0.07
	When foods are fulfilled in the fridge, this will influence circulation of cold air resulting in wasting electricity and not keeping cold.	4.16 [c]	0.06
	I will report to teachers when water pipes leak water.	4.12 [cd]	0.06
	I found directly using a blow dryer will waste more electricity after finishing washing hair.	3.97 [d]	0.07
	I can notice that there are some faces of animals in school.	3.72 [e]	0.08
Experience of Environmental Action	I will suggest my parents not smoke in public place.	4.53 [a]	0.05
	My family members often notice that the volume of TV, talking to each other is not too loud.	4.38 [b]	0.05
	I will prepare bags or recyclable tableware when shopping or having meals outside.	4.09 [c]	0.06
	I often suggest taking a bus, walking or cycling, not driving cars when going to place that are not far away.	4.09 [c]	0.06
	I am always drinking water instead of buying beverages.	4.04 [c]	0.06
	I suggest families use water again after washing fruits and vegetables.	4.03 [c]	0.07
	I often take the stairs instead of taking the lift.	4.00 [c]	0.07
	I will repeatedly use papers, plastic bags and bottles.	3.99 [c]	0.07

Note：The same lower-case letters showed that there is no significant difference at the level of 5%.

In the end, the dimension is shown in table 4. The items of “Which methods are effective to protect soil below?” and “Which animal is not insect?” got the highest correct answer rate, 98.1% and 89.8% respectively. These two items’ standard answers are “plant more trees; reduce the usage amount of fertilizer” and “spiders”. In the answer of first item, another three options are “disafforest, replant fruit trees and betel palm”, “exploit hilly land to build golf ground”, “heavy use pesticide to kill insect pest”, which are all actions against land conservation; about pest description of the answer of second item, pest belongs to arthropod which body is divided into three parts of head, chest and abdomen, but spider just has cephalothorax and abdomen, so it is not pest.

Table 4. The correct ratio of "Conceptual of Environmental Knowledge".

Key goals of environmental education	Item	Number of correct answer	Correct ratio (%)
Conceptual of Environmental Knowledge	Which methods are effective to protect soil below?	261	98.1
	Which animal is not an insect?	239	89.8
	Which one is not the damage caused by acid rain?	238	89.5
	Which one does not influence living things or the environment when soil is polluted?	226	85.0
	Which one is not air pollution that can cause bad influence for the environment and us?	195	73.3
	Which one is not the influence towards the environment brought on by global warming?	168	63.2
	Which one is not the main growth pattern and conditions of mold below?	119	44.7
	Which part in the structure of plants have the function of making nutrients?	63	23.7

3.3 Correlation of various goals in environmental education

In order to know more about the correlation among various environmental education items (except dimension of "Conceptual of Environmental Knowledge"), as well as the degree of their correlation, the research uses Pearson correlation coefficient to test every items. Among environmental education items, the analysis results all present significant difference, even just positive correlation, shown as table 5. According to the relation screening criterion of Pearson correlation coefficient values, "Environmental Awareness and Sensitivity", "Environmental Ethics and Values", "Skill of Environmental Action" and "Experience of Environmental Action" all present low correlation; "Environmental Ethics and Values" has low positive correlation with "Environmental Awareness and Sensitivity", "Skill of Environmental Action" and "Experience of Environmental Action"; "Skill of Environmental Action" has low positive correlation with "Environmental Awareness and Sensitivity", "Environmental Ethics and Values", and has medium positive correlation with "Experience of Environmental Action"; "Experience of Environmental Action" has low positive correlation with "Environmental Awareness and Sensitivity", "Environmental Ethics and Values", and has medium positive correlation with "Skill of Environmental Action".

Table 5. Pearson correlation coefficient of key goals of environmental education.

Key goals of environmental education	Environmental Awareness and Sensitivity	Environmental Ethic and Attitude	Skill of Environmental Action	Experience of Environmental Action
Environmental Awareness and Sensitivity	-	0.41***	0.50***	0.43***
Environmental Ethic and Attitude	0.41***	-	0.43***	0.43***
Skill of Environmental Action	0.50***	0.43***	-	0.66***
Experience of Environmental Action	0.43***	0.43***	0.66***	-

Note: *** showed that at significant level of 0.001 (two tailed), indicated significant correlation.

4. Conclusion

For students' gender, regardless of whether female or male students in grade 5 or grade 6, their parents educational background and occupation have similar trend, but in subdivisions of items have little bit difference; for the item of whether participated in on- or off-campus association, get more students never participated association than participated. Furthermore, students' gender has the lowest correlation with their socio-demographics in Cramer's V, but has the highest correlation with the item of whether participated in on- or off-campus association. For the significance analysis of five key goals of environmental education, the analysis of students' environmental education objectives (except dimension of "Conceptual of Environmental Knowledge") got the value 4.30 which is higher than the options (degree) of five-point Likert scale, which situation indicates that the attitude of students for environmental education goal scale is positive. In the ranking of cognition of various environmental education goals, the scores from high to low are "Environmental Ethics and Values", "Environmental Awareness and Sensitivity", "Skill of Environmental Action" and "Experience of Environmental Action". At last, utilize Pearson correlation coefficient to test the result of environmental education goals. Among different environmental education goals, statistical results present significant difference even is low to medium positive correlation.

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Establishing and Reorganizing the Evaluation Index System of Academic Advising in Sino-foreign Higher Education

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Abstract: Recent years, an innovation education model, the Sino-foreign college has been gaining its popularity in China. Compare to traditional Chinese education system, students under this kind of college will have more specific and complicated requirements. As we know from current literate research, academic advising would be an effective way of solving various problems from students. However, seldom have Chinese college had set up specific academic advising institutions, neither there is a universal standard to estimate the effectiveness of advising. So, this research aims to establish a complete evaluation index system to testify whether the current academic advising method is effective. We composed an original draft of the evaluation index, then conducted a random survey among students from Sino-foreign colleges in China to check out the importance of each evaluation index. Finally, we analyzed the survey result and then reorganized the evaluation index system by using hierarchical cluster method based on the result of the survey.

Keywords: Academic advising, educational evaluation index, hierarchical cluster

1. Introduction

As the world turns, more and more Sino-foreign cooperative higher education institutes had mushroomed in China. This innovation education mode consists of a traditional Chinese university and a foreign corporate college. Students will have similar education experience as foreign colleges while they are still in China. In that case, students under this kind of college will always have more complicated and diversified requirements than that in Chinese traditional colleges.

As we looked up scholarly research, we got to know that in America, colleges have a long history of setting up academic advising institutions (Chen,2014). These academic advising institutions are intended to solve various problems of college students, such as building up learning skills, selecting classes, and choosing or changing majors. According to the experiences of Harvard University and Stanford University, who are known as the pioneers of academic advising, some Chinese colleges also set up certain kinds of compulsory lectures that guide students get familiar with their majors as well as planning their future career in recent years (Ma, Liu,Li, 2004). Although all those methods are intended to help students better adapt to college life as well as prepare for the future, the fundamental form of academic advising in China is still different from that in the United States, and there are only a few Chinese colleges had set up specialized academic advising institution. Under that circumstance, it seems that we need a certain set of standards to estimate whether the current academic advising system is effective and reflected the requirements of students.

So, in this study, we are going to establish a complete system of evaluation index as the standard to estimate the effectiveness of current academic advising system. We will firstly summarize some important points from current literal research and investigate the current educational situation in China as the first draft of evaluation index system, then conduct an on-line survey to testify the importance of each index, and finally delete the repeated indexes and reorganize the evaluation index system by using hierarchical cluster method.

2. Research Process

2.1 Establish the Original Version of Evaluation Index

The process of academic advising requires the participation of both students and instructors. Originally, we considered estimating their behavior separately; however, we noticed that for students, the advising efforts would automatically reflect on some observable aspects, such as test score, psychological condition, and their general satisfaction. Thus, this evaluation index system will merely focus on the performance of instructors.

2.1.1 Investigation Trip in Qinghua University

From the literal research we read, we get the information that Qinghua University is the first college that set up academic advising institution in China (Zhou, J., 2014). So we went there for investigation, and we found out they set up the department of career planning and academic advising separately.

2.1.1.1. Department of Career Planning

The department of career planning in Qinghua University is an exclusive administrative department where recorded occupation status of graduates, stored students' documents and took charge of organizing activities like career fair in graduate seasons. Faculties there are merely taking charge of keeping those documents instead of giving reflective suggestions to student visit there.

2.1.1.2. Center for Student Learning and Development

The center for student learning and development is the right place that we hope to find where open to enrolled students and provided academic advising services. Students can make an appointment online through smartphones, and write feedbacks immediately. Faculties there are almost all the graduate students from Qinghua University, and they work there full-time to help their fellow students. They also told us they used experiences from Harvard University and Stanford University as references in the beginning, and gradually explored a more completed way that tailored to Chinese students. Also, they summarized some questions that frequently asked and printed pamphlets that free for students to take.

2.1.2 Original Version of Evaluation Index

Based on previous literal research papers and this investigation trip, we finished our original draft of evaluation index system. In the first draft of evaluation index system, we set up four general categories, which are known as the first-level index. They are Advising attitude and content, The qualification of advisors, Support from advising and Academic advising as a compulsory course. Each first-level index included several more detailed second-level index which will list in following passages.

2.1.2.1. Advising attitude and content

This first-level index evaluated whether the overall content is useful to students, which included nine second-level indexes: Patience of advisor, Accessibility of information provided, Motivation of advisor, Respect student privacy Communication with class instructors, Reflection and suggestions to the college, Contributions and improvements to study environment, Timely inform internship and social practice opportunities, and Practice of accessory services.

2.1.2.2. Academic advising as a compulsory course

This first-level index evaluated the qualification of advisors, which included six second-level indexes: Past experience of advisors, Professional ability of advisors, Current status of students had been consulted, Attitude of advisors, Reliability of advisors and Attendance of advisors.

2.1.2.3. Support from advising

This first-level index evaluated whether the information provided by academic advising content is useful for students, which included eight second-level indexes: Current situation of the job market, Relative research programs, Occupational requirements, Process of applying post-graduate education, Accessory services (Such as mock interview and resume revising), Relative academic lectures, Relative research programs, Internship and social practice opportunities.

2.1.2.4. Academic advising as a compulsory course

Since more and more Chinese Colleges had set up academic advising lectures, or similar academic advising courses, this first-level index evaluated the quality of academic advising when it set up as a compulsory course, including twelve second-level indexes: Course goal and syllabus, Quality of contents, Gratification of the content, Time management of the instructor, Evaluation mode of the course, Attendance of the instructor, Classroom manner of the instructor, Attitude of the instructor, Responsibility of the instructor, Classroom management, Keep on track with teaching process and Accessibility of the course content.

2.2 Estimate and Reorganize the Evaluation Index

2.2.1 Online Survey

After we settle down the original draft of the evaluation index, we need to get the opinion of students by turning the complete evaluation index system into a questionnaire.

2.2.1.1. Participants

This research is aiming to college students, so the participants of this survey should be full-time Sino-foreign college students that being randomly chosen in China.

2.2.1.2. Apparatus and Materials

Due to chronology and geographic limit, the most efficient way to get enough samples within the budget would be the on-line survey. The survey was published via Sojump (www.sojump.com), and it could be reached through smartphones. The results can be downloaded from Sojump in the form of Excel, which is suitable to be processed in SPSS in following sections. For convenience, we renamed each second-level index by arranging name from X1 to X35 to make the process of analysis easier.

2.2.1.3. Procedure

At the beginning of questionnaire, we asked some basic demographic information about participants, including their gender and current grade in college. We also asked participants to declare whether they are from Sino-foreign corporate college. If the answer is no, this survey will automatically terminate, and the result will not count as valid.

In the main section of the questionnaire, subjects were asked to estimate 35 second-level indexes and rate them according to their importance as five-point interval Likert-like scale. We suppose 5 points means strongly agree; 4 points means somewhat agree; 3 points means neither disagree nor agree; 2 points means somewhat disagree; 1 point means strongly disagree.

2.2.2 Reorganize the Evaluation Index

2.2.2.1. Reliability test

To make sure the collected data is amenable and reliable, we need to do a reliability test after we get the data. Reliability test estimated the consistency and stability of a sample (Jin, X., 2011). In this study, we use Cronbach's Alpha for the standard. The higher value of Cronbach's Alpha means higher reliability of the scale. To affirm the data set is reliable, the Cronbach's Alpha of a scale needs to be greater or equal to 0.6, and when the Cronbach's Alpha reach 0.8, this experiment will be regarded as ideal.

2.2.2.2. Clustering analysis

After testified the reliability of the sample, we can reorganize our evaluation index by conducting a clustering analysis. The clustering analysis would measure the similarity of each element, and build clusters even we do not know the specific number of categories (Zheng, Y., 2012). In this study, we will establish the final draft of evaluation index by reorganizing our 35 second-level indexes and use the method of Hierarchical Clustering for variable clustering (R).

3. Results

3.1 Reliability Test

Table 1: Reliability Statistics.

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.982	0.982	35

3.2 Descriptive Information of First-level Index

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Table 2: Descriptive Information of First-level Index.

Index	Number of rating 4	Number of rating	Mean	Sd.
Patience	67(21.54%)	201(64.63%)	4.42	0.95
Accessibility of information provided	66(21.22%)	199(63.99%)	4.41	0.94
Motivation	69(22.19%)	142(45.66%)	4.02	1.09
Respect student privacy	45(14.47%)	218(70.1%)	4.46	0.98
Communication with class instructors	88(28.3%)	145(46.62%)	4.11	1.04
Reflection and suggestions to the college	77(24.76%)	171(54.98%)	4.24	1.04
Contributions and improvements to study	72(23.15%)	175(56.27%)	4.27	1.01
Timely inform internship and social practice	76(24.44%)	157(50.48%)	4.15	1.03
Practice of accessory services (Such as mock interview and resume revising)	93(29.9%)	148(47.59%)	4.42	1.05

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Table 3: The qualification of Advisors.

Index	Number of rating	Number of rating 5	Mean	Sd.
Past experience of advisors	101(32.48%)	141(45.34%)	4.13	1.01
Professional ability of advisors	52(16.72%)	227(72.99%)	4.54	0.91
Current status of students had been consulted	77(24.76%)	186(59.81%)	4.36	0.96
Reliability of advisors	102(32.8%)	142(45.66%)	4.16	0.95
Attitude of advisors	94(30.23%)	161(51.77%)	4.25	0.97
Attendance of advisors	94(30.23%)	138(44.37%)	4.09	1.02

Table 4: Support from Advising.

Index	Number of rating 4	Number of rating	Mean	Sd.
Current situation of the job market	85(27.33%)	166(53.38%)	4.25	0.99
Relative research programs	69(22.19%)	183(58.84%)	4.30	1.01
Occupational requirements	79(25.4%)	176(56.59%)	4.31	0.95
Process of applying	85(27.33%)	176(56.59%)	4.32	0.95
Accessory services	95(30.55%)	164(52.73%)	4.27	0.98
Relative academic lectures	98(31.51%)	112(36.01%)	3.93	1.01
Relative research programs	93(29.9%)	131(42.12%)	4.04	1.02
Internship and social practice opportunities	87(27.97%)	158(50.8%)	4.19	1.02

Table 5: Academic Advising as a Compulsory Course.

Index	Number of rating 4	Number of rating	Mean	Sd.
Course goal and syllabus	89(28.62%)	179(57.56%)	4.36	0.91
Quality of contents	70(22.51%)	193(62.06%)	4.39	0.93
Gratification of the content	89(28.62%)	165(53.05%)	4.26	0.98
Evaluation mode of the course	91(29.26%)	169(54.34%)	4.31	0.92
Time management of the instructor	93(29.9%)	164(52.73%)	4.29	0.92
Attendance of the instructor	75(24.12%)	183(58.84%)	4.33	0.98
Classroom manner of the instructor	88(28.3%)	154(49.52%)	4.18	0.99
Attitude of the instructor	51(16.4%)	224(72.03%)	4.53	0.91
Responsibility of the instructor	84(27.01%)	145(46.62%)	4.09	1.06
Classroom management	87(27.97%)	169(54.34%)	4.28	0.97

Index	Number of rating 4	Number of rating	Mean	Sd.
Keep on track with teaching process	84(27.01%)	181(58.2%)	4.36	0.92
Accessibility of the course content	66(21.22%)	204(65.59%)	4.45	0.93

3.3 Clustering Analysis

3.3.1 Cluster Process

Table 6: Cluster Process

Stage	Cluster Combined		Coefficients	Stage Cluster First Appears		Next Stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	17	18	0.893	0	0	2
2	16	17	0.873	0	1	9
3	26	27	0.865	0	0	8
4	24	25	0.857	0	0	11
5	1	2	0.834	0	0	17
6	6	7	0.819	0	0	25
7	31	35	0.818	0	0	10
8	26	28	0.812	3	0	15
9	16	19	0.807	2	0	13
10	31	34	0.801	7	0	14
11	11	24	0.789	0	4	15
12	21	22	0.783	0	0	19
13	16	20	0.780	9	0	27
14	31	33	0.770	10	0	16
15	11	26	0.757	11	8	22
16	29	31	0.743	0	14	23
17	1	4	0.735	5	0	29
18	10	13	0.722	0	0	28
19	21	23	0.721	12	0	33
20	8	9	0.711	0	0	25
21	14	15	0.704	0	0	28
22	11	12	0.700	15	0	27
23	29	32	0.695	16	0	26
24	3	5	0.691	0	0	29
25	6	8	0.689	6	20	31
26	29	30	0.680	23	0	30
27	11	16	0.655	22	13	30
28	10	14	0.637	18	21	32
29	1	3	0.635	17	24	31
30	11	29	0.623	27	26	32
31	1	6	0.609	29	25	34
32	10	11	0.597	28	30	33
33	10	21	0.581	32	19	34
34	1	10	0.565	31	33	0

3.3.2 Tree Diagram

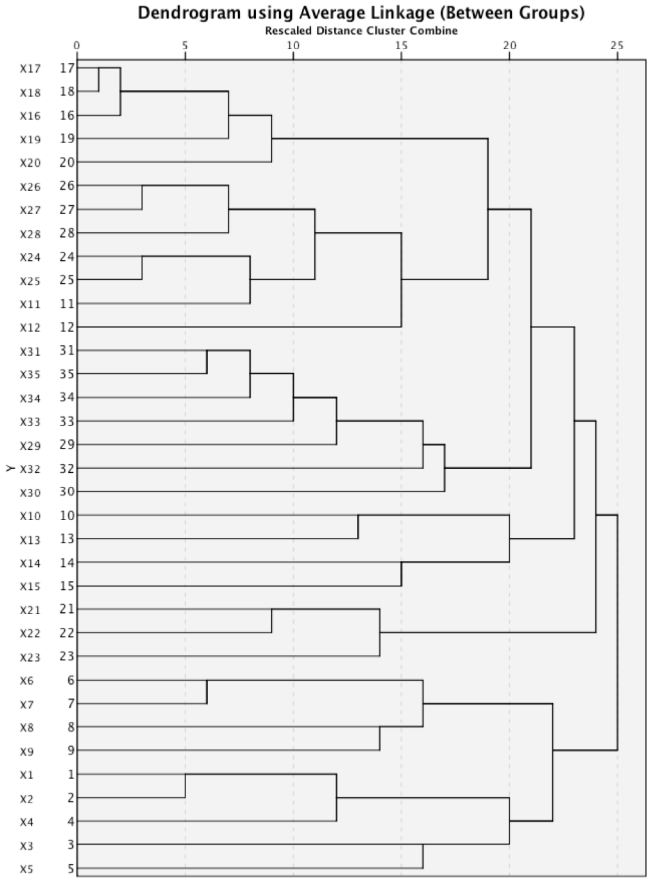

Figure 1. Diagram Using Average Linkage.

4. Discussions

4.1 Reliability Test

Although we found out that some students are giving all index the lowest score, we still keep this part of the data. By using SPSS, we observed that the Cronbach's Alpha of this scale had reached 0.982, which indicates the questionnaire has a great internal consistency and reliability. It also showed the independence of the sample is strong, and the target of this questionnaire is clear.

4.2 Descriptive Information of First-level Index

The charts showed general descriptive information of each index. As we can see, there are only six indexes whose number of people rating 4 and 5 are less than 75%. They are Motivation, Communication with instructors, Attendance of advisors, Responsibility of the instructor, Relative academic lectures, Relative research programs. Also, the standard divination of almost all indexes is around 1, which demonstrated there were merely minor influences of extreme value. The original version of the criteria could be regarded as well represented the requirements of students.

4.3 Clustering Analysis

The Agglomeration Schedule listed the detailed cluster process and relative coefficient. Under the circumstances that several second-level indexes may including similar meaning, we can merge them to make the evaluation index simple.

As we can see from the diagram, the result of cluster analysis could be observed as seven general clusters. Except for Professional ability of advisors (X11) and Current status of students had been consulted (X12) that are rearranged to the group that contains indexes X24 to X28, the number in each category is overall in sequence, which indicated that the original organization of index is appropriate.

The first general cluster included Current situation of the job market (X16), Relative research programs (X17), Occupational requirements (X18), Process of applying post-graduate education (X19) and Accessory services (Such as mock interview and resume revising) (X20). The index X16, X17, and X18 had been merged in an early step, so we merge them as Developmental information for students, and this category will be renamed as Support for future planning.

The following cluster included Course goal and syllabus (X24), Quality of contents (X25), Gratification of the content (X26), Time management of the instructor (X27), Evaluation mode of the course (X28), Professional ability of advisors (X11), and Current status of students had been consulted (X12). X26 and X27 will be merged as Manipulation of course content. X24 and X25 will be merged as General information of the course. Since the general content of this category had not been changed, this category will be still named as Academic advising as a compulsory course.

The following three clusters are quite independent when compared to other clusters. Each second-level index had not been merged until very late so that we will preserve the name of each second-level index in these three clusters. The cluster including Attendance of the instructor (X29), Classroom manner of the instructor (X30), Attitude of the instructor (X31), Responsibility of the instructor (X32), Classroom management (X33), Keep on track with teaching process (X34), and Accessibility of the course content (X35) will be renamed as Classroom management of advising compulsory course. The cluster including Past experience of advisors (X10), Attitude of advisors (X13), Reliability of advisors (X14), and Attendance of advisors (X15) will be renamed as The qualification of advisors. The cluster including Relative academic lectures (X21), Relative research programs (X22), Internship and social practice opportunities (X23) will be renamed as Practical opportunities provided by academic advising.

Another cluster including Reflection and suggestions to the college (X6), Contributions and improvements to study environment (X7), Timely inform internship and social practice opportunities (X8), and Practice of accessory services (X9). In this cluster, X6 and X7 will be merge as General improvements to the college, and the cluster will be renamed as Contributions to academic advising.
The last cluster is consists of Patience of advisor (X1), Accessibility of information provided (X2), Motivation of advisor (X3), Respect student privacy (X4), and Communication with class instructors (X5). X1 and X2 will be merged as The kindness of advisor, and this cluster will be renamed as Properties of advisor.

4.4 Rearranged Index Based on Cluster Result

4.4.1 Support for future planning

This first-level index will evaluate the support of academic advising in the aspect of future planning, including following three second-level indexes: Developmental information for students, Process of applying post-graduate education and Accessory services (Such as mock interview and resume revising).

4.4.2 General administration of advising compulsory course

If we set academic advising as a compulsory course, this first-level index will evaluate how well will this instructor maintain and planning the class. This first-level index including following seven second-level indexes: Manipulation of course content, Evaluation mode of the course, General information of the course, Professional ability of instructors and Current status of students had been consulted.

4.4.3 Classroom management of advising compulsory course

Following the general administration, this first-level index will typically evaluate the classroom manner under control of instructor, including following seven second-level indexes: Attitude of the instructor, Accessibility of the course content, Keep on track with teaching process, Classroom management, Attendance of the instructor, Responsibility of the instructor, and Classroom manner of the instructor.

4.4.4 The qualification of advisors

To evaluate the qualification of the instructor as an academic advisor, we need to including following five second-level indexes: Past experience of advisors, Attitude of advisors, Reliability of advisors, and Attendance of advisors.

4.4.5 Practical opportunities provided by academic advising

This first-level index will evaluate the practice opportunities that informed by academic advising, including following three second-level indexes: Relative academic lectures, Relative research programs, Internship and social practice opportunities.

4.4.6 Contributions to academic advising

We also need to evaluate the contributions that provided by academic advising. This first-level index will include three second-level indexes: General improvements to the college, Timely inform internship and social practice opportunities, Practice of accessory services.

4.4.7 Properties of advisor

Finally, we need to estimate the general characteristic of advisors. This first-level index consists of four second-level indexes: The kindness of advisor, Respect student privacy, Motivation of advisor and Communication with class instructors.

4.5 Limitations and Future Planning

The current stage of our study had already finished the complete evaluation index for academic advising in Sino-foreign corporate higher education. However, the best way to check if our estimation model is useful is to have a real practice. We can accomplish this by collecting the result from colleges that using our estimation index. Furthermore, reading more literal research papers will always contribute a wider view of our study. These are all improvements we could make in later stages.

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Scaffolding of Thinking about Structure with Kit-Building Task

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Abstract: In this paper, we introduced interactive environment for "learning by problem-posing" in arithmetic word problems. This problem-posing task is designed based on a structure model of arithmetic word problem and the task is realized by selection and combination task of provided sentences. This research expects that a learner is promoted to think about structure of arithmetic word problem through the activity of the problem-posing. We call this task "kit-building task". We think that design "kit-building task" based on "structure model" is a promising approach to realize promotion "thinking about structure". In this paper, we introduce learning by problem-posing as an example of this approach. Through presentation and discussion about this approach in TELoTS, we would like to make clear the relation between "Thinking Skills" and this research.

Keywords: Thinking about Structure, Kit-Build Task, Learning by Problem-Posing, Thinking Skills

1 Introduction

This paper describes a method to promote thinking about structure [Hirashima et al. 2016] with kit-building task [Hirashima et al. 2015a]. Problem-solving exercise is a very popular activity for learning. However, through the exercise, although a learner works on mastering the way to derive an answer by using a solution method as the purpose of the exercise, the learner often doesn't pay attention to understand the problem or solution method. Without such understanding about the problem or solution method, the learner is usually able to derive a correct answer for the problem with the solution method. Therefore, if we set a goal of learning at such understanding, problem-solving is not an enough task. In this research, we propose kit-building task that requests a learner to compose an understanding target by using components that are provided beforehand. It is possible to say the combination of the components is the structure of the target. Therefore, the activity to compose the target by the components requires a learner to think about the structure of the target in various ways. We call this thinking "thinking about structure" and the task "kit-building task". In this paper, as targeting arithmetic word problems, a structure model of the word problems called "triplet sentence model" [Hirashima et al. 2014], and "learning by problem-posing" [Hirashima et al. 2000] as a kit-building task to promote "thinking about structure" are introduced. Through presentation and discussion in TELoTS, we would like to make clear the relation between "Thinking Skills" [Beyer 88] and a series of our researches.

2 Thinking about Structure through Problem-Posing

2.1 Learning by Problem-Posing in Arithmetic Word Problems

In this subsection, problem-posing task of arithmetic word problems designed on "triple sentence model" is introduced. An interactive problem-posing environment of arithmetic word problems [Hirashima et al. 2007] (we call it MONSAKUN, that is, Problem-Posing Kid in Japanese) has been developed and practically used in arithmetic classes in several elementary schools at the first grade (addition and subtraction) [Yamamoto et al. 2012], the second grade (multiplication) [Yamamoto et al. 2013], and the third grade (multiplication and division) [Yamamoto et al. 2014].

Several investigations have already indicated that problem-posing of arithmetic word problems are promising learning activity [Ellerton et al. 1986]. However, this activity gives heavy load to both a learner and a teacher. It is usually hard for a learner to make sentences from scratch. The learner often feels difficult how to write sentences, select story or numbers that are not so important from arithmetical point of view. Although posed problems and their posed processes are different in each learner, it is impossible for a teacher to diagnose posed individual problems in real time. Therefore the learner is not able to receive individual support. Even if the teacher gives up diagnosing the posed problems in real time, to diagnose all problems posed by a set of learners is a time-consuming task. Moreover, it is not easy for the teacher to use the diagnosed results for teaching effectively because of time lag between the class of problem-posing and the class of feedback based on the results. Because of these difficulties, it was rare that a class of learning by problem-posing was carried out. Agent-assessment is a solution of this issue [Hirashima et al. 2000]. To realize the agent assessment, kit-build approach is a promising approach.

The workspace of the problem-posing activity is shown in Figure 1, and Figure 2 shows a scene where a student is using MONSAKUN for problem-posing. In the upper left side of the interface, a calculation "8-6" and a type of arithmetic story (an increase story) [Riley et al. 1983] are assigned (these words were translated from Japanese into English). A learner is required to pose a problem that can be solved by the calculation and belongs to the specified type of arithmetic problem by using sentence cards provided in the right side of the interface. The set of sentence cards includes not only the necessary ones but also unnecessary ones (the unnecessary card is called dummy card). In the lower left side, there are three blanks where a learner puts sentence cards in order to complete a problem. In Figure 1, two cards have been put in the blanks. In this case, correct problem is {(1) "There are 6 apples.", (2) "Several apples are given.", (3) "There are 8 apples."}. The story of this problem is "increase" that can be expressed as "6+?=8", and then, the calculation is 8-6. In the case of Figure 1, the two cards are wrongly put into the first and the second blank. From the two cards, although it is possible to pose a problem that is solved by "8-6", the story of the problem is "decrease" that is expressed as "8-6=?" and there is no necessary card to complete the problem, that is, "there are several apples". By pushing the "Check the problem" button, the posed problem is diagnosed and the learner is able to receive feedback based on the diagnosis.

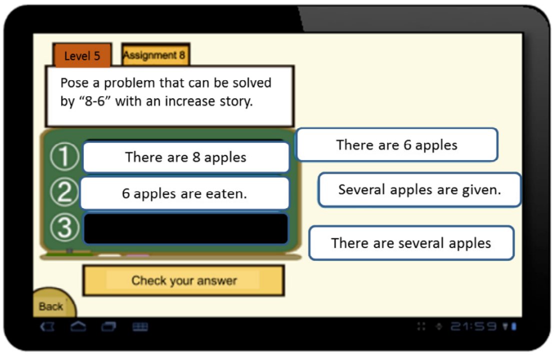

Figure 1. Workspace of Problem-Posing.

Figure 2. A Scene of Practical Use.

In MONSAKUN, the task to pose a problem is externalized as (1) selection of sentence cards and (2) ordering the selected sentence cards based on the model of information structure of arithmetic word problem. In other words, a learner can operate structure of an arithmetic word problem by operating sentence cards. In usual problem-posing situation, only a posed problem appears as the result of thinking of a learner. Therefore, the problem-posing is a typical thinking task in mind. In contrast, in MONSAKUN, components of a problem are visualized for a learner as operatable ones. Then, the learner is able to compose a problem through visual operations of the components. Therefore, it is possible to say that the MONSAKUN realizes a kit-building task to promote thinking about structure.

2.2 Triplet Sentence Model

In MONSAKUN, problem-posing task is designed based on a model of an arithmetic word problem called "triplet sentence model" [Hirashima et al.2014]. In the model, a basic arithmetic word problem is composed of three sentences. Then, the problem-posing task is designed as combination of the sentences. An arithmetic word problem should be solved using one or more basic arithmetic operations. A problem that can be solved by one basic operation is called basic arithmetic word problem. Since one operation composed of three numerical values, that is, two operands and one result, the basic arithmetic word problem includes three arithmetic concepts corresponding to the three numerical values. By writing a pair of the arithmetic concept and its value in a sentence, it is possible to express a basic problem by using three sentences. In the triplet sentence model, the sentences are categorized into two types, that is, (1) existence sentence and (2) relation sentence. The existence sentence includes an independently existing arithmetic concept and its numerical value. For example, "there are six apples" or "there are two dishes" are existence sentences. The relation sentence includes an arithmetic concept and its value that expresses a relation between other two existence sentences. For example, "two apples are eaten" expresses the relation between the number of apples before eating and after eating. "There are six apples" and "there are four apples" is able to be connected by the relation sentence. By arranging the three sentences in the following order: "there are six apples, "two apples are eaten" and "there are four apples", an arithmetic story is formed. The story is transformed to a problem by changing a numerical value to unknown one and requesting to derive the value from other two values.

Based on this model, it is possible to derive several problems from one existence sentence as shown in Figure 3. Bold rectangles are relation sentences and others are existence sentences. An existence sentence can be used in all kinds of stories/problems although its role is different depending on the type of stories/problems. The types of arithmetic word stories/problems solved by addition or subtraction are categorized into following four stories: change-increase, change-decrease, combine, compare. Compare stories are often classified into compare-more story and compare-less story. As for the stories/problems solved by multiplication or division, there is only one story and the story is composed of three factors, that is, "base quantity", "proportion quantity", and "comparison quantity". Relation between them are expressed "base quantity" * "proportion quantity" = "comparison quantity". In both multiplication story and division story, three arithmetical concepts are assigned to one of them. In the story of multiplication or division, an existence sentence plays a role of the proportion quantity or the comparison quantity. The base quantity is assigned only relation sentence. In Figure 3, "one apple is 80 cents" and "2 apples on one dish" are relation sentences that play the role of base quantity. The existence sentence "there are 6 apples" expresses the portion quantity when the relation sentence is "one apple is 80 cents", and it expresses the comparison quantity when the relation sentence is "2 apples on one dish".

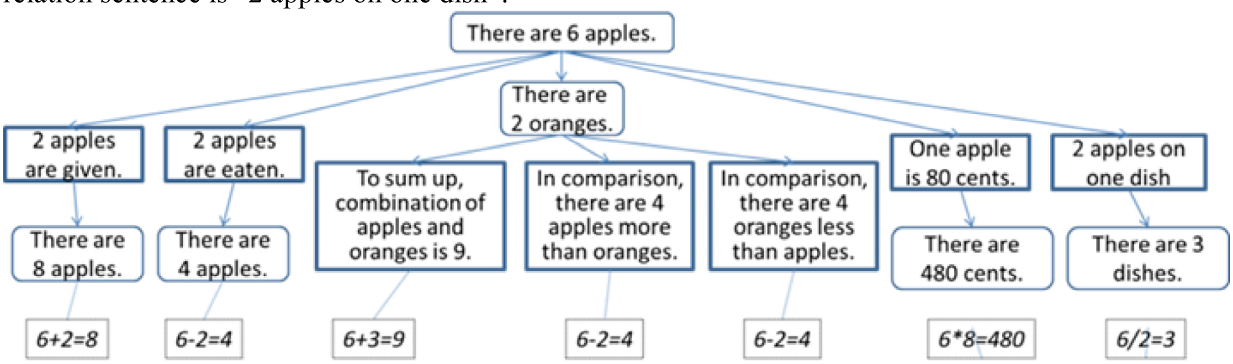

Figure 3. Various Problems Derived by the Same Existence Sentence.

Based on this model, it is possible to design various kinds of activities to manipulate the structure of arithmetic word problems and to implement diagnosis and feedback function for the activities. Through practical use of MONSAKUN, it has been confirmed that operating the sentence cards doesn't disturb learners' thinking process and promotes the task of problem-posing. Moreover, learning effect for structural comprehension of arithmetic word problems has been observed.

Therefore, it is possible to say that the investigation about MONSAKUN is a promising example of externalization of thinking tasks. These researches deal with a basic problem that can be solved by one arithmetic operation. In order to deal with more complex problem that can be solved several operations, triangle block model and interactive learning environment based on the model have been investigated [Hirashima et al. 2015b]. Because of page limitation, they are not introduced in this paper.

3. Conclusion Remarks

In this paper, interactive environment for "learning by problem-posing" in arithmetic word problems was described. In the presentation in workshop, we will introduce practical example of promotion of "thinking about structure". We also discuss other promising challenge for promotion of "thinking about structure" with "analogy" and "reading comprehension" [Hirashima et al. 2016]. Through this presentation and discussion, we would like consider contributions of current our researches to "Thinking Skills".

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Promoting Productive Disciplinary Engagement in Engineering Design Using a CAD tool

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Abstract: Engaging young students with the engineering design process and scaffolding the learning of effective design thinking skills is an ongoing endeavor for engineering education researchers. In this design and deployment paper, we describe the design of an innovative curricular material using a computer aided design (CAD) tool for promoting productive engagement with disciplinary practices of tradeoffs and design optimization. We present preliminary qualitative findings from our design based research study that indicate the effectiveness of our intervention and highlight ongoing as well as future work by our team to advance the community's understanding of how to effectively scaffold the learning of effective design thinking skills via technology as well as curricular materials.

Keywords: Engineering design, design thinking, tradeoffs, computer aided design, design journal

1. Introduction

Over the last decade, there has been a growing attention towards engineering design education amongst K-12 as well as undergraduate education researchers. An improved understanding of the engineering design practices has been identified as being critical for preparing a highly-skilled workforce that is ready to tackle the 21st century challenges. At the heart of the engineering design process is the practice of making tradeoffs (Dym, Agogino, Eris, Frey, & Leifer, 2005). Students have to make connections between multiple design variables, evaluate multiple and often competing solutions based on the design goal, and take design decisions that lead to an optimal design (Dym et al., 2005; Silk & Schunn, 2008). However, students find it challenging to engage with this process and connect multiple parameters to make effective tradeoffs (Zohar, 1995).

In this paper, we suggest a way of tackling this challenge and supporting middle school students' productive engagement with the engineering design process using a computer aided simulation (CAD) tool called Energy3D (available at http://energy.concord.org/energy3d). CAD tools have been found to scaffold students' design thinking process and promote productive work (Kern & Crippen, 2013). These tools afford quick simulation and testing of design ideas. While the use of CAD tools to support the engineering design process is not new, we have designed companion scaffolds to support the integration of Energy3D within the middle school curriculum by providing immediate feedback to the students and helping them connect multiple variables and make effective tradeoffs. Specifically, in this paper, we ask – how can we help students make effective tradeoff decisions and promote design thinking.

2. Framework

2.1 Design thinking

Design thinking involves the systematic process of generating, evaluating, and specifying solutions that satisfy a given set of constraints and meet users' needs (Dym et al., 2005). This characterization emphasizes a process where engineers investigate the solution space using a combination of convergent and divergent thinking to determine the extent of the goal (scope), develop ideas for possible solutions (generate), assess the ideas and check their fit in the solution space (evaluate), and implement their ideas to achieve the intended goal (realize) (Dym et al., 2005; Sheppard, 2003). This is done iteratively to optimize the solution, a process that involves maximizing the "functionality of a design with respect to the design requirements and the resources available" (Silk & Schunn, 2008, p. 5). Design optimization is a continuous process that requires engineers to use design thinking in order to deal with uncertainty due to multiple solution paths or "design trajectory" (Vattam, Helms, & Goel, 2008) that are resolved by making tradeoffs (Dym et al., 2005; Kroll, Condoor, & Jansson, 2001).

Silk and Schunn suggest that "tradeoffs occur both when considering the input variables of a system, those that can be manipulated in the system design, and the outcome variables, those that are used to judge the quality of the design… when a choice to modify the level of one variable impacts the effect of another variable on the outcome… also occur when weighing the different outcomes of a design, such as when considering the cost of a design compared to its effectiveness" (Silk & Schunn, 2008, p. 20). Thus, being able to reason with multiple interacting variables in an engineering system and understand their effect on the design goal is essential for making tradeoff decisions.

This paper investigates how to support this process of making effective tradeoff decisions by using a CAD tool. The next section explains the research setting and the instructional unit designed to be used along with this CAD tool.

3. Method

3.1 Research setting

This study was part of a larger design based research study that was conducted in a middle school in the Midwest US. A total of 421 students participated in this larger study across three grades – sixth (143 students), seventh (152 students), and eighth grade (126 students). The larger study spanned two weeks with 45 minute lessons every day. Every student was given one laptop running the Energy3D software and worked individually on three design tasks. However, individual work was interspersed with whole class discussions led by the teacher. Researchers were present in the class everyday to facilitate and assist the teacher in resolving technical questions about the software. Classes were taught by the respective teachers at every grade level by following a detailed lesson plan provided by the researchers.

3.2 Instructional design

We followed the Learning by Design framework (Kolodner et al., 2003) to guide the instructional activities. This framework couples the engineering design cycle along with the science inquiry cycle. Table 1 below gives an overview of the sequence of activities in the instructional unit.

Table 1: Sequence of activities in the instructional unit.

1. Introduce energy efficient buildings and Energy3D software.
2. Critique a suboptimal model representing poor design choices.
3. Introduce the big design challenge – 'Design a low-cost energy-efficient home in Indianapolis for your principal.'
4. Sub-challenge 1: Learn about solar radiation
    a. Students work on the first sub-challenge – 'Design a one-story house in Indianapolis that captures the maximum light from the sun in the winter.'
5. Sub-challenge 2: Learn about heat transfer
    a. Students work on the second sub-challenge – 'Design a one-story house in Indianapolis that maintains a temperature of 20 degrees Celsius (or 68 degree Fahrenheit) inside the house throughout the year and consumes the least energy.'
6. Solve the big design challenge introduced in step 3 using concepts learned from sub-challenges 1 and 2.
7. Share final designs with the class and facilitate peer-review.

On the first day of using Energy3D, the teachers introduced students to the software and gave a demo of the different functionalities. This was followed by students doing individual work; critiquing a house representing poor design choices. Students had to write their critiques in the design journal given to them. Teachers then introduced the students to the big design challenge but students had to first work on the two sub-challenges as preparatory activities for solving the big design challenge. Students also received a handout with summary of science-concepts related to energy efficiency. Students were prompted to refer to these science concepts while working on their design solution and complete the relevant section of the design journal while working on the design tasks. Figure 1 shows the Energy3D interface that students used to construct their energy efficient designs.

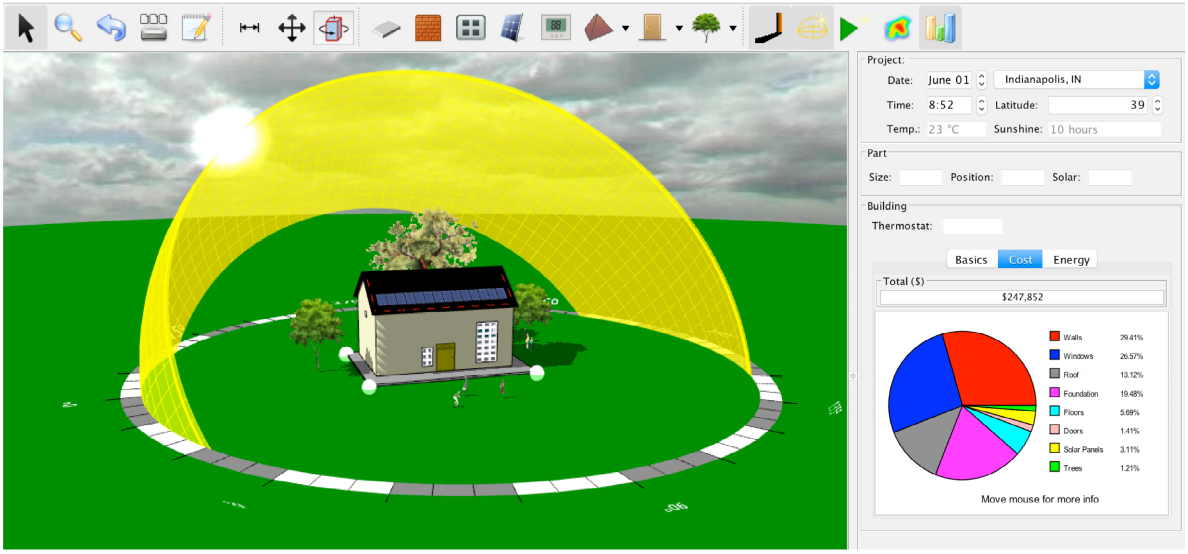


Figure 1. Screenshot of the Energy3D software

In preparation for the big challenge, students had to complete two smaller sub-challenges focused on the concepts of solar radiation and heat transfer. While working on these sub-challenges, they had to complete the design journal and record ‘what they know’, ‘what they needed to know’ and ‘what did they learn’ along with evidence and explanation for each observation. Students worked individually on these sub-challenges but switched to whole class discussion led by the teachers during software feature demonstrations. Once students had completed these sub-challenges, they started working on the big design challenge on their individual laptops. They had to write their design decisions and tradeoffs by hand in their paper-based design journal. Appropriate prompts were provided by the teachers and the journal to scaffold this process. After completing their big design challenge, students presented their final designs along with their design rationale and were evaluated by their teacher.

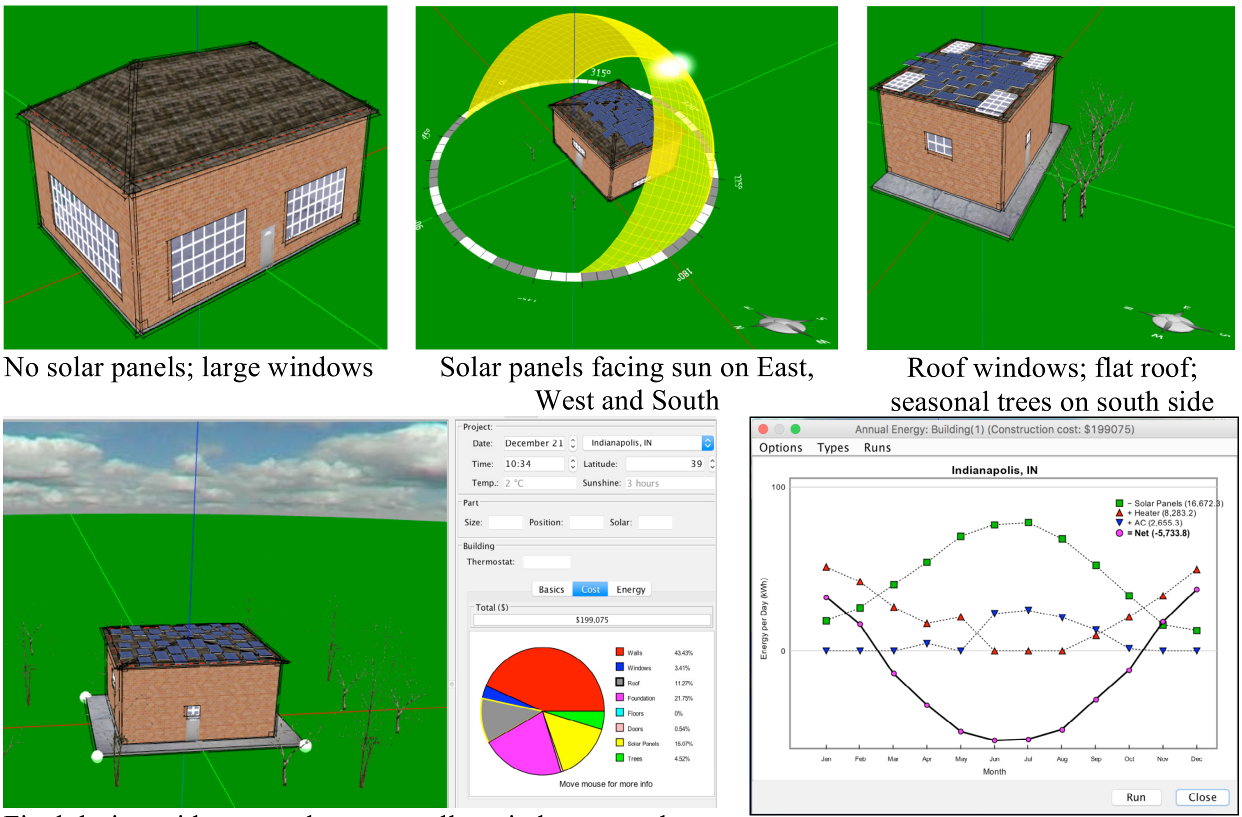
3.3 Data collection and analysis

The dataset for this paper comprises of the design journals, student-generated designs and student responses to a design scenario that was presented after students worked through the unit. The design scenario asked students to select the best design out of two building designs. It presented total cost and energy consumed by the two building designs- Building 1 with no solar panels (cost: $140,439; net energy consumed: 10074 kWh) and Building 2 with solar panels (cost: $142,939; net energy consumed: 7486 kWh). We analyzed the data qualitatively, doing content analysis, to identify patterns in the student responses. The next section presents preliminary findings from this analysis.

4. Findings and Discussion

Preliminary findings suggest that majority of the students were able to make effective tradeoff decisions in the design scenario after working on this unit. Across all the three grades, 74% students selected Building 2’s design as the optimal design. Within the different grade levels, 78% students (grade 6), 74% students (grade 7), and 70% students (grade 8) selected Building 2's design as the optimal design. Students potentially learned about the long term benefits of the solar panels and that it helped offset the high installation cost by iteratively modifying their solutions to the design challenges in the instructional unit. They selected design #2 (or building 2) as the better option out of the two and reasoned that although this design was more expensive out of the two choices, the energy savings afforded by the solar panels would eventually compensate for the cost of the design. For instance, student S259 (grade 7) reasoned that – *"[Building 2 is better] because building 2 [is] only a little bit more expensive but it uses a lot less energy."*

Our initial analysis indicates that during the unit, students optimized their design iteratively, making tradeoffs and modifying different input parameters and seeing the effect on the outcome parameters as well as weighing the outcome parameters. This potentially informed their design choice as they were responding to the design scenario question above. For instance, while working on the final design challenge (step 6 in the instructional sequence – big design challenge) student S259 iteratively improved the design of the house by modifying the input design parameters and observing the effect on the outcome parameter.



No solar panels; large windows

Solar panels facing sun on East, West and South

Roof windows; flat roof; seasonal trees on south side

Final design with seasonal trees; smaller windows to reduce heat loss

Energy3D's analytical tool showing annual energy consumption by the house

Figure 2. Some stages and sequence of design decisions by student S259 (grade 7)

Figure 2 shows some of the stages from student S259's design process. S259 first started by constructing a house without any solar panels and having large windows to capture more sunlight. The student made a note of the relationship between heat loss and insulation in the journal- *"Heat loss can be reduced by adding insulation because heat can't escape through the insulation."* The student then determined that it was beneficial to use the solar panels and used the position of the sun to determine where to place those panels. The student placed solar panels on the east, west and south directions facing the sun in order to capture direct sunlight (the sun is predominantly on the southern side of the house in Indianapolis as shown by the yellow arc in the second figure). S259 referred to the cost of the design and the energy consumed to determine the effect of placing solar panels at specific locations. Next, the student modified the roof to include windows that allowed more solar energy to enter the house and thus reduce the heating bill in the winter. S259 also tested a flatter roof design arguing that this may allow more solar panels to face the sun directly. After each modification, the student ran the energy analysis and reviewed the cost of the design. The student also added trees on the south side facing the sun. These types of trees shed their leaves in the winter and thus allowed sunlight to fall on the house in the winter thus reducing the heating bill but provided shade in the summer to keep the air-conditioning bill low. However, with the same insulation and window thickness, larger and more windows meant greater heat loss from inside the house. S259 eventually removed these windows from the roof after understanding that these were causing too much heat loss. The student recorded in the journal— *"I have 4 windows because if you have more windows your energy cost will go up."* Simultaneously, S259 reduced the size of other windows in the house as well to further reduce heat loss. So finally, the student settled for the design which had more seasonal trees surrounding the house, had smaller and fewer windows and had solar panels directly facing the sun.

Thus, the design journal offered opportunities for the students to reflect on their design decisions and document their observations and explanations for easy reference both during and after the design process. It provided opportunities for students to connect what they already knew about the design problem with new knowledge gained from working on the multiple design challenges. Students conducted systematic investigation and tested different variables (e.g., size and number of windows, insulation, direction of solar panels, trees, etc.) The feedback offered by Energy3D's analytical tools potentially helped the students make connections between multiple variables by showing how the design modifications affected the cost and energy consumption of the house.

These preliminary qualitative findings indicate that this curricular unit using the design journal along with the CAD software potentially helped the students make connections between multiple variables and take effective tradeoff decisions. We are in the process of doing a rigorous analysis of the entire dataset to confirm these preliminary findings. It will also be important to understand differences between the three grade levels and how we can scaffold grade specific requirements based on the specific needs of the students. Another important part of ongoing as well as future work is the integration of the design journal with the Energy3D software. We are working on digitizing the journal and making it easily available in the same workspace as the CAD tool instead of a separate paper handout. In future, we also intend to provide automatic and personalized feedback to the students based on their observations and explanations noted in the design journal.

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Abstract visual notations as an aid for historical problem solving

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Abstract: Historical problem-solving normally involves textual answers with students using various primary and secondary sources to solve historical problems. This study used abstract visual notations on the lines of unified modeling language (UML) to aid the visualisation of historical events and concepts and thus recreate the "explanation space" diagrammatically. These diagrams are then translated into text to create richer explanations. The feedback from participants guided the development of a software called the History-Maker, which addressed the difficulties faced by the pencil-paper approach.

Keywords: historical problem-solving; history; thinking skills; historical thinking

1. Introduction

This study aims to support the cognitive task of historical problem solving by using abstract notations as a form of external representation. In conventional problem solving, we are given a question and we use a set of procedures or processes to find a solution. In history, we are given a question of which we already know the outcome and the learner has to reconstruct the objective and state of the system by engaging with the "explanation space"(Wineburg, 1991a). According to the National Center for History in Schools(NCHS) framework, there are several sub-skills that constitute historical thinking of which historical problem solving is considered a higher cognitive skill(Nash, 1997). First, the learning strategies used to develop historical problem solving and its sub-skills were identified and evaluated. Next, abstract notations that represented historical events and concepts were provided to first year undergraduate students along with historical sources and they were asked to answer a historical question. The history specific abstract notations consisted of individual identity, class identity, community identity, group or collective identity, religion-caste, trade, profession, war and artifact. Generic notations consisted of event, concept, process, activity, actor, condition, destruction, document, idea, note, start and stop. It was hypothesised that the use of abstract visual notations to create diagrammatic explanations would improve historical problem solving over simple text only explanations. The notations would aid a novice learner to better visualise the "explanation space". Once combined into a larger diagram, the notations would allow the learner to construct, deconstruct and reconstruct their solutions to historical problems. A paper-based two-group experiment post-test only randomized design was conducted using the notations. The data showed that while there was improved learning the results were not statistically significant. Based on the feedback from the participants, a software tool called the History-Maker was developed that would allow the learner to easily create and manipulate the diagrams. Future studies will evaluate the use of the notations through the History-Maker.

2. Background

2.1 Use of historical events and conceptual history to learn historical problem solving

Throughout the papers surveyed related to historical thinking, the focus of the content has been on specific instances of history like American history (Stahl, Hynd, Britton, McNish, & Bosquet, 1996), world history(Vansledright & Frankes, 2000), medieval history(Wineburg, 1991b), Indian history and so on. Thus, there is always a question of whether some technique used in teaching world history would be relevant in, say, American history and this makes generalisation difficult. In order to make better generalisation for learning historical thinking, we chose two basic abstractions of history – historical event and conceptual history. It should be noted that history can be abstracted in several ways like historical process, historical theory, historical structures, historical themes and so on. The terms 'event' and 'concept' in history are so fundamental that it was difficult to find a standardised definition of what the terms mean. Mathews describes historical event as a mental construction which has a beginning, a middle and an end(Matthews, 1937). He further elaborates that all historical events have their basis from a historical process and thus are arbitrary units that are extracted for convenience. An example for a historical event would be the first war of Indian independence. However, this could broken up into smaller events such as 'causes of the revolt', 'stages of the revolt', 'aftermath of the revolt' and so on.

It is suggested that it is better to teach conceptual history to students in order to reduce the memorisation of historical facts as this would help learners "structure and organise" historical data to make sense of it(Vansledright & Frankes, 2000). Working examples of historical concepts, also called foreground concepts(Vansledright & Frankes, 2000), are 'culture', 'democracy', 'freedom', 'the state', etc. From the examples of historical event, 'revolt', 'independence' and 'war' would also be considered historical concepts. We would like to differentiate them from other concepts of history, also called background concepts(Vansledright & Frankes, 2000), such as "evidence, assertion, point of view, source validity, reliability, evidence, change, continuity"(Nash, 1995). Thus, with these two abstractions, the effort is to make the learning strategy content-independent.

2.2 Pedagogical interventions to support learning historical problem solving

Of the papers surveyed for historical problem solving six of the solutions were based on paper-based activities and three were based on the use of technological tools to support learning of the required sub-skills. The non-technological approach required active involvement of the teacher with the students. The strategies included reading multiple documents and writing opinion pieces(Stahl et al., 1996), thinking aloud(Kucan & Beck, 1997), providing an authoritative entity to guide the learners(Paxton, 2002), the use of annotations, highlighting, marking and notes with a combination of individual and group work(Donovan & Bransford, 2004) and providing learners with documents that contradict each other(Nash & Symcox, 1991). These strategies were identified as they would form the control for future studies.

Three studies used 'inquiry based learning'(Vansledright & Frankes, 2000)(Prangsma, Kanselaar, & Boxtel, 2008)(Regist, 2011) and one used 'authentic learning'(Hillis, 2008). Incidentally, the NCHS framework chosen for this research work is based on 'inquiry based learning'. In all these cases, a historical question, which was to be answered, along with related historical documents were provided to the learners. The setting for seven of the studies was the classroom, one was in the library and one in the laboratory. Homework was given to the students in all the studies quoted. All, save one experimental study, were long term studies spanning a whole semester or a whole year.

The use of representations was explored for chronological thinking(Prangsma, Kanselaar, & Boxtel, 2008). Chronological thinking is the first skill-set that students need to develop as a part of the historical thinking framework by NCHS. Based on the classifications set forth(Lohse, Rueter, Biolsi, Walker, & Arbor, 1990), Prangsma developed a set of visual notations to help history students learn 'chronological thinking' coupled with the skills of identifying causation in historical events. Her work used "concrete representations of abstract phenomena and abstract relations" and specifically visual-textual representations integrated into a timeline. The visual representations included 1. process diagram, 2. network chart, 3. structure diagram, 4. cartograms. This has two disadvantages: First, as stated by the author, concrete representations are more useful to aid memorisation rather than conceptual knowledge construction. Second, it is difficult to construct concrete representations for every single use-case that is historically relevant. Thus, abstract notations which can be used in different contexts are proposed as a solution.

2.3 Theoretical basis for notation-based intervention

The representations used to visualise history such as maps, graphs, pictures, cartograms, multimedia and timelines can be classified as multimodal representations(Lohse et al., 1990). It was shown that the learners are able to make deeper connections with the concepts they are working with when using multimodal representations due to visual linking(Ainsworth, 1999). A study conducted by Prangsma on the effects of collaborative construction of multimodal representations in history shows that the use of multimodal representations helps the students to easily remember historical data because they are actively constructing visual-textual representations of the historical data. However, the appropriateness of the external representations could play an important role. External representations not only support memory but also offloads certain critical cognitive tasks into the physical realm (Zhang, 1997)(Kirsh, 2010). Prangsma claimed that the type of notations used could affect the learning process.

3. Methodology

3.1 Experiment to check effectiveness of the notations for historical problem solving

The research question of the study is, "Given a set of abstract visual notations, how effective were they in helping novice learners learn historical problem solving?" Sixty first-year undergraduate history students were selected through purposive sampling. The participants had no prior exposure to historical thinking though they did study history in school. The division of the sixty participants into control and experimental group was done randomly. The experimental design was two-group post-test only. The duration of the session was 50 minutes with both group being briefed about historical thinking for the first ten minutes. The experimental group was then given a ten minute treatment on the use of notations along with a few simple examples from the chapter on "First war of Indian independence". The examples covered both conceptual history and event-based history to ensure that both abstractions of history were present. The post-test for both groups was from the chapter "Totalitarianism – Case study: Stalinist Russia". The question to be answered by both groups textually was:" How would your life change if you lived in a totalitarian state?" Both groups were given a sheet containing the relevant sources required to answer the question. The test was a pencil-paper test.

3.2 Results and discussion

The Shapiro-Wilk test was used to check normality of their internal scores in history. The internal scores were based on the sum of two tests and one mid-term exam. For the control group, it was found that the scores were normal p-value=0.47, alpha=0.05, mean= 38.23, standard error= 0.895 For the experimental group the scores were not normal with p-value=0.04, alpha=0.05, mean=38.6, standard error=1.006. Thus, the Mann-Whitney test for two independent samples was conducted. One-tail: alpha=0.05, p-value=0.320, not significant. The null hypothesis (h0) for Mann-Whitney test is the group means are equal i.e. p>alpha indicates that the probability of that happening is not by chance and hence one cannot reject h0.

Post test scores - Control group: Mean=3.067, SD=1.172, p-value=0.005, alpha=0.05, normal=no; Experimental group: Mean=3.233, SD=1.318, p-value=0.018, alpha=0.05, normal=no
Mann-Whitney test for two independent samples for one tail where alpha=0.05, p-value=0.264, significant=no. Since p>alpha, the null hypothesis (there is no relation between a and b) cannot be rejected.

Inter-rater reliability: Fleiss' Kappa for m Raters (exact value) - Subjects = 24; Raters = 3; Kappa = 0.653. The kappa value is on the borderline. However, this could be because the number of parameters of the evaluation rubric were several. The data for the inter-rater reliability was obtained from the pilots and was discarded after the the inter-rater reliability.

Hypothesis: The use of abstract visual notations improves historical problem solving over simple text only solutions. While there is an improvement in learning with the notations as treatment, there is no statistical significance in the paper-pencil based test.

4. Discussion and future work

Some of the experimental group members opinioned that they were not completely familiar with the notations and many were using notations to solve problems for the first time and hence it was difficult to use them in problem solving. The papers that were discarded used the abstract notations without textual explanation or labels to contextualise them. A longer treatment to familiarise the participants would have been more beneficial. Pencil-paper approach had several disadvantages. Participants expressed "*some of the notations are difficult to draw*" and "*how would I use the symbols if I do not have a copy?*" Further, paper based solutions have inherent problems like it is difficult to resize drawings, move around elements, display complexity within the 2D paper unless one is an expert, not possible to insert meta-data for analysis, difficult to sort and search through the diagram and so on. Initially, the concept map(cmap tool) and UML drawing tools like yEd and Umbrello were used but they did not have history specific notations.

The feedback from the participants in the experiment informed the design of a software based tool. The user interface (UI) consists of the 'canvas', where the history-maker map is created, and the 'elements' panel, where the elements of the historical thinking notation can be selected, a question box and an answer box. The links between the elements are created by clicking on an element and dragging the link from one element to another. When creating either nodes or connectors, the user is prompted to enter the name of the element, the type of connector and some meta data. A sample use-case has been provided below in figure. The question being answered is "How would your life change if you lived in a totalitarian state?" Further studies based on abstract notations using the tool will be performed.

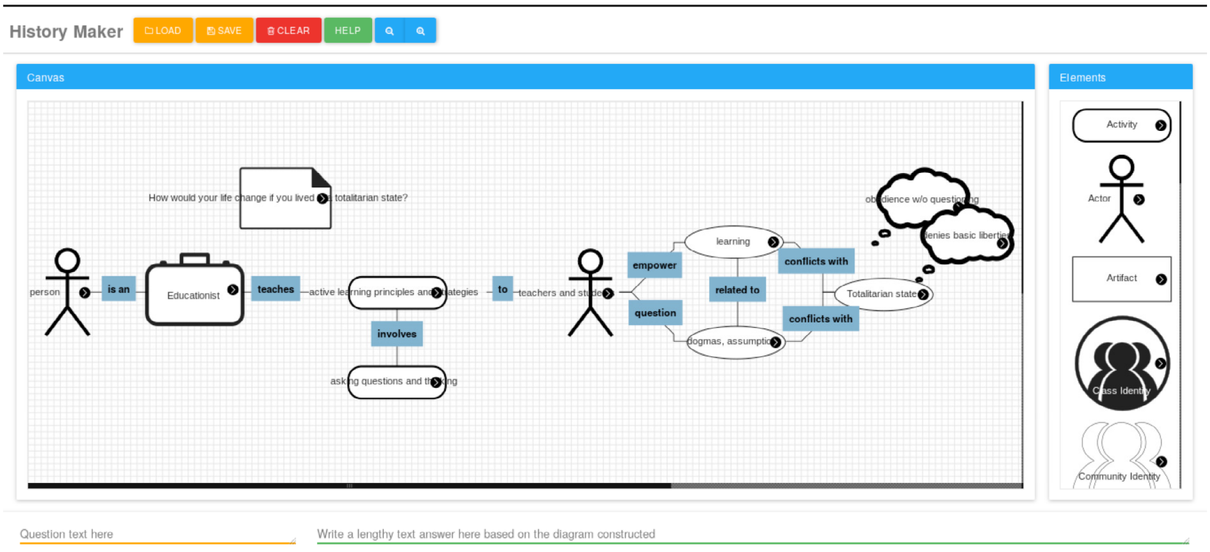

Figure2: Use case of how notations and history-maker map will help answering questions

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Designing PHyTeR: a system to teach troubleshooting skill

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Abstract: Troubleshooting skill is required by undergraduates in Computer Science training to be IT professionals. Current curriculum in Computer Science doesn't give sufficient emphasis on teaching troubleshooting to learners. We are following educational design research (EDR) to engineer a solution to teach troubleshooting skill. In this paper we present an overview of EDR applied to this problem and the design of a system called 'PHyTeR'. PHyTeR is intended to teach troubleshooting to CS undergraduates by choosing scenarios from the domain of Computer Networks. A plan of evaluation to evaluate the design of the system is also discussed.

Keywords: Troubleshooting Skill, Teaching thinking skill, Design of learning environments, Computer Networks, Educational Design Research

1. Introduction

Computer Science undergraduates interact with various types of systems – it might range from running a program on an IDE to building a drone or building/interacting with multiple versions of libraries, APIs. Troubleshooting is an important component in building and working with all these systems. "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). According to Jonassen (Jonassen, 2010), troubleshooting is an ill-structured problem which needs troubleshooters to have an understanding of the system they are troubleshooting and keep track of troubleshooting process. Also it involves higher level cognitive activities like analyzing the behavior of the system, generating plausible explanations for errors seen, switching between different levels of details of the system etc. Troubleshooting like many other thinking skills is pan-domain since it is applicable in the domains of electrical, chemical, mechanical & computer science engineering.

Traditionally, tools like gdb, wireshark, circuit analyzers are used by educators to teach troubleshooting. However, the problems chosen to teach troubleshooting are usually simple compared to the open ended problems faced by professionals. Our solution approach is that by allowing students to practice troubleshooting skill with fairly complex problems would prepare them better for their profession. The tools will be of more use if the students understand the process of troubleshooting. The goal of this paper is to describe the solution approach that we are following to teach troubleshooting skill to Computer Science undergraduate students. Then the design of a system which we call 'PHyTeR' is described in detail followed by an evaluation plan for the solution.

2. Related Work

2.1 Troubleshooting skill

Troubleshooting is a moderately ill-structured problem because the troubleshooter has to determine what information is needed, require deep level understanding of the system. The competencies of troubleshooting skill has been defined by researchers from different domains (Johnson, 1987; Ross & Orr, 2009; Schaafstal et al., 2000). Some consider it as iterative testing of hypotheses and others argue that troubleshooting includes all processes between representing problem space and verification of the solution. We are considering the following competencies of troubleshooting which we have synthesized from literature: i) Problem Space Representation, ii) Hypothesis Generation, iii) Hypothesis Prioritization, and iv) Design & Run Tests.

2.2 Approaches to teach skills like troubleshooting

There have been worksheet based approaches to teach troubleshooting (Schaafstal, Schraagen, & Berlo, 2000). They give a process overview of troubleshooting but fail to give contextual, domain dependent & independent in-time scaffolds. One such approach was to train students to become better troubleshooters by giving them structured practice on authentic problems (Ross & Orr, 2009). There have also been many technology enhanced learning environments to teach complex skills like design, scientific inquiry and modeling especially for school children (Basu, Dickes, Kinnebrew, Sengupta, & Biswas, 2013; Sun & Looi, 2012; White et al., 2002) but for troubleshooting skill. These aim to teach reasoning & skills to students in different contexts. On the other hand there have been number tools which help college students and professionals to troubleshoot systems viz wireshark, debuggers built in IDEs etc. They give opportunity to learners to interact with real systems/simulations but don't help learners in the 'process' of troubleshooting. It has been argued that troubleshooting needs to be taught separately because teaching learners to build and design systems is not sufficient for them to troubleshoot systems (Jonassen, 2010).

2.3 Expert systems to troubleshoot

Another thread of literature related to troubleshooting is where expert systems were developed to do better troubleshooting or 'better' debuggers were designed. Some examples of designing better debuggers were providing visualizations of programs being executed, providing stack traces etc. is intended to reduce the cognitive load on troubleshooters (Hejmady, 2011). Studies on design of expert systems have emphasized the need for students representing the problem space and having a functional understanding of the components of a system (Kleer, Williams, & De Kleer, 1989).

3. Research Methodology – Educational Design Research

Educational Design Research (McKenney & Reeves, 2014) is a way of engineering practical solutions to problems in educational domain. EDR can be used in designing policies, educational products, processes or programs (McKenney & Reeves, 2014). Along with developing solution, an important aspect of EDR is to develop theory/understanding about the development of solution or how the solution works in a context. EDR is an iterative process of cycles consisting of problem analysis, design & development of solution and evaluation of solution. The following diagram shows the EDR process employed in designing the TEL environment 'PHyTeR'. Based on the available literature on troubleshooting skill we have designed task structure of the TEL environment. Literature on expert and novice studies informed the affordances and scaffolds. Expert and novice studies in the domain of Computer Networks are planned to obtain detailed inputs from the domain which would further inform design decisions.

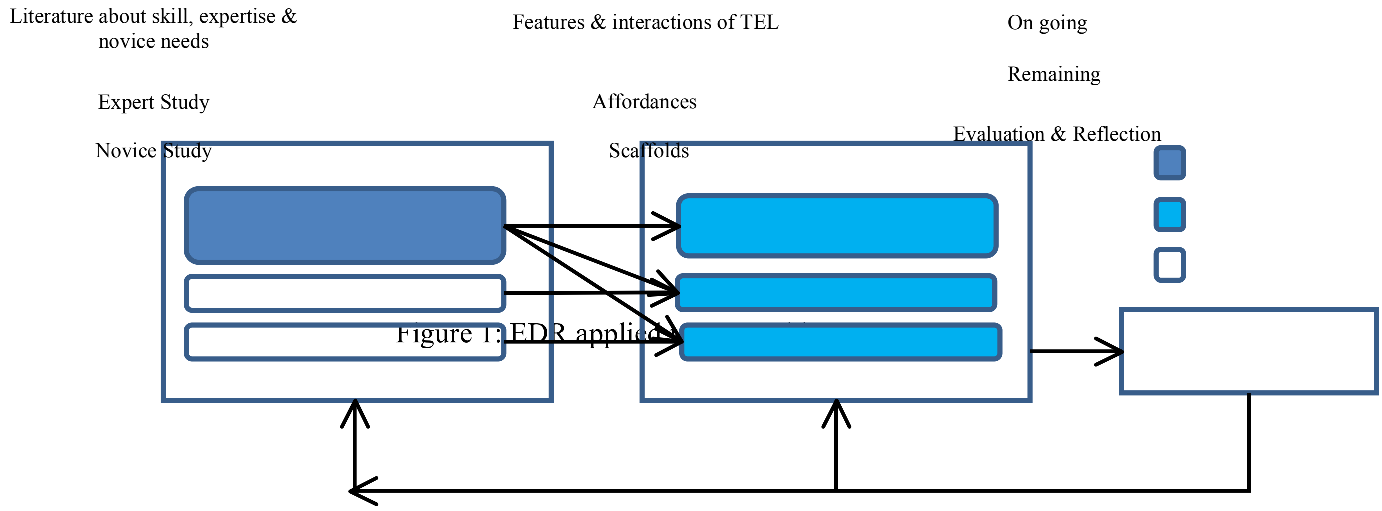


Figure 1: EDR applied

4. Theoretical Basis for solution

Following are the theoretical backings for our conjectures about learning. Modeling is aimed at developing mental models about troubleshooting. External representations and scaffolds help in reducing the complexity of the task.

4.1 Model based learning

Models are concrete representations of abstract objects/systems in the real world. Usually models are built by reducing the complexities of real world to focus on few aspects of interest (Seel & Blumschein, 2008). Modeling helps as a concrete external representation while interacting with it and also helps in 'meaning-making' in the process of building it. An internal 'mental model' is created when people interact with the above modeling activities and 'meaning' appears when these mental models become coherent, rich with experiences, ideas, thoughts (Seel & Blumschein, 2008). Modeling is also the activity suggested for decomposing complex processes to simpler elements and mechanics (Sengupta, Kinnebrew, Basu, Biswas, & Clark, 2013).

4.2 External Representations

Troubleshooting requires learners to have a picture of system being troubleshot & its components, keep track of the process of troubleshooting and interpret the cause and effect relationship within the system. Kirsh (Kirsh, 1995) argues how such complex activity can be not just supported but also enhanced and mediated by using external representations. External visual representation have shown to reduce the difficulty of process of problem –solving. Experts have also been shown to use visual representations frequently during problem-solving to support reasoning (Moreno, Ozogul, & Reisslein, 2011).

4.3 Scaffolds

Quintana (Quintana et al., 2004) argue that even though introducing software tools to learners might make the task more difficult initially, there is credit in using software tools to scaffold learners in structuring an ill-structured problem, giving guidance and allowing them plan and monitor their performance. Narciss (Narciss, 2013) provide a framework for providing such scaffolds using interactive contextual feedback at different levels: cognitive, metacognitive and motivational. We are using some of these in the design of PHyTeR.

5. Design of 'PHyTeR'

Our design is based on a framework called 'TELoTS framework' (Murthy, Iyer, & Mavinkurve). This framework gives actions & guidelines on developing a smart learning environment specifically for thinking skills like troubleshooting. Design starts with defining the competencies of a skill, coming up with learning objectives and assessments to evaluate the competencies. Then the framework suggests analyzing expert actions and integrating the requirements with design principles to come-up with the design of the system.

Based on this, we have designed a system called 'PHyTeR' to teach troubleshooting in the domain of Computer Networks for Computer Science undergraduate students. 'PHyTeR' stands for P – Problem Space Representation, Hy – Hypothesis generation & prioritization, Te – Testing which are the competencies and R – Reflection. Next sub-sections describe the design in detail.

5.1 Key Features of 'PHyTeR'

PHyTeR is intended to

a. Support students to switch between big picture and small picture
b. Provide in-time scaffolding & reflection questions to guide the process
c. Provide modeling and interaction with simulations in the same interface

5.2 Design of learning activities

The system provides learners with troubleshooting scenarios that are ordered from simple to complex. There is a task corresponding to each competency and a reflection task at the end. At the beginning of the task, the students will be explained how that task is a step towards troubleshooting. Reflection questions will be asked when the students take decisions like selecting a hypothesis or complete a task. The system features were derived based on learning outcomes for the competency, assessment rubrics for the competency and inputs from expert novice literature. The following table shows how the learning design elements for the task of problem space representation were derived.

Table 1: Components of design decisions

Competency	Learning Outcome	Input from expert study	Input from novice studies	Learning design principles	Features in PHyTeR
Problem Space Representation	Students will be able to analyze the system in structure and function terms	Experts describe the system in functional terms	Novices have inadequate system understanding	Make students describe structure, & function of the system	Question prompts to identify relevant components, link between them and their functions

5.2.1 Problem Space Representation Activity

Experts are said to have a rich representation of the problem that they are trying to solve (Jonassen, 2010). With respect to troubleshooting, this representation consists of various devices present in the network, the links between them (structure). It also includes a representation of the function of each device and how they combine to produce the function of the whole network.

PHyTeR helps students in building a representation of the problem by using 'annotated topology builder'. The topology creator has a device bar consisting different types of network devices like terminals, links, access points etc. Students will have to drag and drop the devices on the topology space to create the annotated topology. They will have to annotate the devices with protocols and configurations that have to be set on the device for it to work correctly. Learners might not have all the required domain knowledge. For this purpose, there is a domain book which has computer networks related information (text or animations or video).

The topology that the learners create is like a reference for them to perform next activities. Let us consider an example scenario which consists of many devices and one of the device (terminal T2) is not able to connect to another device (Terminal T1). An example of the annotated topology is shown in figure 2.

5.2.2 Hypothesis Generation Activity

Once students have an understanding of the problem space, they need to come up with multiple plausible causes for the error. Learners are asked to generate hypotheses and attach these hypotheses to the device & component to which it is related. There is a general window where hypotheses not related to any specific device can be noted down. Examples for the hypotheses: Internet is down, firewall is blocking the port etc.

Figure 2: An interface to interact with the simulator

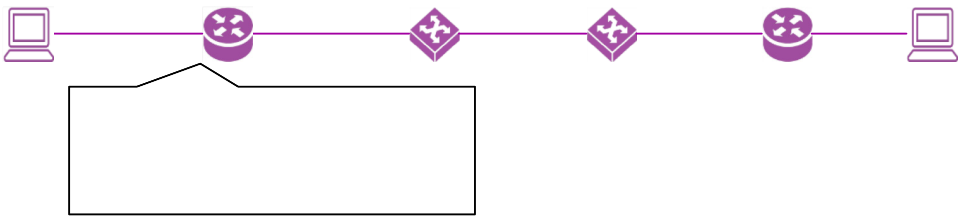


Figure 2: Annotated Topology Map

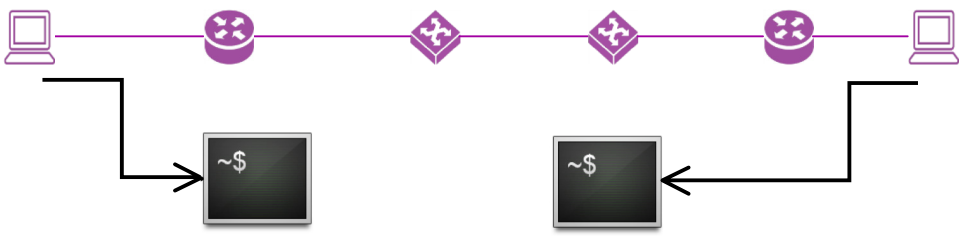
5.2.3 *Hypotheses Prioritization Activity*

With a number of hypotheses at hand, the progress of troubleshooting depends on the order of selection of hypothesis to test. This is done by prioritizing the hypotheses using different strategies. One example of a strategy is described in a study which suggested that experts suggests hypothesis at higher level (system/sub-system level) and then generate hypotheses at specific level (device/component level) to investigate further (Johnson, 1987). This sort of strategy information is given as hints to learners when they click on the hint button. A list of all the hypotheses generated by learners is displayed along with all details related to hypotheses (the device/component to which it is related etc.). They have to drag and order the hypotheses according to the prioritization strategy.

When the learners select one hypothesis, they will be asked a justification question – to justify their prioritization of the hypotheses. This is intended as a metacognitive reflective prompt and has been claimed to enhance linking between the error and plausible explanations.

5.2.4 Design & Run Test Activity

After a hypothesis is selected for testing, the learners have to design a test. For this they have choose the testing methods (commands to be executed, logs to be checked, configurations to be checked etc.). Then they have to predict the result that would be obtained by performing the test. Then an interface to the real erroneous topology (with a simulator in background) is displayed as shown below:



This topology has simulated network devices and connections between them. The learners can click on any of these devices to open a console to interact with the corresponding device. When learners have completed the test and obtained the result, they have to compare it with the predicted result. If the predicted and observed results match, it means they have found a causal relationship. They will have to record this in their causal map book. If the predicted and observed results don't match, then it means either the hypothesis was incorrect (then they have to test a new hypothesis) or the test that they performed is incorrect (then they have to redesign the test). Based on the interpretation of the result students might want to generate new hypotheses or discard previously generated hypotheses. At this stage students can use a 'Route Map' which shows them a summary of all the previous tests performed and results obtained. This is intended to help them in switching between 'small picture' (design & perform a test) to 'big picture' of the overall troubleshooting process.

5.2.5 *Reflection Activity*

Apart from the justification reflection activities spread in between the activities, learners will do a 'Reflection by summarizing' activity. Here the students will have to give a summary of the troubleshooting process that they did and then compare it with an expert solution.

6. Proposed evaluation of 'PHyTeR'

The first part of evaluation is to validate the competencies, troubleshooting scenarios and system design by experts in Computer Networks. This is required because the competencies and current design are based on literature from other domains like chemical plants and mechanical systems. The second part of the study is to evaluate that PHyTeR actually helps in learning troubleshooting. For this, as a first step a study is intended to improve the user interface of the system and ensure that learners doesn't have any difficulty in using the system and do the required tasks. This would complete the first cycle of EDR. The research questions that we are considering for initial evaluation of the system are: i) Does the features or scaffolds in the system help learners to complete a troubleshooting task? ii) What is the perception of students with respect to learning and usability? A single group pre-post study with 30 students will be conducted to evaluate their troubleshooting abilities before & after using the system.

7. Conclusion

The paper described the design of a system called 'PHyTeR' to teach troubleshooting by considering problems from the domain of computer networks. An evaluation plan based on design is proposed which we intend to use in the evaluation of the solution.

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Interactive Vectors For Model-based Reasoning

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Abstract: Reasoning about the structure and behavior of physical phenomena using abstract and concrete models (model-based reasoning, MBR) is a key thinking skill in science and engineering practice. One of the key areas MBR is introduced in the curriculum, particularly the use of abstract models, is applications of trigonometry, such as calculating heights and distances. In India, high school and pre-college (9-12 Grades) trigonometry curricula include three broad MBR cases: i) heights and distances (ratios in right triangles), ii) resolution and addition of vector quantities (projections in a unit circle to give the rectangular components), and iii) periodic systems (represented as sinusoidal functions). Students find trigonometry and its MBR applications difficult to understand, possibly because reasoning in this domain requires handling cognitive (internal/abstract) operations and symbolic (external/concrete) operations simultaneously, in different and complex ways, across these three MBR cases. A particular source of difficulty is the relationships between these trigonometric operations, which are not clear across the three cases. We are developing an interactive new media system to help students learn model-based reasoning, based on MBR applications of trigonometry. Here we focus on vector resolution and addition, a key application supporting MBR. In the existing curricula, trigonometric and other concepts related to vectors are scattered across 4 textbooks, and students find it hard to integrate these scattered concepts. We report a study outlining how the new media tool helped students integrate the concepts involved in vectors, and the insights from the study for redesign, particularly to support MBR.

Keywords: model-based reasoning, vectors, trigonometry, embodied cognition, new media

1. Introduction

Reasoning using models is a central thinking skill in science and engineering. According to Gilbert (2004), models "function as a bridge between scientific theory and the world-as-experienced ('reality'). They can be simplified depictions of a reality-as-observed, produced for specific purposes, to which the abstractions of theory are then applied. They can also be idealisations of a possible reality, based on the abstractions of theory, produced so that comparisons with reality-as-observed can be made". Trigonometry is one of the key mathematical topics where students learn model-based reasoning (MBR) in the later high school curricula. It is also a topic with wide applications in advanced mathematics, physics and engineering. Research studies (Gur, 2009; Jackson, 1910; Orhun, 2004; Yusha'u, 2013) report that teachers and students find trigonometry a hard concept to teach and learn. Byers (2010) reports a detailed study of trigonometric representations in the Canadian curricula, particularly in the transition from the secondary school to college mathematics, and points out many potential sources of difficulty for students. Gur (2009) also identifies these problem areas, and suggests that the difficulties come from the complex nature of trigonometric symbols.

In India, trigonometry is introduced to students during the later parts of high school, as part of Mathematics, along with many applications across Physics. There are three kinds of model-based reasoning applications of trigonometry in the higher secondary curricula in Indian Schools. These cases which follow the levels of understanding in geometry proposed by Van Hiele (1986) are: (i) Heights and distances: Here a real world scenario is modelled by a right triangle. Trigonometric ratios are used to link the angles (of observation) and the lengths of the triangle (heights and distances). This is one of the first applications of trigonometry, introduced after the basic definitions. (ii) Resolution and Addition of Vectors: Diverse applications in physics are modelled using vector operations, ranging from resolution and addition to products of vectors. In 11th and 12th grade physics, various physical quantities are introduced as vectors (displacement, velocity, acceleration, force, momentum, angular velocity etc.). Vector operations involving trigonometry are used to solve problems such as finding resultant forces, conserving momenta, and the effect of a set of torques. (iii) Sinusoidal Systems: Trigonometry is used to model phenomena with periodically changing physical quantities. In physical systems (like a spring mass system or a simple pendulum), chemical and electrical systems, periodically varying physical quantities can be modelled using a sinusoidal curve. Here the notion of trigonometric ratios as functions of angles is used.

Here we focus on the case of model-based reasoning using vector resolution and addition. Byers (2010) suggests that students find vectors difficult due to unfamiliarity. Difficulty in handling vectors leads to problems in handling Newtonian Dynamics (White, 1983). Students have trouble understanding the wide range of modeling applications of vector concepts, as it is difficult to follow how the vector concepts model the various real world cases. Resolution and addition of vectors thus provides a rich context to explore students' understanding of model-based reasoning using trigonometry, its applications in physics, and how new interactive media could address learning problems in this domain.

2. Textbook Analysis

We first analysed the textbooks in one of the provinces in India (Maharashtra), to understand the manner in which vector concepts are covered. Since the topics related to vectors are spread across mathematics and physics textbooks (grades 9-11), we were interested in documenting the missing conceptual links, both within a text book and between text books.

Figure 1 shows a concept map of how topics are covered and applied in the physics curriculum. Addition of vectors is introduced geometrically using the Triangle Law and Parallelogram Law of vector addition. The Triangle law is just stated, and no connection is made to properties of vectors. The conceptual gap thus gets carried over to the Parallelogram and Polygon Laws, which are proven based on the Triangle Law. Addition of vectors is thus not properly scaffolded.

Different representations of the same vector as a geometrical entity (an arrow mark ↗ with magnitude and direction) and as an algebraic entity (the rectangular components form) are interrelated using the operation called Resolution of vectors. The textbook does not clarify how both these representations denote the same vector. This could lead to students treating a vector under geometrical and algebraic descriptions differently, without a unified perspective. Similarly adding two vectors geometrically (using triangle and parallelogram laws) and algebraically (adding rectangular components) may be perceived as two entirely different operations, and hence need scaffolding to understand how they lead to the same resultant vector. The text book does not provide an integrated understanding of geometric and algebraic representation of a vector.

Further, textbooks don’t emphasize the notion of Resolution as an inverse operation of addition (adding the component vectors back will give the initial vector which was resolved). This leads to a weak understanding of the nature of these operations, and difficulty in understanding the nature of vectors and components in situations such as a changed frame of reference (like a rotated frame in an inclined plane) and also the possibility of non rectangular components of vectors. The conceptual issues here will be carried over to all the connected chapters (right block in Figure 1, various chapters in *mechanics* as well as *electricity and magnetism*).

A central finding from this analysis was that a key transition in learning vectors -- understanding the translation between the geometric mode and the algebraic mode -- is not well scaffolded. The role of trigonometric ratios, which are employed in this transition, is also not discussed. Given the way the chapters are sequenced in the physics and the math curriculum, students have little support to understand and master the application of trigonometry in the context of vectors.

An analysis of the Mathematics text books in the previous grades (blocks to the left in Figure 1) showed that trigonometry is introduced first in Grade 9. Till Grade 10, the text covers the basic definitions, and applications to the problem of calculating heights and distances. A brief mention of trigonometric ratios with varying angles is made in Grade 10. However, these connections are not emphasized enough, for the student to apply trigonometry in the context of resolution of vectors when they move to Grade 11. The mathematics textbook for Grade 11 discusses trigonometric functions, but with no direct applications in the context of vectors.

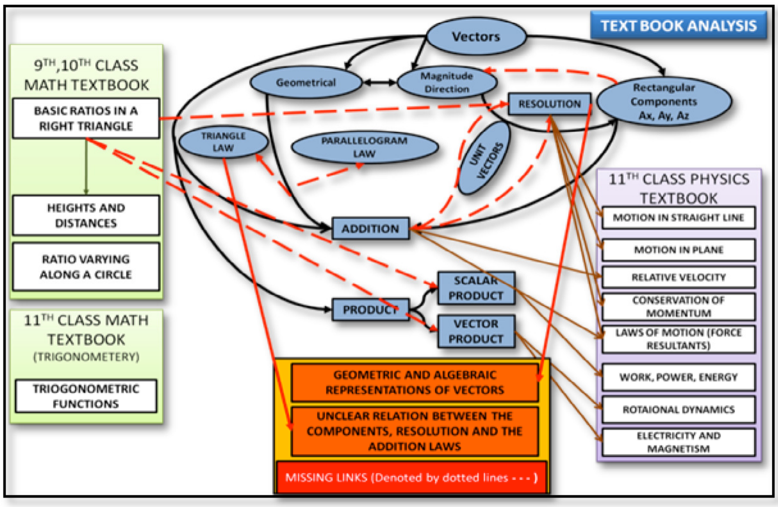

Figure 1. Vector concepts covered in Physics and Mathematics Text books (Maharashtra State). Dotted lines represent improper scaffolding, which could lead to potential conceptual gaps.

The current state of the textbooks and curricula leave the students without enough scaffolding to understand the vector concepts. These improperly understood concepts, when carried ahead to further abstract topics, leave the students highly prone to conceptual confusions, and an inability to make sense of symbolic manipulations and their roles. The only way out for them is to rote learn or devise tricks like Fatima rules (Aikenhead & Jegede, 1999; Larson, 1995).

To check if issues identified by the textbook analysis resonated with teachers, we did a round of interviews with 3 grade 11 physics teachers and 1 mathematics teacher. The focus was problems they found when teaching, and also gaps in student understanding, in the context of vectors and its applications. The interviews were semi-structured, and the teachers used paper to explain when needed. All discussions were recorded for further analysis. The inputs from teachers varied with teaching experience. For example, all teachers noted students' difficulty in resolution and addition of vectors, and finding dot and cross products. But the reasons cited by the teachers varied from procedural aspects (inability to solve a determinant to find cross product; confusions about trigonometric ratios in vector resolution; using the formulae for dot and cross products) to conceptual aspects (not understanding the notion of direction of a vector, and the geometrical addition in a triangle giving the resultant).

3. Design of the Tool

We have developed a new media intervention to address the concept integration issues identified by the textbook analysis and teacher interviews. Computational media is a new way to introduce students to complex mathematical content (Kaput and Roschelle 2013; Kaput 1992; Kaput et al. 2002; Hoyles and Noss 2003). Systems with embodied interactions have been recently found useful in learning abstract mathematical concepts (Sinclair & Heyd-Metzuyanim, 2014). These studies support the idea that mathematical cognition, and symbolic cognition in general, could be understood as embodied cognition (Ottmar, Weitnauer, Landy, & Goldstone, 2015; Landy et al., 2014). Our design approach is inspired by these developments in the cognitive and learning sciences. New media systems to learn trigonometry are not new (Lotfi and Mafi , 2012; Zengin et al. 2012), but existing systems deal with very preliminary concepts, and the design and studies are not based on ideas from cognitive and learning sciences. Our approach is based on learning sciences, identifying key gaps in the curricula, particularly in integration of concepts. The design of the tool is based on embodied cognition theory, where we seek to develop a system that allows students to learn vectors, and more broadly MBR, in an integrated fashion using embodied interaction.

The current prototype is built using JavaScript, and supports learning of vector resolution, addition (dominantly triangle law) and understanding vector components. A demo video of the computer based tool is provided as supplementary material. The tool as in Figure 2 (left), allows the user to create a vector by clicking or tapping the screen in the larger left panel, and change its magnitude and direction by manipulating the vector. The learner can view right triangle projections and the rectangular components. Side panels always show the right triangle projected on the x-axis, and the circles of all the vectors on the screen. Two vectors can be added to see the resultant as in Figure 2 (right) using the triangle law of vector addition. The changes in the magnitude and the direction of any of the component vectors results in a corresponding change in the resultant vector.

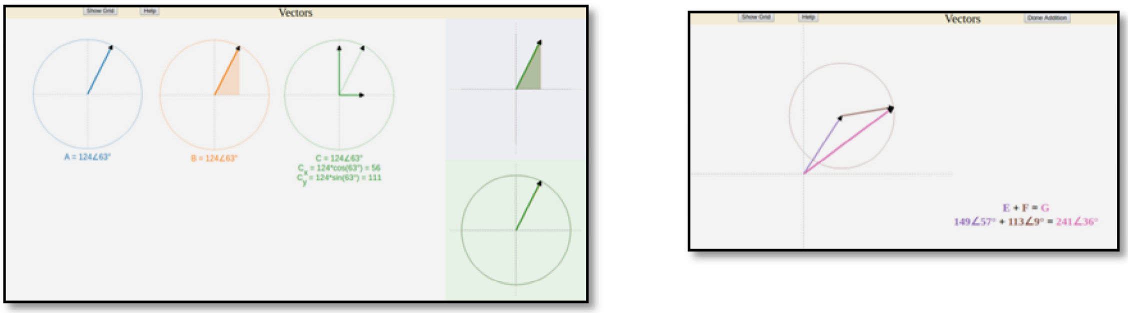

Figure 2. Snapshot of the intervention tool (left): Addition mode (right)

Simultaneous presence of components and the geometric changes modelled using the unit circle (vector inscribed in a circle), could scaffold the gap identified in the Textbook analysis. This feature also allows dynamic real time embodied interaction with vector elements, allowing learning of direction and magnitude, and also understanding how trigonometry is related to the components of vectors. The system thus allows learning both the nature of vectors and that of operations such as resolution and addition, in relation to their components. The possibility of numerous components and notion of non-rectangular components can be modelled using this tool.

4. The Study, Data Collection and Analysis Framework

A group of grade 11 students (n=49), who had finished their academic year dealing with vectors in physics, were first given a short written pre-test with 9 questions (to test pre-requisites and resolution and additions of vectors, as well as components and connections with trigonometry). From this group, 8 students were chosen (representing the range of good and bad performance) based on their responses in the pretest, and ability to externalise their understanding using text or diagrams. This group (n=8) was interviewed in the context of their pretest responses, to get a better understanding of their existing understanding.

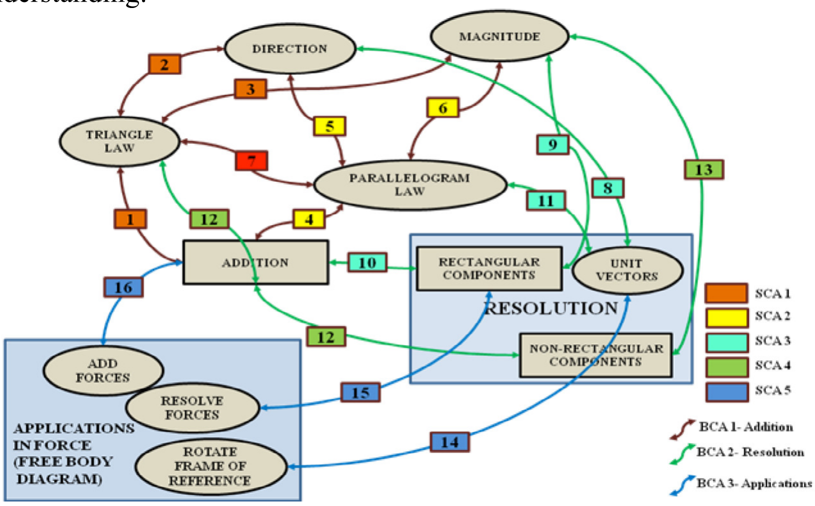

Figure 3. Concepts and the linkages

From this group, 6 students attended the intervention sessions, which involved performing tasks on the interactive vector system for about 70-90 minutes. These tasks were designed to make the students explore various features in the tool. Sample tasks were described in a video in the supplementary material. Their actions were recorded using video, written scripts (rough work), screen capture, and eye tracking (Tobii X2-60). After about a week, these 6 students were given a post test similar to the pretest (without prerequisite questions) followed by an interview in the context of their test responses.

Figure 3 shows the topics probed, categorised into three Broad Concept Areas (BCAs), which are further categorised into 5 sub concept areas (SCAs). These concept areas constitute 16 links between concepts (CLs). The pre and post test answers of all the 6 students were each analysed by 3 raters, and ratings were given to all relevant CL-question pairs. A 5-point rating scale for conceptual understanding (1 = no indication, 5 = strong indication) was developed for each of these concept links. This structure is based on studies examining the shift from conventional problem solving approach (prescribed in the text book) to a more conceptually sound explanation and judgments (Niemi 1996; Besterfield-Sacre et al. 2004; Gerace et al. 2001). The scale does not measure the correctness of the response, but rates the conceptual clarity of that particular concept link, as expressed in the answer to a given question.

If 2 or more raters found a concept link-question pair irrelevant, that pair was deemed irrelevant, irrespective of the third rater's rating. Inter-rater reliability was estimated using a weighted proportion of agreement ('2/3' for two raters agreeing, and '1' for three raters agreeing). If only one rater found a pair irrelevant, the agreed rating of the other two raters was used. The final score for each concept link-question pair is taken as the mode of the three ratings for the cases with agreement. For cases where all the ratings varied, further discussions led to 2 raters coming to a consensus. This exercise ensured an inter rater reliability of more than 67% across all the raters and the CL-question pairs. The ratings (converted to percentages) denote the strength of the CLs. This provides a comprehensive picture of the strengthening of specific CLs after interacting with the system.

5. Results and Discussion

Figure 4 (bar graph) shows the proportion of students whose understanding improved across each of the 5 SCAs (SCA1- Triangle Law; SCA2- Parallelogram Law, SCA3-Rectangular components, SCA4-Non rectangular components, SCA5-Application in context of forces). The colored lines capture the change in conceptual understanding (from pretest to posttest) of each student. The slope of each line captures the growth achieved by the student in the understanding of the CLs in that particular SCA.

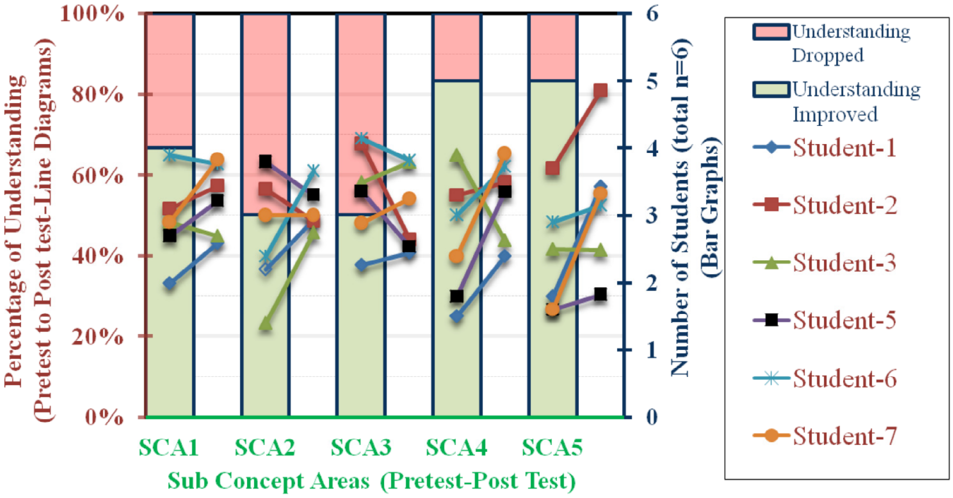

Figure 4. Conceptual understanding growth trajectories across Sub Concept Areas

Students improved in all SCAs, but in different ways. SCA1, SCA4, SCA5 show 3 students improving in their conceptual understanding. Four students improved in SCA1 (triangle law), which is expected, as the interactive system is predominantly based on triangle law. The parallelogram law (SCA2) is not very explicitly expressed in the system, but 3 students improved in this SCA. The two drops were about 2-3%. S6's drop in performance could be attributed to disruption in concept areas SCA3 and SCA4, related to components and addition. Surprisingly, only 3 students improved in the rectangular component (SCA3), even though rectangular components were part of the system. The improvement for this SCA was not more than 5-6%, this suggests this aspect of the tool needs to be redesigned. All the students whose performance dropped had pretest percentages around or more than 60%. This suggests that the system disrupted their existing concepts. SCA3 and SCA4 are closely related to components of a vector, and 5 students showed conceptual growth in SCA4, which pertains to non-rectangular components. Interestingly, all 3 students with weakened conceptual understanding in SCA3 (S2, S5, S6) have shown growth in SCA4. SCA5 (applying vectors and vector operations in the context of forces) improved in all students. Qualitative analysis of interviews showed comments supporting the above observations.

The above data suggests that the interaction with the system helped students improve their understanding of vectors in two ways: 1) understanding of triangle law and the non-rectangular components, and 2) the related disruption in their understanding of rectangular components. The students' interaction process is currently being analyzed for further insight to redesign the system.

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Modeling Learners' Metacognitive Skills in Open Ended Learning Environments

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Abstract: In this paper, we discuss improving thinking skills using Open Ended Learning Environment (OELE). In order to guide the students in OELE, their thinking skills should be inferred from their actions with the OELE. Learner modeling to infer students' thinking skills in OELE and our approach is discussed.

Keywords: OELE, Thinking Skill, Self-regulated learning, Metacognitive, Cognitive skills.

1. Introduction

Thinking Skills are the mental process needed to solve problems – they involve collecting information, identifying various approaches to solve the problem, choosing the best approach, and monitoring one's progress toward finding the right solution. Thinking skills are classified by (Beyer 1987), into three level based on its complexity. Broader thinking skills such as problem-solving, decision making, and conceptualizing are complex skills and labeled as level 1. Problem-solving skill involves recognizing the problem, devising/choosing a solution plan, executing it and evaluating the solutions. Decision-making skills involve choosing the best solution plan. Conceptualizing is also an important component in developing problem-solving skills. Critical thinking skills (level 2) such as determining the credibility of the source, identifying logical fallacies, and determining the strength of an argument or claims are a set of discrete mental operations that analyze the accuracy of data and information collected. These operations include both analysis and evaluation and are used repeatedly in various stages of applying level 1 thinking skills (Beyer 1988). Information processing skills such as Recall, translate, interpret, application, analysis, evaluation, and reasoning (inferencing) are considered as the most basic thinking skills and less complex, that is level 3. These skills are relatively simpler and are used repeatedly in various combinations to execute level 1 and level 2 thinking skills.

Teaching thinking skills to K-12 student is an important but non-trivial task because it requires students to structure the solution process, search for information, interpret it, explore alternate solution paths and apply it, to construct and test potential solutions (Brophy 2013; Winne 2010). Recently researchers have started using open-ended learning environment (OELE) to teach thinking skills to students in K-12 classes (Land 2000; Segedy, et al., 2015; Biswas et al. 2016; Basu et al. 2016). In general, OELE systems provide students with a complex problem to solve, tool and resources that support the problem-solving task (Jonassen et al. 2002). In OELE, the students will use problem-solving skills such as planning, metacognitive monitoring, analyzing and regulating, (Kinnebrew et al. 2016), in order to achieve their learning goal. Examples of such OELE used for education are MetaTutor (Azevedo et al., 2012), Betty's Brain (Leelawong and Biswas, 2008), and Crystal Island (Jonathan et al., 2011).

Students' performance in OELEs can be measured using traditional constructs, such as pre- to post-test gains, transfer learning, and quizzes. However, measuring student metacognitive skills that is, students' awareness of thinking skills and when they should apply, also how students apply their thinking skills to solve problems is still an open-ended research question. In this paper, we discuss the existing methods for learner modeling and propose a data-mining based approach for learner modeling in OELEs. In next section, we briefly describe an OELE that has been used extensively in our group, and also discuss some of the metacognitive processes that students employ to solve problems in this domain. In section 3 we review existing literature in learner modeling. We discuss our proposed approach in section 4 and conclude this paper in section 5.

2. Background

In this section, we describe Betty's Brain OELE and metacognition.

2.1 Betty's Brain OELE

The Betty's Brain learning environment (Leelawong and Biswas, 2008), provides students (learners) the task, of teaching a science topic to a teachable agent named Betty. In order to teach their agents, students construct a visual causal map that consists of a set of entities connected by directed links that represent the causal relation between entities. Betty uses the map to answer causal questions and explain those answers. The students' goal is to teach Betty's by drawing the causal map that matches a hidden, expert model of the domain. Students' learning and teaching are organized into three categories of activities: (1) reading hypertext resources, (2) building the map, and (3) assessing the correctness of the map (Davis, et al., 2003). Students iterate among these activities till they have taught Betty a correct model. Information extraction process that is reading hypertext resources, describes the science topic under study (e.g., climate change) by breaking it down into a set of subtopics. Each sub-topic describes a system or a process (e.g., the greenhouse effect) in terms of entities (e.g., absorbed heat energy) and causal relations among those entities (absorbed heat energy increases the average global temperature). As students read the topic, they extract the causal relations between entities and construct the causal map to teach to Betty. Figure 1 illustrates the Betty's Brain system interface.

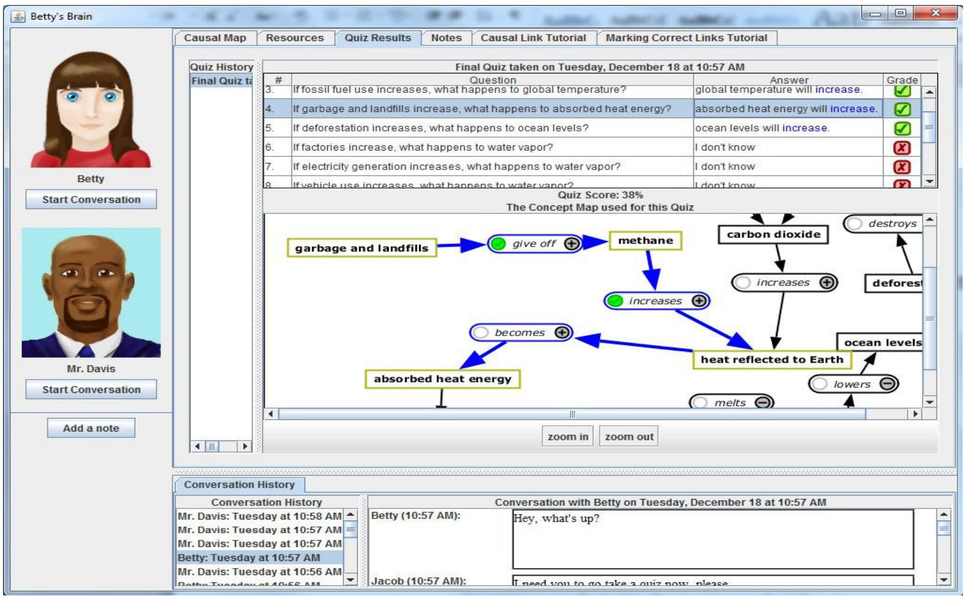


Figure1. Betty's Brain interface. Agent Betty and tutor Mr. Davis are shown. The menu tab in top shows resources to read, tutorial to create the causal map and to take the quiz. The quiz interface is shown in this figure.

To assess their own understanding and success in teaching Betty, students can use two ways, 1) Ask Betty to answer cause and effect questions using a template. To verify Betty's answer, student can ask another pedagogical agent named Mr. Davis, to check the answers. Mr. Davis acts as a tutor. Mr. Davis compares the portion of map developed by a student with the expert model; if both match then Betty's answer is correct. 2) Students can ask Betty to take the quiz on one or all sub-topics in the resources. Quiz questions are selected dynamically by comparing Betty's current causal map to the expert map. Since the quiz is designed to reflect the current state of the student's map, a set of questions is chosen (in proportion to the completeness of the map) for which Betty will generate correct answers. If the student created the causal map for one sub-topic then the rest of the quiz questions show either incomplete or incorrect answers. By analyzing the answer, students can understand that which causal links are correct and which links need to correct. It will help students to collect information again and build the model to teach Betty. If the students are not able to proceed in their learning task, they can interact with the tutor, Mr. Davis and ask for help via menu-based conversation. Then conversation allows the student to choose from a set of pre-specifies options.

2.2 Metacognition

Metacognition (Flavell, 1976) describes the ability to reason about and explicitly manage one's own cognitive processes. In the context of learning, metacognition can be considered a subset of self-regulated learning (SRL). SRL is a theory of active learning that describes how learners are able to set goals, create plans for achieving those goals, continually monitor their progress, and revise their plans to make better progress in achieving these goals (Zimmerman & Schunk, 2011). In terms of SRL, metacognition deals directly with cognition without explicitly considering its interactions with emotional or motivational constructs (Whitebread & Cárdenas, 2012). Our focus on metacognition is centered on students' understanding and use of strategies, which have been defined as consciously-controllable processes for completing tasks (Pressley et al., 1989). Strategies comprise a large portion of metacognitive knowledge; they consist of declarative, procedural, and conditional knowledge that describe the strategy, its purpose, and how and when to employ it (Schraw et al., 2006). The important goal in developing adaptive support for students' working in OELEs is to explicitly teach students the strategies for regulating their learning as they solve complex, open-ended problems. In next section, we discuss related research works to model learners' metacognitive processes.

3. Learner Modeling in Intelligent Tutoring Environment

Learning modeling approaches used in intelligent learning environments (ILE), (Desmarais and Baker 2012) & (Chrysafiadi and Virvou 2013), are briefly discussed in this section. Most commonly used learner modeling approach is the overlay model, it assumes that the learner model is a subset of a domain model that is learner has partial but correct knowledge of some components of the domain. Perturbation model is an extension of overlay modeling; it includes learner's misconceptions that are derived as deviations from the domain model. Stereotype approach is another widely used approach for learner modeling in ILEs (Chrysafiadi and Virvou 2013). Stereotype approach clusters learners based on certain characteristics, which are shared among learners in the cluster. Machine Learning (ML) techniques analyze learner's interaction with the system to classify their behavior. ML techniques canbe used to classify the learners into predefined groups as in Stereotypes (supervised) or new clusters are created based on learner's behavior (unsupervised). Constraint-Based Model (CBM), are developed based on the theory that learners learn from mistakes. In CBM, domain knowledge is represented by a set of constraints and learner knowledge is represented by a set of constraints violated by the learner. To implement constraint knowledge, learning content should contain all possible constraints required to learn that topic. Transfer modeling translates the actions of learners in the systems to skills and knowledge. Learners' skills are represented as ontologies for reuse and to extend the modeling approach to different application contexts.

In OELE, learners are not expected to follow a fixed learning path to achieve their goal hence modeling learners in OELE is a difficult task. From existing research, in OELE, a) stereotype approach using ML techniques are used to cluster the learners based on their behavior (Conati and Kardan. 2013), b) transfer models to model learners' skills or c) combination of a and b were used.

3.1 Learner modeling in OELE

Modeling students' behavior in OELE is a challenging task as it involves modeling students' both students' cognitive abilities as well as their self-regulatory learning behavior. Student model in OELE should capture students', cognitive, metacognitive, and the contextual influence on their performance.

In existing research, researchers have analyzed log data from students' interaction with system, derived analytic measures for characterizing different aspects of student learning behaviors, and and then clustered the students into groups based on the set of analytic measures. One such approach is by Conati and Kardan. (2013). In their system, student behavior in Interactive simulation (IS) environments derived from log data of their interactions with the system is used for classifying students into groups using an k-means clustering algorithm followed by associated rule mining, to create stereotypical models of user behavior. To improve the performance of student modeling (Kardan and Conati 2013), combined the eye gaze data collected using eye-tracker. The results show that combined data improved the performance of student modeling.

In Segedy et al. (2015), students' learning and success in teaching Betty in Betty's Brain are predicted using Coherence Analysis approach on tasks performed by the students. Task modeling is used to interpret student actions on the system in terms of higher level tasks. In task model, student's interaction with the system such as accessing resource page, taking a quiz, building the maps are transferred into a particular thinking skill, for example utilizing the access the resource page is transferred to higher order thinking skill of information seeking and acquisition. CA approach analyzes student's behavior by combining student's actions on the system to produce action coherence. For example, accessing resource page that provides information about two concepts provides support for editing causal link that connects those concepts in the causal map. CA approach analysis reports that CA provides insight into students' open-ended problem-solving strategies and predicts the students' task performance and learning gain.

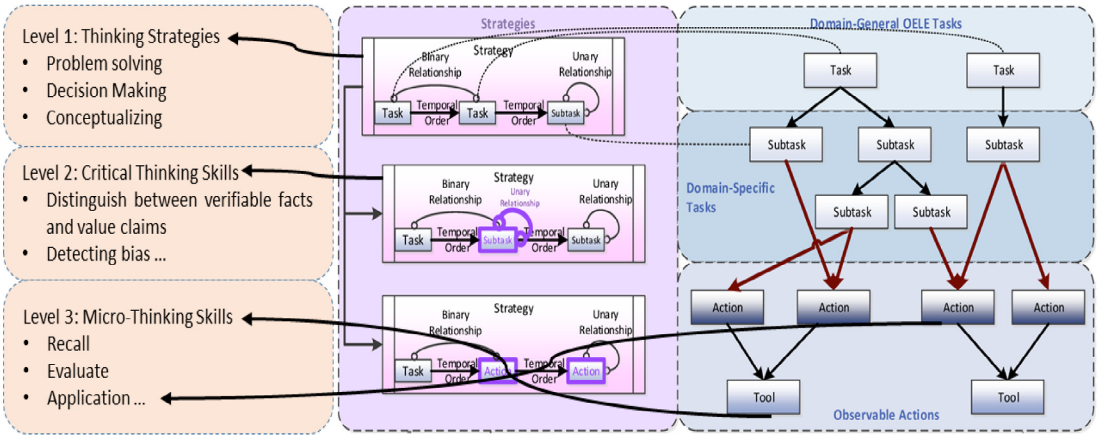
In (Kinnebrew et al. 2014), temporal sequences of students' action in Betty's Brain are analyzed using sequence mining methods. The most frequently occurring sequences of students' action are then interpreted as strategies of the students to succeed in the learning task. The students' cognitive skills and learning behaviors identified using data mining techniques are then used to interpret learning behaviors by mapping to metacognitive strategies based on a cognitive/metacognitive task model. In a recent study, Kinnebrew et al. (2016), analysis of students' activity sequences that access the coherence among students' actions and data-driven pattern discovery methods, which are explained in above two related research work, to interpret students' open-ended learning and problem-solving behaviors. The results show the data mining approach provided important inferences which are not considered in task-based model. For example, the difference in the learning strategies of high and low performing students. In this paper, we extend the sequence mining approach used in (Kinnebrew et al. 2016). Our approach in discussed in next section.

4. Learner Modeling in OELE using Data Mining Techniques

We propose to extend the learner modeling approach by Kinnebrew et al. (2016) in this paper. In this section, we discuss how task and strategy model is created from the students' interaction with Betty's Brain, and our proposed model is explained.

Figure 2b shows the generic task and strategy model proposed in (Kinnebrew et al. 2016). The task model is represented as a directed (acyclic) graph, along with its subtasks in OELE. At the lowest level are the observable actions performed by the student with OELE. Links from a task/subtask to actions indicate the actions to be executed to complete the task/subtask. The strategy model describes how actions, or higher-level tasks and subtasks, can be combined to provide different approaches or strategies for accomplishing learning and problem-solving goals. Figure 2 illustrates that strategy can be created by unary relation of task, binary relation between two task and by temporal ordering of tasks. Sequence mining methods are used to derive frequently occurring sequences of students' actions. They are then interpreted using a task and strategy model.

In the existing approach, sequence mining is performed on sequences of actions. The time spent on each task and the results of the student's action in that task is not considered during the sequence mining. Considering time spent on reading resources might identify new learner behaviors, which may define new strategies after analysis. In our approach, during sequence mining, log data will be represented as triple (task, performance, time) for each instance. We plan to implement our proposed approach in log data we collected from our experiments and analyze the new patterns.



a. Thinking skills by Beyer   b. Task and Strategy Model for OELE (Kinnebrew et al. 2016).

Figure 2. Links between Task and Strategy Model and Levels of Thinking Skills

In next section, we describe the Figure 2, that is discuss how task and strategy modeling is connected to the thinking skills.

5. Connecting Task and Strategy Model to Thinking Skills

Although OELEs are used to teach thinking skills, the learner modeling in OELEs are linked to hierarchical task and strategy models. Typically, they may be considered to be different, but we show that there are links between the task and strategy models used in OELEs and level of thinking skills we discussed in the introduction. The task and strategy model illustrates that a) higher level tasks may comprise multiple lower-level tasks and b) the combination of multiple tasks/subtasks as a strategy represents the coordination of multiple learning and problem-solving activities, with supporting skills and cognitive processes. These two properties and hierarchical representation of strategy model map on to a number of the thinking skills discussed earlier.

Figure 2, shows the link between OELE task model (Kinnebrew, et al., 2016) and thinking skills (Beyer, 1988). Inference from the users' interactions with the system, will inform us about micro-thinking skills such as recall, and application. The strategy model developed from tasks and subtasks is similar to the level 1 and level 2 thinking skills. Both OELE's task and strategy model and thinking skills are further used to infer the learners' metacognition skills (planning, assessing and monitoring).

6. Conclusion

Thinking skills are important for students in middle schools. The significance of OELEs in helping students develop thinking skills has been demonstrated (Basu et al. 2016). To understand students learning in OELE and to guide them, student's metacognitive skills are tracked and modeled in the OELE. In this paper, a) we have discussed how we may use the learner modeling in OELEs to infer the thinking skills and b) proposed a learner modeling approach using data mining techniques to model learner's strategies. The link between OELE task model and thinking skills, established in this research article is preliminary, and we will extend it in future work by extending the task modeling framework to decision making systems, such as UrbanSim (Wansbury et. al., 2010), and establish the link between OELE and thinking skills.

We plan to test our proposed learner modeling approach using data collected from Betty's Brain and CTSiM tutors. In order to test our approach, we preprocess the raw data to include time spent on each task/sub-task and the performance of that task. Using sequence mining techniques, we will discover patterns of tasks and sub-tasks form the log data. These emerging patterns will be further analyzed and used to identify the strategies used by the learner. The learner model comprising domain level skills learned, cognition and metacognition will be developed. The proposed sequence mining approach can be applied to other OELEs and representation of data can be varied based on the OELE used.

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Development and Evaluation of Student-Generated Feedback in an Online Student-Generated Multiple-Choice Questions Learning Space

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Abstract: An online system supporting student-generated feedback (SGF) in the context of student-generated questions (SGQ) was developed. The multi-dimensional scaffolding framework and customizable design for SGF was explained. A preliminary study was conducted to assess the perceived learning potential and difficulty of SGF with SGQ. Fifty-five middle-school aged students participated for seven consecutive weeks, and SGQ with SGF activities were integrated to support Chinese teaching and learning. Data were analyzed by descriptive statistics, chi-squared test of goodness of fit, and constant comparative method. Two major findings were obtained. First, more than 85% of the participants regarded 'SGQ with SGF' as better for promoting their learning of Chinese, by directing them to not only think further and deeper from other's perspectives, but also review course materials or look for content-related materials, altogether leading to better Chinese academic and question-generation performance. Second, more than 80% of the participants perceived SGQ with SGF as more difficult, with its intrinsic task difficulty and time constraint associated with completing the task in class. Suggestions for future research are provided, in light of the current findings and related literature on feedback.

Keywords: Online learning activity, student-generated feedback, student-generated questions, perceived learning difficulty, perceived learning potential

1. Introduction

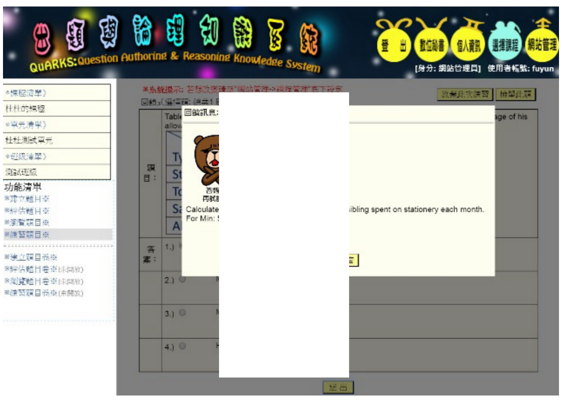
Through decades of scientific inquiry, psychologists and educational researchers have been successful in establishing explicit design principles for instruction. Specifically, engaging students in practice activities that are directly related to learning objectives, followed up by feedback to student performance, has been suggested as one of the most powerful components that facilitates learning (Dick, Carey & Carey, 2005). Despite their highly recognized pedagogical value, the questions used in drill-and-practice (D&P) learning activities are predominantly based on test banks from textbook publishers, or constructed by teachers (Brown & Walter, 2005), with feedback mostly provided by teachers.

While the effects of a student-generated questions approach (SGQ) are well attested by researchers in a wide area of disciplines over the past decades, the potential of engaging students in generating feedback corresponding to answers to SGQ (i.e., student-generated feedback, SGF) has yet to be fully explored and understood. Since few, if any, systems supporting online SGF in response to answers given to the generated questions are available, the aim of this work is to design and develop such a system (SQG with a feedback-generation component). In addition, a preliminary study was conducted to collect data on students' perceived learning potential and difficulty regarding SGF in a SQG context.

2. Design and Development of a Scaffolded and Customizable Student-Generated Feedback Component in an Online Student-Generated Questions Learning System

To enable students to generate feedback for each of the options of a multiple-choice question, one of the authors lead her research team to design and develop a feedback-generation component within an existing online system supporting SGQ learning activities (i.e., QuARKS) (Yu, 2009). Basically, a new question format is built—student-generated multiple-choice questions (SGMCQ) with SGF. For SGMCQ, students generate a question stem, four options including the correct answer, and an annotation explaining the main ideas being tested (Figure 1a). For SGF, students provide justification for the correct answer and explanation for incorrect responses to accompany each of the options of the generated question (left of Figure 1b) to be used during online D&P sessions (Figure 2).

Figure 1. (a) SGQ (left); (b) SGQ with SGF (right)



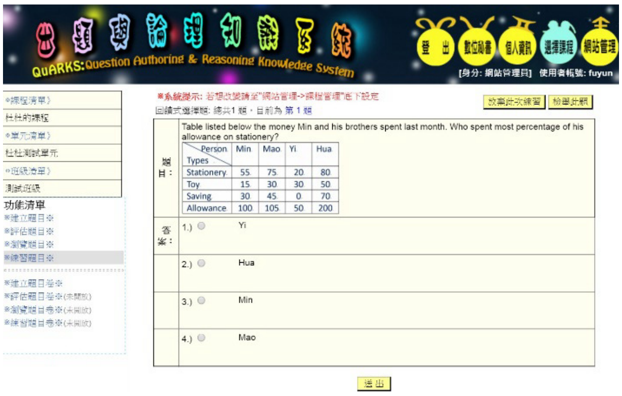


Figure 2: Sample screen-shot of system feedback to student's incorrect selection (left) to SGMCQ (right) during online D&P sessions

In addition, in light of the wide acceptance and use of emoji (i.e., emoticons) in social networking sites, and to take advantage of the multimedia capability of computer technologies, the content of the feedback is not limited to textual forms. Multi-media files, including illustrations (e.g., diagrams, charts, photographs, and graphics), animations, videos, and audio are also permissible (for example, see left of Figure 2), to allow the learner to determine the extent of media richness used.

Moreover, since students at all levels rarely have any experience of SQG (Moses, Bjork, & Goldenberg, 1993; Yu, 2009), never mind generating feedback for SQG, support mechanisms and functions for feedback-generation are designed and built. With reference to the related literature on feedback (e.g., Butler, & Winne, 1995; Chi, 1996; Dempsey, Driscoll & Swindell, 1993; King, 1994; Kulhavy & Stock, 1989; Narciss, & Huth, 2004; Schwartz & White, 2000; Shute, 2008), the support built for SGF in the system adopts a multi-dimensional framework. Briefly, as shown in Table 1, the first dimension is about the 'focus' of feedback, and concerns the substantial content of feedback. The second dimension deals with the 'forms and types' of feedback. Lastly, the third dimension relates to the 'criteria' of feedback, and deals mainly with the technical details of effective feedback.

Table 1: The 3-dimension scaffolding framework for SGF

Focus of feedback	
▪	Task specific
▪	Instruction-based
▪	Extra-instructional
Forms and types of feedback	
▪	Verification of response accuracy or inaccuracy
▪	Justification of response accuracy
▪	Explanation of the incorrect response: referring to the what, how, and why the exhibited performance or behavior is incorrect
▪	Hints, non-specific queries, or suggestions, like 'are you sure?' 'is this correct?' 'have you considered…?' to alert the responder that the chosen answer is incorrect and some areas of importance may be overlooked
Criteria of feedback	
▪	Supportive
▪	Specific (referring to the current learning objectives or learning tasks)
▪	About the task
▪	Appeal (relating to peers' academic motivation, prior knowledge and skills)

Finally, as scaffolding should be carried out in relation to the intended context and target audience (i.e., context-sensitive) (Pea, 2004), the designed support function for feedback-provision adopts a customizable structure (in terms of the number of dimensions and its respective content). That is, online prompts for SGF can be revised accordingly by individual instructors to ensure that scaffolding is termed, framed, and explained appropriately for the targeted group of learners, classrooms and current instructional plans. By so doing, the situational characteristics of the instructional context, as well as individual characteristics of the learner, which Schwartz and White

(2000) and Shute (2008) suggested should be considered during feedback provision, can be included as part of the online prompts for students' consideration in SGF.

3. Preliminary Study Assessing Students' Perceived Learning Potential and Difficulties Regarding Student-Generated Feedback Learning Task besides Student-Generated Questions

Two seventh-grade classes (N=55) participated in this study for seven weeks. The learning activities (SGMCQ and SGF) were introduced to support the participants' Chinese learning by using the last of the six 45-minute instructional sessions allocated for Chinese instruction each week in the participating school's computer lab during the study.

This study consisted of three stages: training, SGQ, and SGQ with SGF. During the training stage (1st session), topics to help equip the participants with the needed knowledge and skills were emphasized. These were: the purposes and fundamentals of SGQ; criteria of multiple-choice question-generation; operational procedures for SGQ with the system; and hands-on practice on the system. For both SGQ (2nd session) and SGQ with SGF stages (3rd~7th sessions), reviews of the Chinese instruction in the current week (in the form of delineated learning objectives) and whole-class feedback on student performance with regard to the previous online learning activity was given by the instructor (10 minutes), before the students were directed to individually generate three multiple-choice questions without feedback during stage 2 (SGQ), and then questions with feedback during stage 3 (SGQ with SGF), according to the learning material covered in the current week in the system (35 minutes). During whole-class feedback, three to six pieces of student-generated work (i.e., SGQ, or SGQ with SGF), were purposively selected and shown to highlight exemplary work from the participants in their respective classes. Prior to students' first engagement in SGQ with SGF, a brief training session on SGF was arranged. During the session, the focus, types, forms, and criteria of feedback with context-specific examples from the previous lessons and the operational procedures involved in SGF within the system were first introduced, before showing how SGF works during online D&P sessions (Figure 2). Figure 3 shows the implementation procedures used in this study.

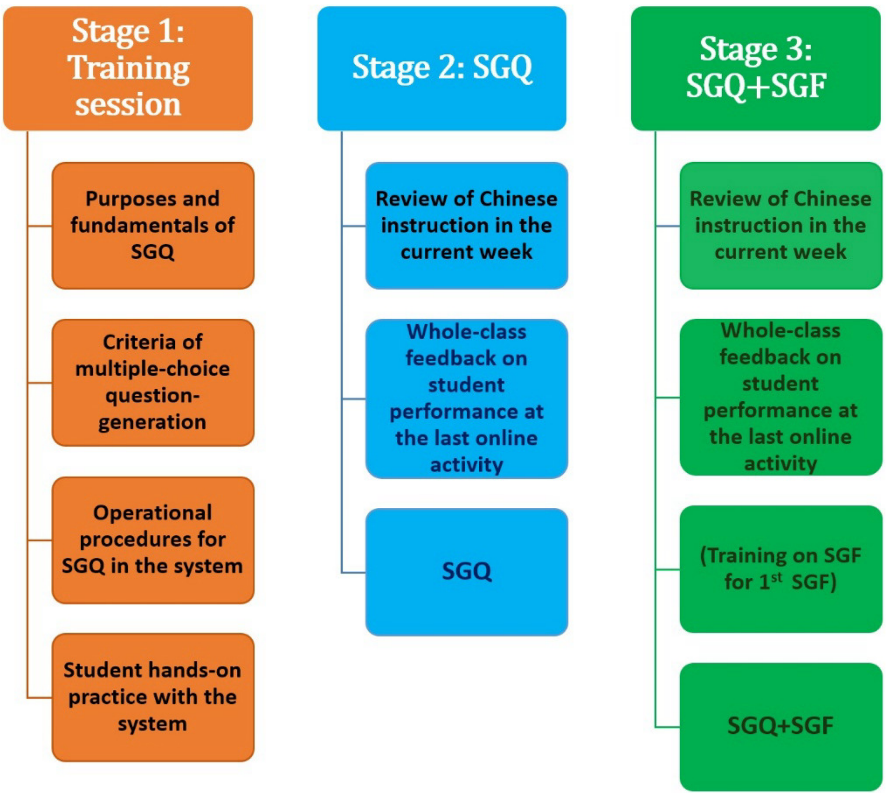


Figure 3. Implementation procedures used in this study

At the conclusion of this study, the participants were asked to individually complete a two-item questionnaire to solicit their views regarding perceived learning potential and difficulties with regard to SGQ and SGQ with SGF. Specifically, they were asked:

1. Which of the two approaches do you think better promote your learning of Chinese (SGQ, SGQ with SGF, no difference)? Please support your answer.
2. Which of the two approaches do you think are more difficult (SGQ, SGQ with SGF, no difference)? Please support your answer.

Descriptive statistics and Pearson's chi-squared test of goodness of fit were used to analyze the quantitative data, and the constant comparative data analysis method proposed by Lincoln and Guba (1985) was adopted to analyze students' descriptive responses.

Data analysis done on perceived learning potential indicated that the majority of the participants (85.45%, n = 47) regarded 'SGQ with SGF' better promoted their learning of Chinese, with 10.91% (n = 6) feeling the two approaches had similar learning potential, and only two participants voting for SGQ (n = 2). A X^2 test further indicated that the observed frequency distribution among the three arrangements was statistically significant, $X^2 = 67.67$, $p < .05$. Two salient themes emerged from the reasons the students provided to support their responses. First, more than three-quarters of the students (76.67%, n = 36) made responses that reflected the 'opportunity SGQ with SGF provided for thinking further and deeper from others' perspectives' theme (in this case, possible test-takers). As such, the constructed explanations and justifications given in response to each of the options not only helped the students to better understand the main ideas being tested in the questions, and why the answer key is the correct answer, but also raised their awareness of some possible misconceptions associated with the incorrect options. Second, the 'directing them to review course materials or look for content-related materials in other sources' theme appeared in 23.40% of the responses in favor of SGQ with SGF (n=11). As a result of engaging in the abovementioned active processes, 42.55% (n =20) of the students clearly expressed that their Chinese academic performance was promoted, and 27.66% (n =13) mentioned that their question-generation ability was enhanced.

On the other hand, data on perceived learning difficulty showed that most of the participants (83.64%, n =46) regarded 'SGQ with SGF' as more difficult, while less than 10% (9.09%, n = 5) regarded SQG as more difficult, and 7.27% (n = 4) felt there was no difference between the approaches in this regard. The results of a X^2 test showed a statistical significance of the frequency distribution observed among the three arrangements, $X^2 = 62.65$, $p < .05$. Constant comparative analysis of the students' responses further highlighted two themes—'the intrinsic task difficulty of SGF' and 'time constraint.' As many participants noted in their responses, the provision of SGF required them to look for explanations or reasons that could help test-takers to understand why each of the four options are correct or incorrect, which in itself is very demanding in terms of time and effort. In order for the SGF task to be successfully achieved, some of the participants noted that the questions should not be at low difficulty or discrimination level, and that the students should have adequate knowledge or learning materials. On another note, as the task was arranged to be completed within a 45-minute class time, it was understandable that SGF with SGQ was perceived, by most participants, as more difficult and challenging.

4. Conclusion

This study introduced an existing online learning system extended to support SGF, which included a multi-dimensional scaffolding framework and customizability to fit different classrooms and instructional plans. A preliminary study was conducted to assess its potential. The results revealed that while the majority of the participants recognized that it could enhance their learning, a number of difficulties were also noted with regard to SGF with SGQ.

The positive learning effects with regard to students' cognitive gains can be expected with reference to self-explanation theory (Chi, Bassok, Lewis, Reiman & Glaser, 1989; Chi & VanLehn, 1991; Wylie & Chi, 2014). However, the additional SGF task entails a number of cognitively demanding and time-consuming activities, and thus the learning effects of SGF with SGQ on cognitive gains as well as other learning outcomes of importance are interesting directions for future research.

5. Acknowledgement

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Comparison between Kit-Building Task of Concept Map and Multiple Choice Task of Fill-in-the-blank Question Generated from the Same Series of Propositions

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Abstract: We have already proposed a framework of kit-build concept map where a learner is provided a set of parts of a concept map and is requested to build a concept map by composing the parts. In this framework, a build map by a learner is able to be diagnosed automatically. The kit-building task of a concept map is a promising exercise for strengthening and assessing learner's comprehension for a topic that a learner already has learnt. We have implemented an interactive learning environment based on the framework and practically used the environment in several schools. In this paper, in order to investigate the value of the kit-building task of a concept map, we compare it with multiple-choice task of fill-in-the-blank questions. The multiple choice task of fill-in-the-blank questions is also used to strengthen and assess learner's comprehension, and the answer can be automatically evaluated. Then, the both task can be generated from the same series of propositions, that is, from the same contents. We have compared the two tasks through 3 lessons of science learning of 5th grade students in two classes. One class used KB map (KB class) and another class used Fill-In-the-Blank questions (FIB class). Individual student in both classes used a tablet PC. The tablet PC was connected to a server though wireless LAN and a teacher could receive the results of evaluations of the maps or answers' of the questions immediately. Based on the evaluation results, the teacher conducted additional teaching. As the results, the KB task evaluated learner's comprehension more adequately than the question task, and the students in the KB class had higher performance than the students in the question class.

Keywords: Kit-Build Task of Concept Map, Multiple Choice Task of Fill-in-the-blank Questions, Strengthening of Comprehension, Assessing of Comprehension

1. Introduction

Concept map is a diagram that depicts relationships between nodes that expressing a topic (Novak et. al., 2006). This diagram is often used as a tool to structurally represent idea or knowledge in various situations. In education, the concept map is used as a tool to let a student to express their understanding for a target learning topic (Novak, 1990). There are many investigations that report the learning effects to use the concept map. However, concept maps built by students' with their own words are very difficult for teachers to evaluate them immediately. Therefore, although the concept map is useful as learning activity and is able to be useful for summative assessment, it is difficult to realize real time feedback based on evaluations of the concept maps.

In Kit-Build Concept map (KB map in short), all components, that is, nodes and links are provided to a student, and then, the student is required to build a concept map by combining them to express their understanding for a lecture(Yamasaki, et.al., 2010, Hirashima et. al., 2011, Hirashima, et. al., 2015). Therefore, the kit-building task of a concept map is a promising exercise for strengthening and assessing learner's comprehension for a topic that a learner already has learnt. The components are generated by decomposing a teacher map that is built by a teacher who conducts the lecture as an ideal understanding for the lecture. The map build by a student is easily compared with the teacher map because all components are the same ones. Therefore, the KB map framework realizes automatic evaluation of a concept map as comparing with a teacher map. We have already implemented the KB map framework and practically used it in several elementary schools. The results have suggested that using KB map has learning effects (Sugihara, et. al., 2012).

In this paper, in order to investigate the value of the kit-building task of a concept map, we compare it with multiple-choice task of Fill-In-the-Blank (FIB) questions. The multiple choice task of fill-in-the-blank questions is also used to strengthen and assess learner's comprehension, and the answer can be automatically evaluated. Then, the both task can be generated from the same series of propositions, that is, from the same contents. Because of these two reasons, it is adequate to investigate the value of the KB map task by comparing with the FIB questions task. As a learning task, the KB map task and the FIB question task are categorized as learning by recalling or paraphrasing. In recalling or paraphrasing, usually memory is reconstructed and the reconstruction has learning effect (Teun et. al.,1983, Roediger, et. al.,2015). In this research, we try to find difference between the KB map task and the FIB question task in learning effect and assessment of comprehension.

In this research, we have implemented an authoring tool that supports to generate (1) Kit-Building Task of Concept Map, and (2) Multiple Choice Task of Fill-in-the-blank Questions from a series of propositions. In the practical use of KB map and FIB questions, 5th grade students in two classes received 3 lessons of science learning. One class used KB map (KB class) and another class used FIB questions (FIB class). Individual student in both classes used a tablet PC to build KB map and answer questions. The tablet PC was connected to a server though wireless LAN and a teacher could receive the results of evaluations of the maps or answers of the questions from the server immediately. Based on the evaluation results, the teacher was allowed to conduct additional teaching. As the results, the KB task evaluated learner's comprehension more adequately than the question task, and the students in the KB class had higher performance than the students in the question class.

In this paper, in Section 2, relationship between FIB questions and KB map are explained in more details. In Section 3, implementation of the authoring tool is explained. In Section 4, experimental uses of KB map and FIB questions are explained and comparison of learning effects of them is reported.

2. Relationship between Fill-In-the-Blank Questions and Kit-Build Concept Map

A semantic unit of concept map is a combination of two nodes representing two concepts respectively and one link representing relationship between the two concepts. The link has a link word/phrase to specify the relationship. The combination of two nodes and one relationship represents a proposition. In other words, a concept map expresses a series of propositions. Semantic network (Carbonell, 1970) and RDF expression (RDF Working Group, 2004)have adopted the same notational system and they have the same ability to represent semantics basically. In this paper, a concept map is regarded as a set of propositions composed of two concepts and one relationship

For an example, in a topic of "Movement of the Sun" in science learning in elementary school, it is possible to depict a teacher map as shown in Figure 1. This teacher map was used in a practice reported in (Yoshida et. al., 2013). This teacher map is composed of four propositions: (1) the "sun" "rises in" the "eastern sky", (2) the "sun" "passes through" the "southern sky", (3) the "sun" "sits in" the "western sky", and (4) the "sun" "doesn't pass through" the "northern sky". These four propositions are connects by "sun" and form a series of propositions. Here, a colored rectangle expresses a node and a phrase composed of one or few words in the rectangle expresses the label of the node. We call the phrase "node label". A phrase in white rectangle between two nodes expresses a label of link. We call the phrase "link label". "Western sky" and "Sun" are node labels and "Sets in" is a link label.

In this case, when a teacher inputs the four sentences and specifies three parts (one or a few words) corresponding to two nodes and one relationship in each sentence, the four sentences are regards as four propositions. Because the propositions are connected to a series of ones, a concept map is generated. This is a procedure of authoring of a concept map from a set of sentences. When a series of propositions is generated, it is possible to generate FIB questions by specifying a blank in each proposition. For an example, when all link words are specified as blanks in the above propositions, four FIB questions are generated from the same content. This is a procedure of authoring of FIB questions from the same content with a concept map.

There are several automatic assessment methods of concept map. CmapTools is a representative implementation of automatic assessment of concept map (Novak et. al., 2006). However, CmapTools allows students use their own words as node and link words. Therefore, CmapTools has adopted synonyms matching. Therefore, as right/wrong judgement of a proposition, it is not reliable. In contract to CmapTools, KB map is able to precisely judge right/wrong to each proposition. CMT Mapping Tool realizes automatic and precise assessment in the level of propositions (Ben, 2010). However, CMT requests a teacher to build a map formal way that can be assessed by using diagnosis rules. This kind of concept map is often called formal concept map. Formal concept map is usually very difficult to adequately prepare because it requires knowledge not only the domain but also knowledge engineering. Current our target is a concept map that a usual teacher is able to prepare. Such concept map is often called informal concept map. KB map realizes automatic assessment in the level of proposition for informal concept map.

From viewpoint of these assessment characteristics, a set of FIB questions has the similar ability. Therefore, in this research, we realized activities of KB map building and answering FIB questions for the same content and compared their learning effects. Procedure of authoring KB map and FIB questions in this research shown in Figure 2. In this example, a teacher writes a summary about "movement of the sun" as a learning topic (step-1) at first. Each sentence consisting of the summary is required to form a proposition. Then, the teacher is requested to specify two concepts (as node labels) and a relationship (as a link label) in each sentence. By the specification, a proposition is made from a sentence. So, a set of propositions are generated from a summary (step-2). From the set of propositions, a concept map for the learning topic is generated (step A-1). This map is a teacher map. If the propositions are not connected to one, the teacher is required to modify the sentences or specification of nodes or link. By decomposing the teacher map, a set of components that are provided to students are generated (step A-2). In order to make FIB questions, the teacher is required to specify a place to make the blank in each sentence. The place should be corresponds to a node label or a link label (step B). Consequently, both KB map and FIB questions are made from the same proposition set. And then, both are possible to realize automatic assessment in proposition level.

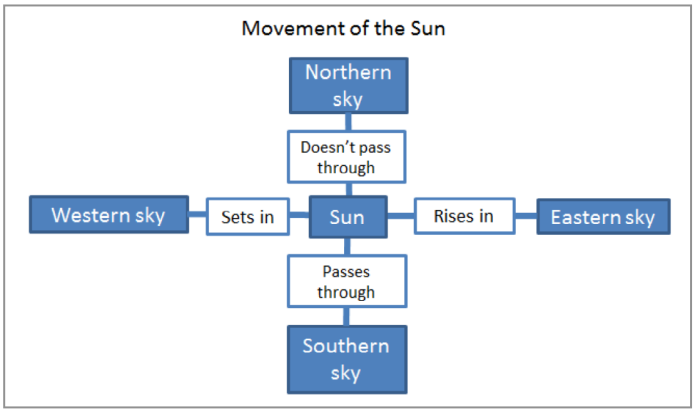


Figure 1 One example of a teacher of the map about "Movement of the Sun"

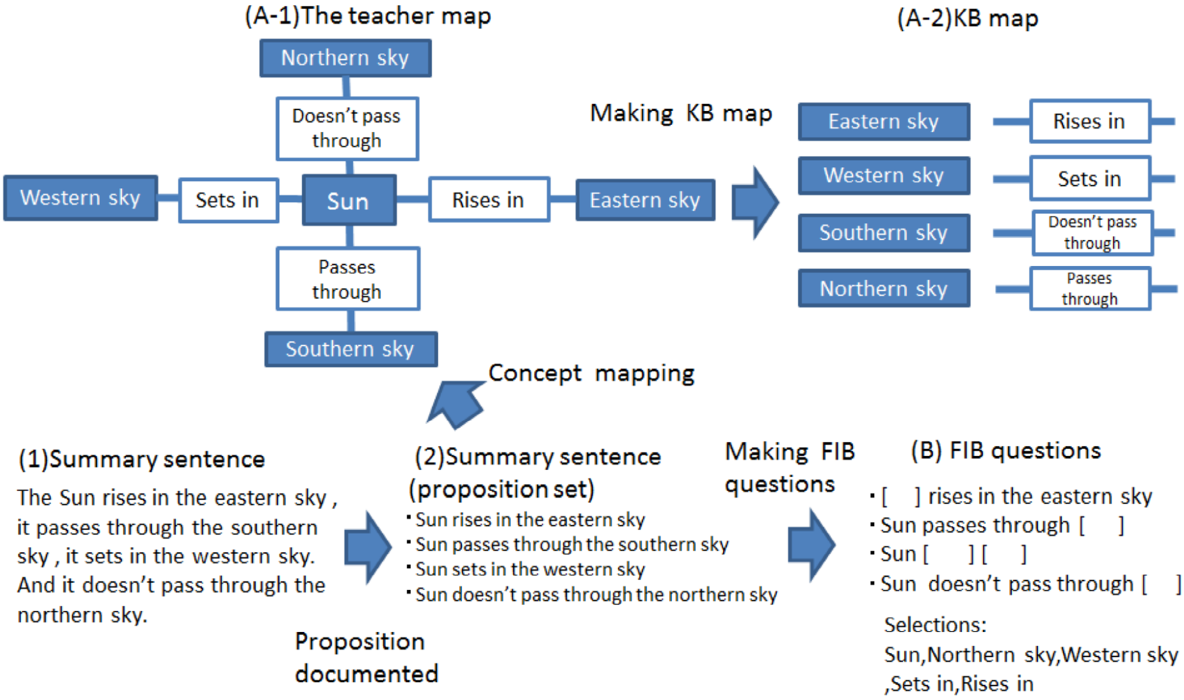


Figure 2 Example of the relationship between KB map and FIB questions

3. Implementation

3.1 Framework of Implementation

Figure 3 shows the framework of the implementation of the system to deal with both KB map and FIB questions. This system has been developed as an extension of the KB System (Hirashima et. al., 2015). Based on this framework, implementation of the system is explained.

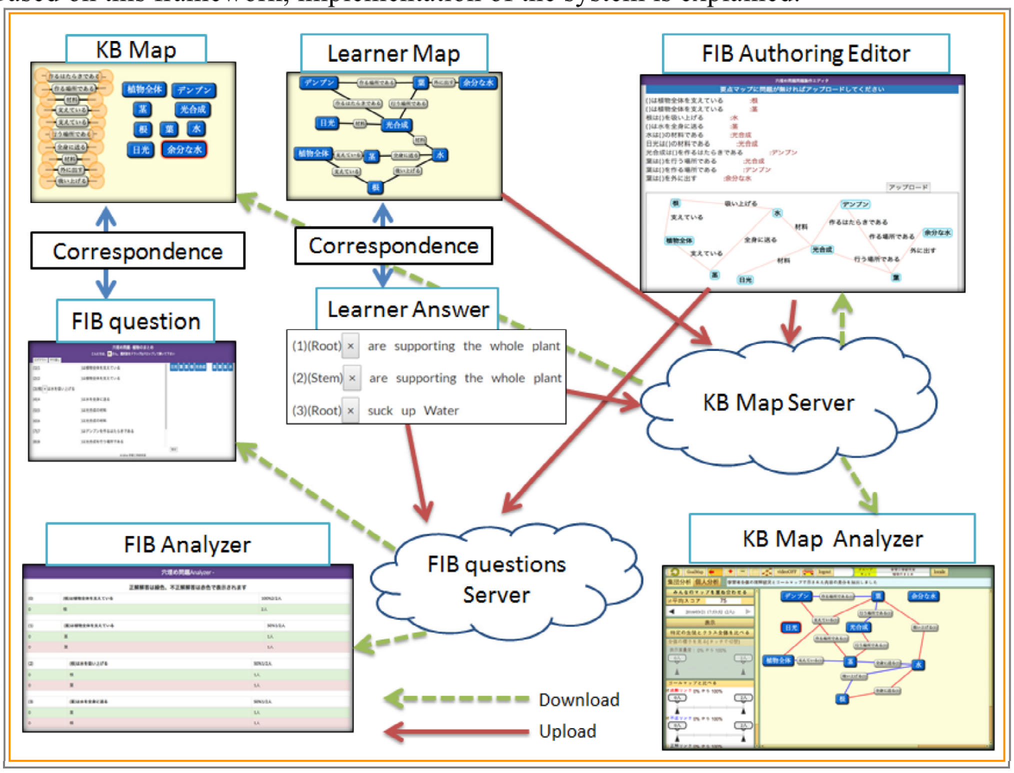


Figure 3 Framework of Implementation

3.2 Authoring Process of KB map and FIB Questions

3.2.1 Making a Set of Propositions and KB map and FIB Questions

Figure 4 shows the process to make a set of propositions. In this interface, a teacher specifies two node words/phrases and one link word/phrase in each sentence. Nodes are marked by "#" and "&", and link word is marked "@". By this marking, it is possible to make a set of propositions automatically. Then, the propositions are directly translated into a concept map shown in Figure 5. The layout of the teacher map is determined automatically and can be modified the layout later as the teacher by drag and drop manipulation of the nodes and links. The teacher map is registered in KB map system and a student is allowed to build a concept map with KB map editor.

3.2.2 Making FIB Questions

From the set of propositions shown in Figure 4, FIB questions are able to generate by specifying the blanks. Figure 6 shows an example of the process. In this case, the first concept in each proposition is specified as the blank. Then, choices for the blanks are given as a set of deleted words to make the blanks. Figure 7 shows answering editor of FIB questions generated by specification shown in Figure 6. In the answering editor, several sentences with blanks are shown in the left side and the set of choices are given in the right column. By drag and drop manipulation, a choice is put into the blank in a sentence. In Figure 7, sentence (4) and (5) are filled the blanks correctly corresponding to propositions.

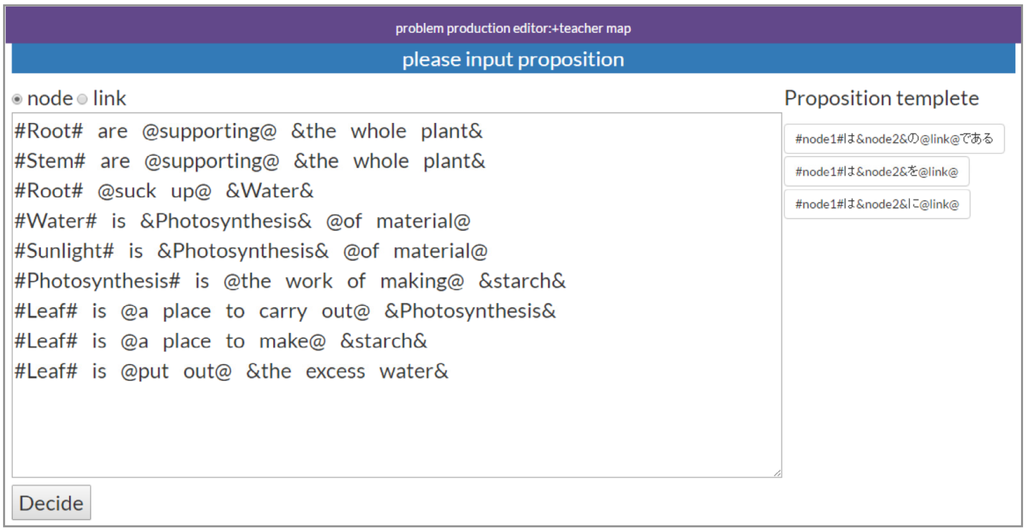


Figure 4 Inputting proposition

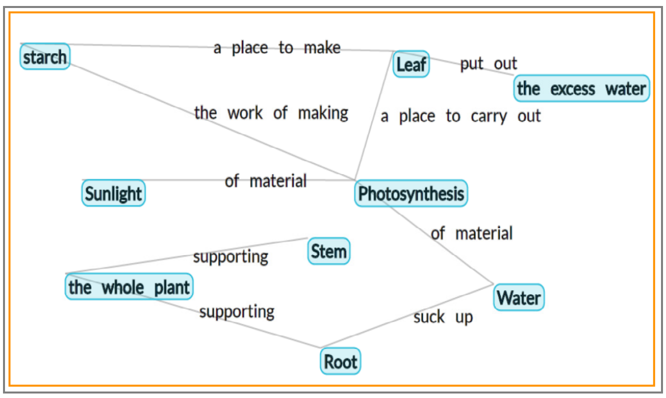


Figure 5 Teacher map that teacher was layout

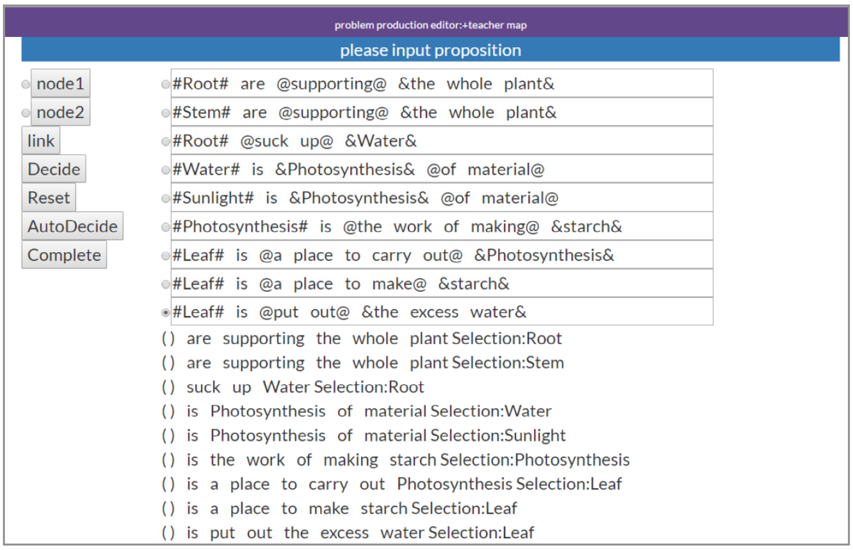


Figure 6 Creating FIB question

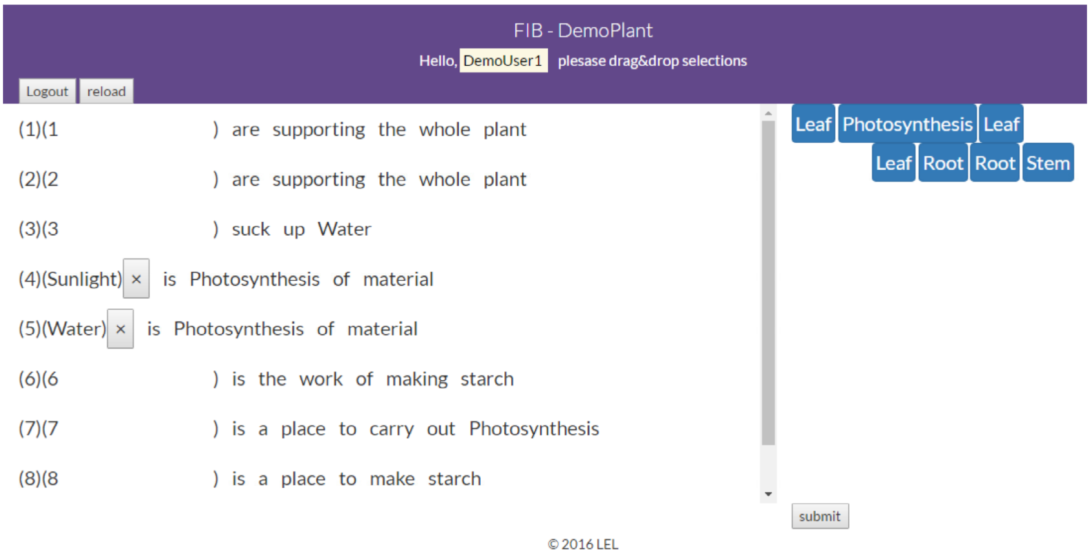
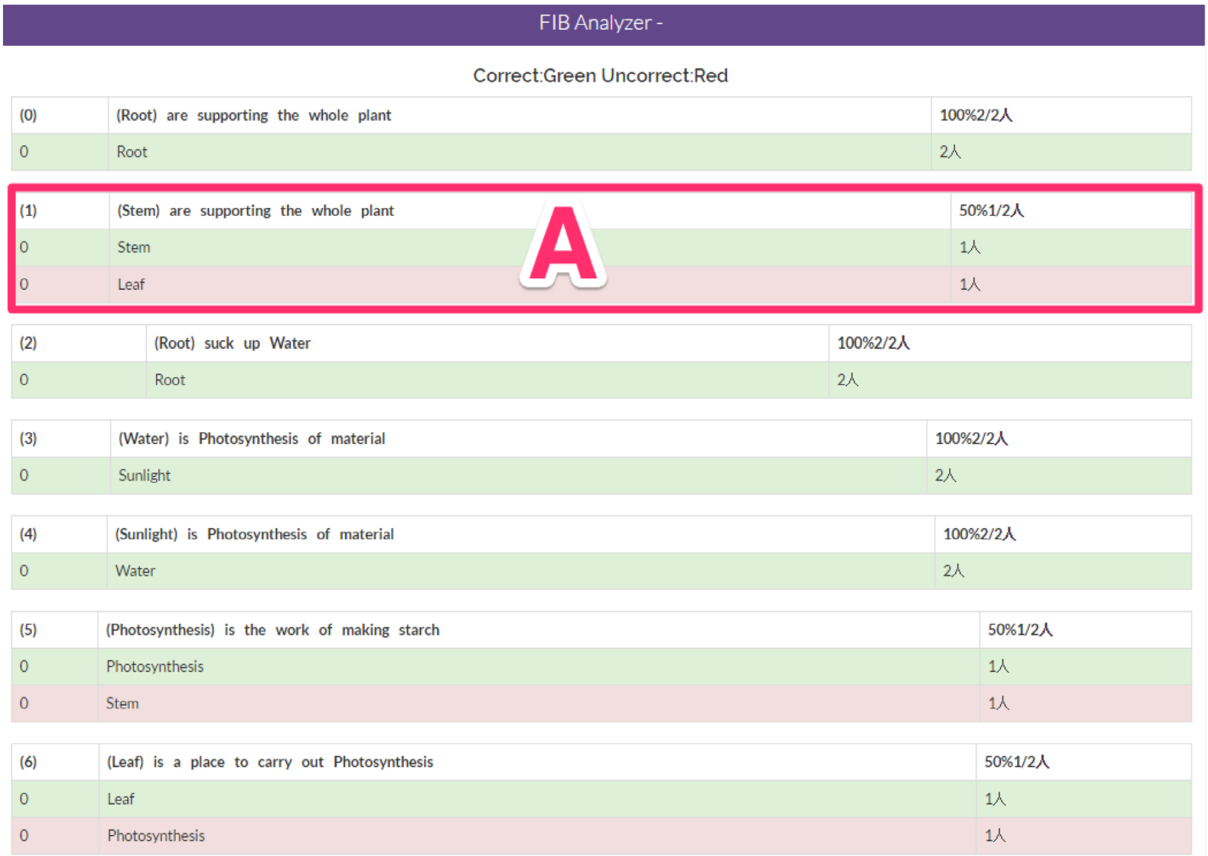


Figure 7 FIB Questions

3.2.3 Analysis of Answers for FIB Questions

A teacher can use an analyzer to check the results of answering as shown in Figure 8. In this analyzer, for each question, the number of correct answers, types of incorrect answers, their numbers, and their percentages for the total answers. The teacher is also able to check each student's answers. Because these questions and answers can be translated into propositions, they can be represented as a concept map. We visualized the results of answering for FIB questions by using KB analyzer as shown in Figure 9. These two figures correspond reciprocally. For an example, Question(A) in Figure 8 was made from the proposition "#Stem# is @supporting@ &the whole plant&" that is at the top of the list of propositions in Figure 4. Then an incorrect answer for the Question(A) corresponds to an incorrect proposition "#Leaf# is @supporting@ &the whole plant&". This mistakenly composed proposition is visualized with red colored link as shown in Figure 9 marked (A1). In KB map, a mistakenly composed proposition is interpreted as an incorrect connection of a link. So, this mistake is called "excessive link". Because the link @supporting@ was used in the wrong proposition, a correct proposition, that is, "#Stem#" is @supporting@ &the whole plant&" is lacking in the answers. So, in the map shown in Figure 9, the lacking proposition is visualized by a blue link marked (A2). We call the link "lacking link". This is a visualization of answers of FIB questions with KB map.



FIB Analyzer -

Correct:Green Uncorrect:Red

(0)	(Root) are supporting the whole plant	100%2/2人
0	Root	2人
(1)	(Stem) are supporting the whole plant	50%1/2人
0	Stem	1人
0	Leaf	1人
(2)	(Root) suck up Water	100%2/2人
0	Root	2人
(3)	(Water) is Photosynthesis of material	100%2/2人
0	Sunlight	2人
(4)	(Sunlight) is Photosynthesis of material	100%2/2人
0	Water	2人
(5)	(Photosynthesis) is the work of making starch	50%1/2人
0	Photosynthesis	1人
0	Stem	1人
(6)	(Leaf) is a place to carry out Photosynthesis	50%1/2人
0	Leaf	1人
0	Photosynthesis	1人

Figure 8 FIB Analyzer screen

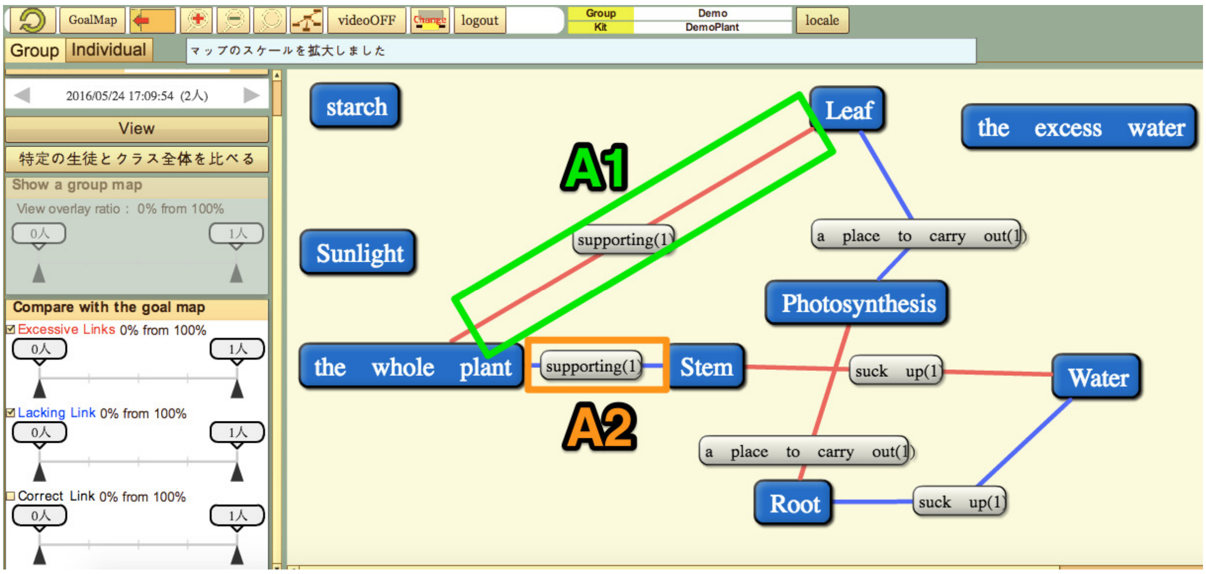


Figure 9 Visualization of Answers for FIB Questions with Concept Map

4. Comparing KB Map Task and FIB Questions Task through a Practical Use

4.1 Practical Use in an Elementary School

In this practical use, two classes of 5th grade students in an elementary school attended. The same teacher taught them three class times. The subject is science and the topic is “plant ecology”. In every last 10 minutes in each class time, the teacher conducted an exercise to strengthen and confirm students' understanding for the lecture. One class used KB map exercise and we call this class KB class (37 students). The other class used FIB question exercise and we call this class FIB class (37 students). In KB map exercise, a student is requested to build a concept map from provided components. In FIB question exercise, a student is requested to answer several fill-in-the-blank questions by selecting multiple choices. The map and questions are made by the same teacher map. The teacher map made by the teacher corresponds to the lectures. The teacher map is confirmed by another teacher of science in the elementary school.

In order to examine the equivalence of the two groups, we used scores of a general test of science provided by an exercise book used in the elementary school. Full marks were 100. Because there was no significant difference in the scores of the two groups as shown in Table 1, we assumed that the two groups were equivalent in science learning. After all classes of this use, the teacher conducted a post-test that requested the students to answer several questions about the learning topics by description. The post-test was made by the responsible teacher based on the learning topic and marked the teacher. The answers of the questions in the post-test are implied in the propositions but cannot derive the answer directly. So, the questions request a student to understand the meaning of the propositions.

In this practice, KB map exercise and FIB question exercise were carried out three times respectively in each class. The average score of KB map exercises was 79.3(SD=24.4), and then, FIB question exercise was 100(SD=0.0). In KB class, after the exercise, the teacher found several incorrect propositions in the class and gave feedback about the propositions. In FIB class, because there was no incorrect answer, the teacher explained the propositions as important points of the class. Therefore, FIB question exercise didn't detect misunderstanding of FIB class students, and then, the KB map exercise detected misunderstanding of KB class students.

Table 2 shows the results of the post-test. There was significant difference between the score of KB class and FIB class (p=1.17E-13) and the effect size was large (d=0.71). There were statistically significant correlations between the general test scores and the post-test scores in the both groups as shown in Table 1 (r=.63 in FIB class, and r=.59 in KB class). This correlation suggests that the scores of the post-test were reliable. Based on these results we concluded that KB map exercise has better learning effect than FIB question exercise. This result also suggests that FIB exercise was not enough to detect students' misunderstanding.

Table 1 Results of General test (full marks:100) and Post-test (full marks:11)

	General Test(SD)	Post-test (SD)	Correlation between Two tests (p-value)
FIB group	60.0(12.7)	7.2(2.4)	r=0.63(p=3.1E-05)
KB Map group	60.9(15.5)	8.8 (2.1)	r=0.59(p=0.0001)

5. Conclusion and Remarks

We have proposed the kit-building task of a concept map (KB map task) as a promising exercise for strengthening and assessing learner's comprehension for a topic that a learner already has learnt. In this paper, in order to investigate the value of the KB map task, we compare it with multiple-choice task of FIB questions (FIB question task). The multiple choice task of fill-in-the-blank questions is also used to strengthen and assess learner's comprehension, and the answer can be automatically evaluated. Then, the both task can be generated from the same series of propositions, that is, from the same contents. We have compared the two tasks through 3 lessons of science learning of 5^{th} grade students in two classes. One class used KB map (KB class) and another class used Fill-In-the-Blank questions (FIB class). The results suggested that the KB task evaluated learner's comprehension more adequately than the question task and the students in the KB class had higher performance than the students in the question class.

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Can Students Build Cognitive Models That Reflect Their Own Cognitive Information Processing? Results of Preliminary Class Practice

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Abstract: We have developed a learning environment to enable students to build rule-based cognitive models. Participants were required to build cognitive models that solve a cryptarithmetic task. To solve this task, multiple types of procedural knowledge were used during the solution processes; participants were required to externalize their knowledge when constructing a model. Twenty-two participants successfully constructed sophisticated models that were able to solve the given task in approximately 21 steps. We compared the participants' and their models' problem-solving behaviors. As a result, only 9 of the 22 (41%) models trance the participants' problem-solving paths. This implies that it was relatively difficult for the participants to construct a model that reflects their own cognitive information processing.

Keywords: Cognitive models; Procedural knowledge, Production system

1. Research question

Students encounter challenges while posing problems. Preceding studies have reported that when students are required to pose problems, they merely replicate a familiar example problem, not employing effective styles of problem posing (Christou, et al., 2005; Kojima, Miwa, & Matsui, 2010; 2015). To enhance students' problem-posing activities, we must investigate the processes that underlie problem-posing activities.

When we pose an arithmetic problem, we must possess the procedural knowledge required to solve that problem. Our previous studies have confirmed that learning activities of creating computational cognitive models are effective for understanding such procedural knowledge (Miwa, et al., 2015). Especially, in such activities, it seems important to externalize their knowledge by constructing cognitive models that reflect their own cognitive information processing.

In cooperation with the experimental approach, the model-based approach is a primary methodology in cognitive science (Fum, Missier, &Stocco, 2007). Cognitive scientists have used computational models as research tools to understand the human mind. The authors have examined the functions of cognitive modeling as a learning tool and proposed the "learning by creating cognitive model" paradigm (Miwa, et al., 2009; Miwa, et al., 2014a). Previous studies have confirmed that creating cognitive models improves theory-based thinking (Saito, et al., 2013; Miwa, et al., 2014b) and active construction of mental models (Miwa, et al., 2015).

In our previous class practices, participants were required to construct cognitive models that solve a cryptarithmetic task. The results showed that nearly two-thirds of the students successfully constructed sophisticated models that reached the solution within a considerably small number of steps (Miwa, et al., 2016). This implies that the participants successfully externalized procedural knowledge to perform relatively complex arithmetic information processing. However, it is unclear whether such models actually reflect their own cognitive information processing.

Our research question in this study is whether students can construct cognitive models that reflect their own cognitive information processing. We conducted a cognitive science class wherein participants were required to build computational models that behave similarly as the students themselves behave. We report a preliminary analysis in this paper.

6. Task

The task used in our study is a cryptarithmetic task (Newell & Simon, 1972; Miwa, et al., 2009). The following is an example problem used in our class practice. The problem is to assign digits (0, 1, 2, ..., and 9) to the letters (A, B, C, D, E, F, G, H, I, and J), so that when the letters are replaced by their corresponding digits, the sum is satisfied. Here information F = 6 is given in the initial statement of the problem. The reason why this problem was used is because to solve this problem, various types of procedural knowledge that will be described below in detail are expected to be used.

```
  IGEAF F = 6
 +DBJAD
 CIHEGH
```

There are two solutions in this task. Specifically, I and E are undecided (2 or 4).

This problem is simple; however, the cognitive information processing for its solution is relatively complex. In fact, multiple types of procedural knowledge are used during the solution processes. The following describes some examples.

Numeral processing: If a column is x + y = z, and both x and y are known, then we can infer z by summing x and y. For example, in the rightmost column, when we know F = 6 and D = 9, 5 is assigned to letter H by applying this procedure.

Specific numeral processing: If a column is x + y = x, then we can infer that y = 0 or 9. For example, in the fifth column, we can obtain D = 0 or 9 independently without any other information. In this case, we can determine that D = 9 by the following process because C should be 1, meaning that a carry is sent to the left-side column.

Parity processing: If a column is x + x = y and we have a carry from the right column, then we can infer that y is an odd number. For example, in the second column, we obtained a carry by the inference in the first (i.e., rightmost) column; therefore, we conclude that G is an odd number.

Inequality processing: If a column is x + x = y, and no carry is sent to the left column, then we can infer that x is less than 5. For example, in the second column, when we know there is no carry to the left column; thus, A is less than 5.

University students easily understand such procedural knowledge sets if they are given; however, they may face challenges finding the knowledge by themselves and externalizing it while solving the problem.

7. Learning System

We have developed a learning environment to enable students to construct rule-based cognitive models. The system consists of two modules, i.e., a knowledge editor and a problem-solving simulator.

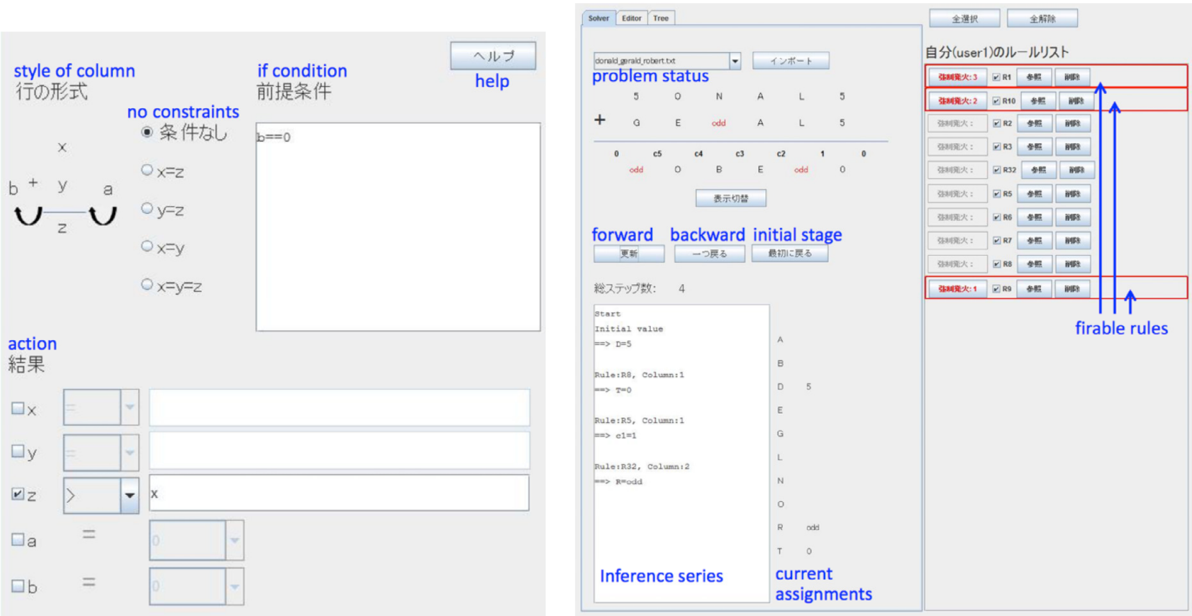
7.1 Knowledge editor

First, students externalize a set of procedural knowledge, i.e., describing rules, to solve cryptarithmetic tasks using the knowledge editor.

Figure 1 (a) shows an example screenshot of the knowledge editor wherein the rule of inequality processing is described, i.e., if a column is x + y = z and no carry is sent to the left column (b == 0 in the figure), then we can infer that z is greater than x.

7.2 *Problem-solving simulator*

The problem-solving simulator is mounted on the learning system. The problem solver that simulates behavior has the potential to perform an exhaustive search for the assignment of digits to letters. Specifically, it selects one of the letters that have not been determined and systematically assigns each digit to a letter. If a contradiction is found in the inference process, another assignment is tested. If the problem solver has no procedural knowledge, it is impossible to derive the solution because the problem space spreads exhaustively. Students must give the problem solver adequate procedural knowledge using the knowledge editor.



2. Knowledge Editor (b) Problem-solving simulator

Figure 1 Example screenshots of the learning system

Figure 1 (b) shows an example screenshot of the problem-solving simulator, which presents a problem status (the assignment status of digits to letters) and an inference status (a step-by-step series for information processing). A list of rules installed for the problem solver is presented on the right-hand side of the window. Rules that can fire at a specific problem-solving step are marked by bold red lines. In this case, three rules are available. The conflict resolution mechanism is simple, and the most specific rule that provides the most specific inference result has priority for firing. Students can test any rule by forcibly firing it and confirming the resulting inferences. Moreover, students can modify the model very easily. For example, if we uncheck items in the list, students can simulate the behavior of the problem solver with that knowledge excluded.

The system also presents the problem solver's behavior, represented as a search tree of problem-solving processes. Students can confirm inference steps one by one by forwarding the inference by clicking the inference button. At any point in the problem-solving process, students can install, delete, or revise knowledge using the editor and restart the inference from the given problem-solving point.

8. Class Practice

The class practice was performed as part of a cognitive science class in the first author’s university. Participants included 25 undergraduates from Nagoya University. In the initial week, the participants spent one hour learning how to manage the knowledge editor and operate the problem-solving simulator. Specifically, participants were given an example problem: MEST + BADE = MASER. They then installed seven pieces of procedural knowledge to solve the given problem with a tutor's guidance, and they simulated behavior at each stage of the construction process.

In the second week, in a 70-minute training phase, the participants were given a training problem: DONALD + GERALD = ROBERT. By themselves, they were required to find a procedural knowledge set for the solution, install it in the problem solver with the knowledge editor, and then construct a model. In the third week, the participants were given the target problem: IGEAF+DBJAD = CIHEGH. They were required to construct a model for its solution. After model construction, they were required to solve the same problem by hand by writing their solution processes on an experimentation sheet. Both the model and participant solution processes were analyzed.

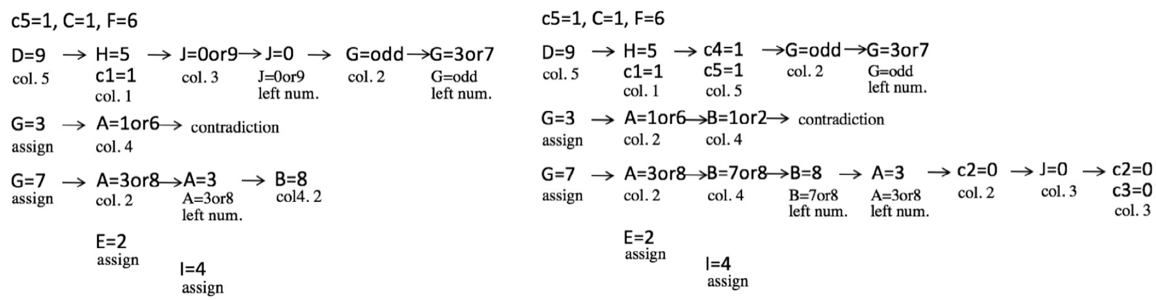
9. Results

One participant could not construct a complete model that reached the solution within 100 problem-solving steps. Two other participants' problem-solving paths were not clearly identified due to insufficient descriptions of the problem-solving paths written on the examination sheets. We excluded these three participants from our analysis.

The average number of problem-solving steps for the other 22 participants was 20.9 steps. We analyzed the participants' problem-solving paths. All participants initially processed the fifth column (I + D = I) and drew the decisive information D = 9. Then, the participants processed the other columns, coordinated multiple pieces of information obtained through the preceding problem-solving processes, and focused on a specific letter to which a possibility of assignments of numerals was limited for the following trial-and-error search. Specifically, for the example in Figure 2 (a), first, G = odd was determined by processing the second column where the same letters (A and A) were summed and a carry was received from the right-side column. Then, based on the information that G = odd, a limited possibility of assignments (i.e., G = 3 or 7) was obtained because other odd numbers (1, 5, and 9) had already been assigned to other letters (i.e., C, H, and D, respectively). Then, the participant began to examine G = 3 in a trial-and-error search.

Figure 2 (b) shows a problem-solving path of this participant's model. The path is similar to that of the participant shown in Figure 2 (a). Initially, the model drew G = 3 or 7, found that G = 3 was impossible, and reached the solution by examining another assignment, i.e., G = 7.

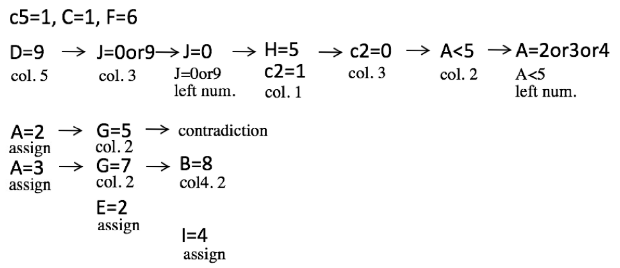
We focused on the overall patterns of the problem-solving paths determined by trial-and-error search driven by an examined letter, such as G in Figures 2 (a) and (b). In 9 of the 22 cases, the patterns of the participants' behaviors were similar to those of the models; however, the 13 other cases were not similar.



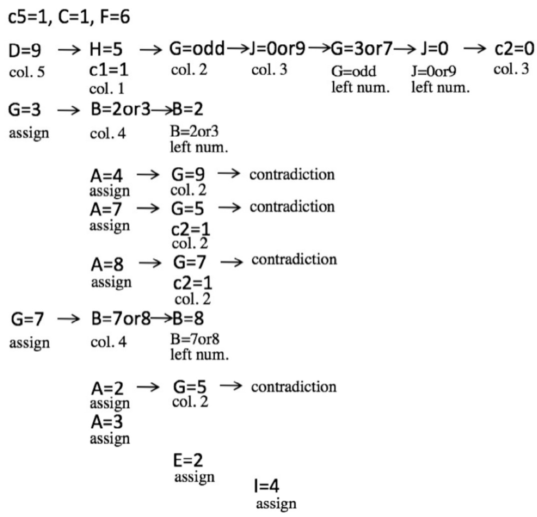
(a) Participant behavior (b) Model behavior

Figure 2 Comparison of human and model problem-solving behaviors; example case of similar processes

Figures 3 (a) and (b) show an example case where the participant and model behaviors did not match. In Figure 3 (a), the participant inferred that A = 2, 3, or 4 by combining A < 5 that had been obtained by processing the second column with the information that no carry was sent to the left-side column and the information that 1 was already assigned to C. Based on this information, the participant examined each assignment to the letter A. Figure 3 (b) shows a problem-solving path through which the model that the participant constructed had run. The model initially inferred that G = 3 or 7, guiding a subsequent trial-and-error search that differed from the participant's path. The model did not infer information related to letter A and did not focus on letter A for the initial trial-and-error search, thereby changing the problem-solving path.



(a) Participant behavior



(b) Model behavior

Figure 3 Comparison of human and model problem solving behaviors; example case of different processes

10. Conclusions

We analyzed 22 participants who successfully constructed sophisticated models that can solve the given task in approximately 21 steps. However, only 9 of the 22 (41%) models trance the participants' problem-solving paths. This implies that it was relatively difficult for the participants to construct a model that reflects their own cognitive information processing. First, this problem comes from the participants' programming abilities. It appears that some participants could not implement appropriate rules even though they noticed their own procedural knowledge. This implies that our next step is to improve the learning environment developed in the current study. Another reason is that model construction that reflects each participant's cognitive processing was not emphasized in the current class practice. Some participants attempted to construct high-performance models that solve the task as quickly as possible or general models that can solve a variety of tasks. We believe this can be improved based on instructor suggestion.

Acknowledgement

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Investigating Strategies used by Novice and Expert Users to Solve Parsons Problems in a Mobile Python Tutor

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Abstract: We present PyKinetic, a mobile tutor for Python. The tutor is aimed at novices and meant to be a complement to traditional lectures and labs. The first type of activities implemented in the tutor is Parsons problems, which present code snippets to be ordered by the student to produce the desired output. As a starting point towards an intelligent tutor, we conducted a pilot study to evaluate the interface and usability of PyKinetic, and to identify and contrast strategies used by novice learners with those of experts. Great feedback and enthusiasm was received for the prospect of PyKinetic and interesting strategies were revealed from both groups. The study revealed that experts, as can be expected, outperformed novice users and used superior problem-solving strategies. In future work, we will improve PyKinetic's problems, feedback, activities and extend PyKinetic to provide instruction on optimal problem-solving strategies.

Keywords: Mobile Python tutor; Parsons problems; novice/expert differences; problem-solving strategies

1. Introduction

Learning programming is challenging: the student has to learn the syntax and semantics of the programming language and understand its purpose in context, perform problem solving tasks, logical thinking, as well as develop design skills and strategies (Linn and Dalbey, 1985). Apart from learning programming concepts, the student must also understand concepts behind programming like how code structures are being compiled and translated, as well as how programs are executed. Novice programmers find it rather difficult to grasp these concepts, which might lower their motivation to learn more and to practice. It takes about ten years of experience for a novice programmer to become an expert (Winslow, 1996).

Intelligent Tutoring Systems (ITSs) are knowledge-based systems that simulate the behavior of good human teachers and provide individualized feedback to students (Woolf, 2010). ITSs have been proven effective in supporting student learning in different domains (Koedinger et al., 1997; Heift and Nicholson, 2001; Melis et al., 2001, Mitrovic, 2003, 2012; van Lehn et al., 2005; Weber and Brusilovsky, 2001). When learning a programming language, having access to an ITS is valuable for students to practice, as it is impossible to have a human tutor available at all times. The activities included in the ITS can be designed to focus on increasing engagement, improving students' self-efficacy and motivation for learning. Some students may also find that using an ITS is less socially awkward since it does not involve directly communicating with a human tutor. Hence, this may motivate some students to use an ITS more frequently in their own time and will therefore contribute to opportunities of gaining deeper understanding of the domain.

Python is widely used as a programming language in universities nowadays to teach introductory programming (Guo, 2013). This project aims to develop *PyKinetic* (Fabic, Mitrovic and Neshatian, 2016), a mobile tutor hoping that it would appeal better to a new generation of students, compared to desktop or Web-based educational tools. Apart from the thriving popularity of smart phones and mobile applications, a mobile tutor could potentially target engagement.

We present a prototype of PyKinetic, aimed to be developed as a constraint-based intelligent tutoring system (Ohlsson, 1994). PyKinetic will be a complement to traditional lecture and lab-based introductory programming courses. The current version of PyKinetic contains only one type of activity – *Parsons problems*. Parsons problems (Parsons and Haden, 2006) are exercises requiring the student to rearrange a given set of randomized lines of code to produce an expected outcome. The prototype currently contains two types of Parsons problems, with and without distractors (extra lines of code). In the future, we plan to add additional types of learning activities.

As an initial step towards an intelligent tutor for Python, we performed a study with PyKinetic, in order to identify problem-solving strategies used by novices and experts. Our hypothesis was that experts would outperform novices in speed and efficiency in solving problems, and use optimal problem-solving strategies. The motivation of the study is to enhance PyKinetic to teach students not only about Python, but also to provide instruction about optimal problem-solving strategies. In the following section, we present research done on Parsons problems, educational systems for Python and evaluations of problem-solving strategies used in solving Parsons problems. We then introduce PyKinetic, followed by the experiment design and the findings. Section 7 discusses the problem-solving strategies used by novices and experts. Lastly, we present our conclusions and compare problem-solving strategies observed in our study with those of other studies.

2. Related Work

Parsons problems were originally designed to promote a fun way for students of an introductory course in Turbo Pascal to improve their skills in syntactic constructs (Parsons and Haden, 2006). These programming activities are suitable for novices, as they contain syntactically correct code that only needs to be put in the right order. A variation includes puzzles with syntactically incorrect or unnecessary lines of code (referred to as *distractors*) which students need to eliminate.

Denny et al. (2008) considered five variants of Parsons. The first two variants contain no distractors, with the difference that one of them includes scaffolding such as curly braces and indentation (since this was used in the context of Java), while the second variant does not provide any. The next two variants are composed of paired options for each line of code given in a randomized order but the paired options are clearly placed right next to each other. These variants were available with and without scaffolding. The last variant contains pairs of options for each line of code, but these pairs are provided in a random order. It was not specified whether the last variant was presented with or without scaffolding but this variant ended up being discarded as it was perceived to be unreasonably difficult. For example, 7 lines of code for the puzzle becomes 14 and having these 14 lines of code in a completely randomized order may be viewed by students to be overwhelming to attempt.

There is no widespread agreement on how Parsons problems compare to other types of exercises typically used in introductory programming courses, such as code reading, tracing, writing and explaining. Code tracing falls into lower categories in Bloom's taxonomy, while code writing requires higher order skills (Thompson et al., 2008). Some researchers find Parsons problems are easier than code tracing (Lopez et al., 2008), while others view Parsons problems to lie in between code tracing and code writing (Lister et al., 2010). Denny et al. (2008) found a moderate positive correlation between scores on Parsons problems and code writing questions, but only a weak correlation between Parsons problems and code tracing questions. Therefore, they suggested that Parsons problems were similar to code writing. There are also opinions that the position of Parsons problems in the hierarchy of programming skills can vary, depending on their type (with or without distractors) and complexity (Ihantola and Karavirta, 2011). Other possible factors could include the interface used (on paper or online), and scaffolding and feedback provided.

There are some Python learning environments developed as mobile applications. An example is Quiz&Learn Python[1], which is a game to test and improve knowledge on Python 2.x programming available on Android and iOS devices. The aim of the game is to answer 20 multi-choice questions and to answer them correctly within one minute for each question as fast as possible to gain more points. There are four help options that can be used only once each for every game: remove two incorrect answers, skip a question, debug the code and stop the timer. Remove incorrect answers

[1] http://www.villekaravirta.com/projects/quizlearn-python/

removes two incorrect choices out of the four given. Choosing to skip a question, skips the current question to move on to the next without answering it. Choosing the help option to debug the code gives the users an access to a debugger which shows a line by line visualization of the execution of the given code snippet. The last option (stop the timer) gives the user unlimited time to answer a question. The game ends when the user answers a question incorrectly, has ran out of time, or has successfully answered all 20 questions. The application is developed using Apache Cordova, Zepto.js, Topcoat, SASS, Node.js and PostgreSQL. Based on observations while using the application, it seems that it is presented more as a game rather than a tutor with game elements. It seems to be more focused on gaming features rather than providing pedagogical aspects to support learning.

There are some educational environments for Parsons problems. Ihantola and Karavirta (2011) present js-parsons, a JavaScript library for developing Parsons problems. The library supports "two dimensional" Parsons problems, which allow students to drag lines of code (LOCs) from a set on the left-hand side of the screen and drop it on the solution space on the right-hand side. The second dimension feature is that indentations are supported and students can change the indentations of the LOCs in their solutions. The library is language independent, and can be used to develop Parsons problems for any programming language. Since js-parsons is a JavaScript library, it can be used to develop Parsons problems on webpages designed for personal computers or mobile webpages for tablets and smartphone devices.

There are limited results in literature about problem-solving strategies used by novices and experts for Parsons problems. Ihantola and Karavirta (2011) report on a small study involving four experts. The study was conducted in JSParsons, a Web environment for Parsons problems built using the js-parsons library. The study presented ten Parsons problems with distractors, which required indentations to be specified. For each problem, the name of the algorithm was provided (such as insertion sort). All experts used the same strategy, starting with method signatures, then proceeding with loops and conditionals, and only at the end dealing with initialization of variables and indentation. Another study conducted with students (Helminen et al., 2012) found that students followed a top-to-bottom strategy for simple Parsons problems. In two problems, the first step in 98.5-99.3% of the solutions was to position the function signature. The same researchers also developed MobileParsons (Karavirta et al., 2012) for iOS and Android mobile devices. The interface presented the problem area on top and the solution area below in portrait mode, and side by side in landscape mode. MobileParsons was further developed to allow limited editing of lines (Ihantola et al., 2013).

3. PyKinetic

PyKinetic is a Python tutor developed using Android SDK to be used on smartphones. The tutor is aimed to serve as an additional resource for novice learners to enhance their Python 3.x programming skills. The prototype currently contains 53 Parsons problems, covering the following topics: *String Manipulation*, *Conditional Statements*, *Lists*, *For Loops*, *While Loops*, *Dictionaries*, *Tuples* and *Data Types*. The learner needs to rearrange given LOCs to form a correct code snippet that would produce the expected result. There are two types of problems, with or without distractors. The number of LOCs per problem ranges from 3 to 16, with a maximum of 5 distractors. The learner can expand any topic to see available problems (Figure 1, left), and select either a specific problem or ask for a random problem. The selected problem is then presented to the learner, together with the problem statement (Figure 1, middle). The learner can view the problem statement at any time during problem solving (by clicking on the "?" icon on the top-right hand corner). Distractors can be removed by tapping on the red X on the right of each LOC. Deleted lines can be retrieved by tapping on the trash icon and selecting desired LOCs (Figure 1, right).

In this prototype, the problem space containing LOCs also serves as the solution space. This is different to other implementations of Parsons problems (Ihantola and Karavirta, 2011; Helminen et al., 2012; Karavirta et al., 2012; Ihantola et al., 2013), where LOCs need to be dragged across from the problem area to the solution area. We decided to combine the problem and solution into a single area in order to maximize the use of space.

There are problems of varying difficulty and complexity in the tutor. Each problem is assigned the complexity level, ranging from 1 (the easiest problems) to 9. Most problems are only code snippets, but some are functions and include function calls.

The learner can submit his/her solution to be checked at any time. The tutor contains correct solutions for problems including alternative solutions, and the student's solution is matched to them. The prototype currently only provides simple feedback, informing the learner that the solution is correct, or specifying that there are still some distractors left, or LOCs missing. Feedback also informs the student whether the order of LOCs is right, when LOCs are selected correctly. We plan to enhance the diagnosis process in the next version by developing a constraint-based model of the domain (Mitrovic, 2012).

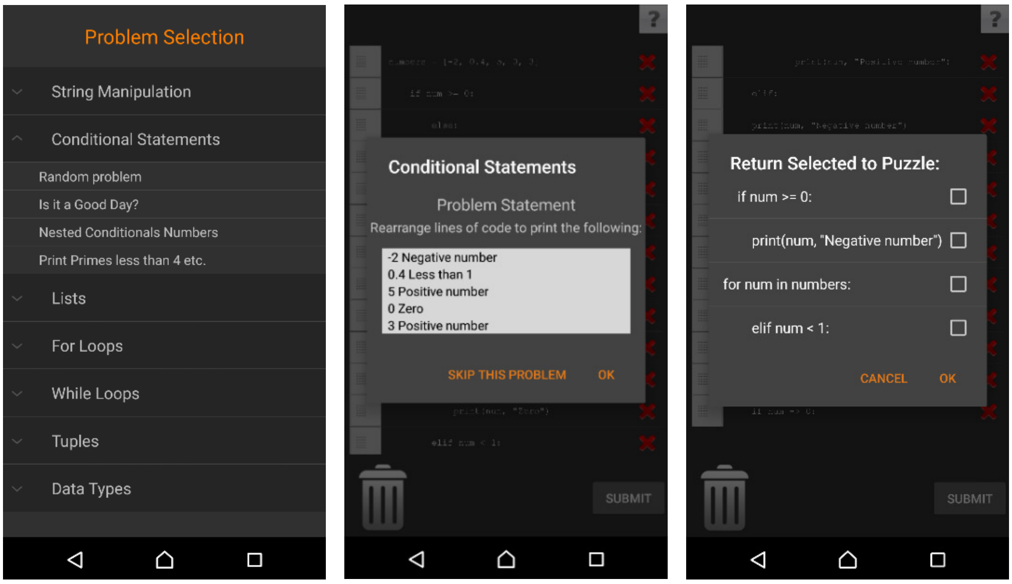

Figure 3. Topic/problem selection screen (left); an example Parsons problem (middle); Retrieving LOCs from trash (right)

4. Experiment Design

The novice participants were 8 volunteers (4 male, 4 female) recruited from an introductory programming course at University of Canterbury. The five expert participants were tutors teaching the same course. The study consisted of individual, one-hour long sessions. The pilot study was conducted in September 2015, by which time the students had learnt about seven topics covered in PyKinetic (problems on Dictionaries were not included in the pilot). The version of PyKinetic used in the study contained 21 problems in total: for each topic, there were two problems with distractors and one without. The problems used in the study had 3 - 16 LOCs, with a maximum of 5 distractors. Four problems were forced to the landscape mode since they contained long LOCs, while the rest were in the portrait mode.

After providing informed consent, the participants interacted with PyKinetic. The novices were free to choose problems as they wished, but were asked to attempt at least one problem from each topic. We used the think-aloud protocol (Ericsson and Simon, 1993), asking the participants to verbalize their thoughts while interacting with the tutor. The screen of the device used for the study was recorded including audio verbal comments of participants. At the end, participants filled a questionnaire, the first part of which included questions about their background, while the second part included multi-choice and open questions about PyKinetic.

We conducted sessions with experts later on, and asked them to attempt the problems that the majority of novice participants attempted, in order to compare the problem-solving strategies used. The experiment design was similar to the setup by (Ihantola and Karavirta, 2011). In their study, they have observed strategies used by experts in solving Parsons problems. Ihantola and Karavirta also conducted a study with novices to identify other strategies (Helminen et al., 2012).

5. General Findings

When asked how much experience the participants had with Python, using the Likert scale from 1 (*Not so experienced*) to 7 (*Highly experienced*), the mean reply of novice participants was 2.12 (sd = 1.25), with only one novice judging his/her experience as 5, and the rest as either 1 or 2. The mean on the same question for experts was 5.4 (sd = 1.34), ranging from 4 to 7.

We eliminated data about problems which the participants only viewed but performed no actions on, and also data about two problems that were found to be buggy. A problem is considered as attempted if the participant made at least one action on it, either by dragging and/or deleting LOCs, viewing the trash, or submitting the solution. A move is defined as the moving of LOCs when attempting a problem. In the way the Parsons problems were setup in the tutor, each move could affect the positions of other LOCs. The analysis was made simpler by counting a move as one regardless of the difference between the starting and ending positions. However, a move is considered as an abandoned move if it was dropped on the same position where it was dragged from.

We used the Mann Whitney U test to analyze similarities and differences between the two groups, with the significance level of 0.05. Table 1 reports the averages (standard deviations are given in parentheses) for the number of abandoned and completed problems. The table also reports the averages for attempted problems: submissions, moves, abandoned moves, time taken, problem complexity, the number of LOCs/distractors, and the number of times problem statement was viewed. The experts have not abandoned any problems, while two novices abandoned two problems each, and two other novices abandoned a single problem each. The experts solved more problems in fewer submissions/moves and in a shorter time, as expected. The only significant difference on the distributions of the two groups was found for the number of submissions per problem (p = .002), and there was a marginally significant difference on the number of moves per problem.

Table 1. Overall Results (** denotes significance on the .01 level)

Measure	**Novices**	**Experts**	**U, p**
Abandoned problems	.75 (.89)	0 (0)	ns
Completed problems	10 (3)	12.8 (3.7)	ns
Submissions	2.72 (1.63)	1.29 (.08)	U = 0, p < .005**
Moves	13.65 (11.51)	7.3 (1.45)	U = 8, p = .093
Abandoned moves	.62 (1.02)	.26 (.17)	ns
Time taken (min)	4.02 (2.6)	2.82 (1.1)	ns
Problem complexity	3.79 (.78)	4.36 (.55)	ns
Distractors	1.66 (.67)	2.03 (.34)	ns
LOCs	8.75 (1.52)	8.87 (1.3)	ns
Problem statement viewed	3.1 (.85)	3.7 (.8)	ns

We also categorized problems by topic (for the seven Python topics used in the study), as well as by the number of LOCs and distractors, and calculated the same measures. Using the number of LOCs, we divided problems into long (11-16 LOCs), medium (7-10 LOCs) and short (3-6 LOCs). The significant and marginally significant differences found are reported in Table 2. The experts were faster in solving problems of most types, apart from While loops, but the only significant difference in time was for Conditionals. The reason why the experts needed more time for the While loop problems is that they attempted more complex problems of this category (in terms of the problem difficulty, and the numbers of distractors and LOCs – all three differences are significant). The experts also attempted more complex problems on Data types, and were significantly faster (in terms of time and the number of submissions) in problems containing many distractors. They needed fewer submissions to complete problems on Lists (marginally significant difference) and also fewer submissions for long problems.

The highest number of errors for both groups was for the problems on Lists. One source of confusion was related to indexing lists (e.g. *my_list[:2:-1]*). All novices and two experts commented that they were used to using only one colon indexing a list. This was probably one of the reasons for the marginal difference between average submissions for this category.

Both groups were advised that the problems were presented in the increasing order of difficulty. We observed that most novices started with easier problems, while the experts randomly picked a problem from each topic without focusing on their difficulty. There was a significant difference for difficulty and the number of LOCs for short problems. The experts also needed significantly fewer moves for problems with a medium number of distractors (2-3 distractors). In addition, the experts viewed the problem statement significantly more often in the case of problems with few distractors (0 or 1). A potential reason for this difference is because experts use better strategies: many novices used trial and error (as discussed in the following section), while experts are likely to think about the problem more and review its requirements.

Table 2. Results by Problem Category (* denotes significance at the .05 level)

Problem Category	**Measure**	**Novices**	**Experts**	**U, p**
Conditionals	Time	6.1 (2.96)	4.26 (.71)	6, .045*
Lists	Submissions	3.6 (2.98)	1.33 (.33)	7, .065
While Loops	LOCs	5.25(2.74)	10.3 (1.56)	38, .006**
While Loops	Distractors	.75 (.8)	2.7 (.67)	38, .006**
While Loops	Difficulty	1.87 (1.25)	4.6 (.89)	38, .006**
Data Types	Difficulty	3.46 (2)	5.53 (.96)	35, .03*
Long problems	Submissions	2.76 (1.58)	1.18 (.25)	5, .03*
Short problems	LOCs	4.53 (.68)	5.17 (.47)	35.5, .019*
Short problems	Difficulty	1.78 (.97)	2.37 (.44)	34, .045*
Many Distractors	Time	6.76 (2.77)	3.18 (.52)	1, .003**
Many Distractors	Submissions	3.85 (2.35)	1.22 (.22)	.5, .002**
Medium Distractors	Moves	11.6 (9.82)	5.97 (.74)	6.5, .045*
Few Distractors	Distractors	0 (0)	.21 (.04)	40, .002**
Few Distractors	Viewed	1.65 (.49)	2.96 (.95)	38, .006**

6. Questionnaire Responses

Overall, the participants were enthusiastic about the tutor, as seen from the questionnaire responses, summarized in Table 3. The participants from both groups found PyKinetic intuitive, easy to use and fun (the average ratings ranged from 5 to 5.6). Some participants seemed to appreciate the interface and commented: "*It's nice how it pops up showing you what to do*" and "*Oh wow, that's cool how you can like slide them up... that's nice*."

When asked whether they improved their skills by interacting with PyKinetic, the average response from novices was significantly higher than that of experts (U = .5, p = .002). It is not surprising that the experts' responses to this question are much lower, as the problems were designed for novices. A few novices seemed surprised that they learned something from the tutor: some comments were "*I'm actually learning something here!*", "*Oh cool I didn't know you could do something like that*." and "*I'm learning stuff while doing it so that's always a plus*."

Both groups seemed to perceive the provided problems having the right amount of difficulty (the experts were asked whether problems are at the appropriate level of difficulty for novice learners). The lowest rating was received from the novices about the amount of feedback provided by the tutor

(2.88). This was expected, since the prototype only provides simple feedback which is only available upon submission. It is interesting that experts scored the feedback much higher. There was a statistically significant difference on feedback rating (U = 34, p = .045).

When asked whether they would use the tutor again, seven out of eight novices agreed (the novice who disagreed specified he/she was not interested in learning more about programming). Two experts also stated they would like to use the tutor again since they gained new knowledge from the tutor, specifically on indexing lists. One participant mentioned "*I can really see myself practicing Python with this on the bus or if I'm waiting for someone*." Both groups were also asked to select programming skills they used in the tutor (reading, syntax and structure and/or logical and semantic reasoning skills). Half of the novices responded they used all those skills, while the other novices selected 2/3 skills. All experts responded they used all the skills.

Table 3. Summary of questionnaire responses

Question (1 Lowest to 7 Highest)	**Novices**	**Experts**
Was the tutor's interface intuitive and easy to use?	5.13 (0.83)	5.6 (0.55)
Was the tutor fun to interact with?	5.13 (0.99)	5 (1.41)
Would you say you have learned some new things and/or enhanced your skills by interacting with the tutor?	5.75 (0.89)	2.4 (1.34)
Do you think it is beneficial that this tutor is developed on a mobile platform?	5.25 (1.04)	4.8 (1.92)
Were problem statements clear enough to understand what needed to be done?	4.5 (1.41)	4.8 (1.92)
Please rate the average difficulty of the problems in the tutor.	4.5 (0.53)	4 (0.71)
Do you think there is enough feedback given when attempting a problem?	2.88 (0.99)	4.2 (0.84)

7. Problem-Solving Strategies

We watched the video recordings of the participants' interactions with PyKinetic and manually observed and identified strategies made by the participants. A wide range of strategies was observed, some of which were used by participants in both groups. An example is to focus on a particular type of LOC and move it (referred to as *Selecting a LOC*). The participants usually looked for variable declarations, function calls and print statements, possibly because variable declarations and function calls are normally located somewhere at the beginning of a program, whilst print statements are normally positioned at the end. One participant made a comment along these lines: s/he just started a problem, noticed a print statement and mentioned the following while dragging the LOC in position: "*Print statements at the end*." This strategy was used at least once by each novice. One expert used this strategy. However, it is important to note that this strategy was not used in all problems; it was observed that the participants' strategies changed depending on the nature of the problem and its expected output.

A more specific version of this strategy was used for problems with functions, when the participants moved the function statement first, followed by the docstring. This strategy was very evident in both groups: five novices and four experts used this strategy for all problems that contained functions. The only situations when this strategy was not used were when those statements were already in place (please note that LOCs were presented in a random order), or when the participant was clearly missing the relevant declarative knowledge. The latter was observed only with novices who used sub-optimal strategies (discussed in Section 7.1).

Another strategy used by both novices and experts was to move distractors (except the very obvious ones) to the end of the solution. Some of the statements novices made during this strategy were "*just in case I still need it*" or "*I don't want to delete the other print lines yet just in case I do need them, but I'll put them down the bottom*." Only two experts used this strategy since experts were generally better at eliminating distractors. Having said that, it seemed that the experts were only doing so because they were too focused on their model solutions to deal with distractors immediately.

All of these strategies require domain knowledge: knowing relative position for specific types of statements, or being able to identify distractors. However, the majority of other observed strategies were used exclusively by one group of participants; those strategies clearly show the difference in domain knowledge between novices and experts. We present those strategies in the following subsections.

7.1 Strategies Used by Novices

Half of the novices grouped LOCs on the basis of their indentations. Such a strategy shows lack of knowledge, as novices were relying on a superficial feature rather than trying to understand the meaning of LOCs. The reliance on the indentations as scaffolding was also mentioned by a participant: "*Sometimes with the loops … the indentations give away a lot and you can just you know … without having to read much on what they mean*." This strategy allowed novices to eliminate distractors. The strategy was also useful for arranging the LOCs logically, especially with conditional statements. After applying this strategy, the novices either tried to reason about the LOCs in each group, or used the trial and error strategy. One participant mentioned "*Okay let's put all the indentations at the same…*" then tried to read the code, to find the correct lines. Another novice mentioned: "*So I'm like trying to find the systematic way of like sorting it*." Following this, the novice also mentioned "*So now I'm gonna work out which ones would make sense*."

A common strategy used by novices was trial and error. After solving parts of the problem the participant was knowledgeable about, the participant then tried to solve the rest of the problem by exploring possible solutions, which resulted in multiple submissions. For example, the participant would move a single LOC and submit the solution immediately, in order to eliminate wrong solutions. In some of the situations, the novices asked the researcher for help. This strategy was used when the novices were struggling with problems, therefore illustrating lack of knowledge. Additional evidence can be observed from their utterances, such as "*I'm just gonna get to try all of them and figure out why*" and "*This is one of the questions that is probably more complex than my brain … whether or not I give up … I don't know*". Three out of eight novices used trial and error, and two other novices commented that they could see that trial and error can be used as a strategy.

One novice used a unique strategy, when he/she deleted all the LOCs, and then retrieved the necessary ones from the trash. The participant eventually abandoned the problem, so this strategy might be due to high cognitive load.

7.2 Strategies Observed in Experts

A common strategy used by experts was to build the solution from top to bottom (referred to as the top-down strategy). For example, some experts mentioned that function statements have to be first, so they looked for this line and moved it first, then the docstring and other LOCs, until the return or print statement. This strategy shows that experts have a model of the solution, and are working towards matching it. All experts used this strategy, but not always exclusively. One expert alternated between this and another strategy, which consisted of combining syntactically and logically similar LOCs with similar indentations and then logically placing them in the correct order (e.g. similar print statements with similar indentations placed at the bottom).

While the experts were searching for LOCs according to their model solution, three of them were at the same time deleting distractors which were syntactically incorrect lines of code. The other two, on the contrary, left such LOCs and deleted them at the end, although it was clear they understood those LOCs were distractors. Generally, the experts were good at identifying distractors.

8. Discussion and Conclusions

We reported on a pilot study with a prototype of a mobile Python tutor which contained Parsons problems. Our primary goal was to investigate problem-solving strategies used by novices and experts. The study was conducted with 8 novice students and 5 experts. The participants were generally enthusiastic about the prospect of using PyKinetic as an additional tool to learn Python, and found the problems of appropriate nature and complexity. We received good suggestions for further improvement of PyKinetic, such as adding a short tutorial for first-time users, improved feedback and hints on solving problems. The enthusiasm from the participants was encouraging, with seven out of eight novices and two out of five experts interested to use the tutor again.

Feedback received also included suggestions for the interface. Overall, the interface was considered to be intuitive and user-friendly. As mentioned earlier, Parsons problems were presented in PyKinetic in either portrait or landscape mode, which gave us additional insights about the interface. It was observed that in problems presented in the landscape mode, most LOCs were obscured, which seemed to increase extraneous cognitive load for many novices. Some participants commented that the problems in the landscape mode seemed more difficult because the full view of the problem was not available.

We have observed several effective problem-solving strategies used by both novices and experts such as using declarative knowledge to focus on particular LOCs and position them first, and moving distractors to the end of the code. The strategies used by experts demonstrated a higher level of knowledge, as they mostly used the top-down strategy. One expert used an optimal strategy of grouping LOCs with similar indentations, syntax and semantics then logically placing them in their respective positions. We have also observed several strategies when dealing with distractors. Experts appeared to be better in identifying distractors compared to novices.

As mentioned in Section 5, our experiment design was similar with the study conducted by Ihantola and Karavirta (2011). The number of experts in their study were similar to ours. Most experts in our study followed a top-down strategy, solving the problem from the function statement through to the return or print statement. Ihantola and Karavirta reported a similar top-down strategy. However, they have not observed the experts to move all lines perfectly (in the correct order). This is maybe because of the algorithmic nature of their problems compared to ours, which focused on honing basic Python programming skills for novices. Nevertheless, we have confirmed their findings on the top-down strategy observed in experts. This shows that experts solving Parsons puzzles are working towards a mental model solution.

The novices used sub-optimal strategies such as trial and error. None of the novices used the top-down strategy; this contradicts the findings reported by Helminen et al. (2012), where majority of the novices were observed to follow the top-down strategy. The reason for this may be the noticeable difference between the length and complexity of the problems used in their study (five problems with 3-8 LOCs without distractors), compared to our study involving 21 problems with 3-16 LOCs and 0-5 distractors per problem. Helminen et al. (2012) also focused on analyzing only three out of the five problems, which made their data set smaller. However, they have also observed a more specific strategy for Selecting a LOC which was to select a *for* loop or an *if* statement first (Helminen et al., 2012).

Another strategy we have observed for novices was to group LOCs by indentation, which is based on superficial scaffolding feature rather than on code logic and semantics. One expert was observed to have used an optimal variation of the strategy to group LOCs by indentation. The expert demonstrated a strategy of grouping syntactically similar statements with the same indentation while also positioning LOCs in place and removing distractors. Both groups were also observed to have strategies on dealing with distractors.

A limitation of this study is the low number of participants. PyKinetic is still in the early ages of development and several evaluation studies will be designed and conducted using the next versions of the tutor. Based on our observations and feedback received from the study, we plan to improve PyKinetic in various aspects: problem authoring, feedback and activities included in the tutor. The buggy problems discovered in the study have since been fixed, and we have added context for problems. We also aim to develop additional types of activities for the tutor such as Parsons problems with missing keywords, erroneous examples, and predicting output.

As mentioned in Section 1, we plan to extend PyKinetic to provide instruction about optimal problem-solving strategies. For example, the system could offer instruction on specific topics the students are struggling with, or the system could refer the student to other potential sources. The system could also advise students about more effective problem-solving strategies, observed in experts. Lastly, we plan to include support for self-explanation, an important meta-cognitive skill which improves learning outcomes, and also to introduce game elements to maximize engagement (Mayer and Johnson, 2010).

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Development of a Programming Learning System Based on a Question Generated strategy

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Abstract: In recent years, Computer programming has become a very important subject, and it is a basic literacy in the digital age. But learning programming skills is not an easy task as supported by many studies. On the other hand, many studies have concluded that student question generation has a positive effect on students' learning. However, few studies have geared toward supporting its use in programming classes. Therefore, this study aimed to develop a programming learning system named Peer-Interaction Programming Learning System based on a question generation strategy. The system was built by adding and intergrading learning assistance functions by system initiative into existing open-source Q&A system. In this paper, we reported the design of the system and its user interface, identified several related systems, discussed our motivation and underlying teaching philosophy.

Keywords: online learning system, student question generation, peer comment, question posing

1. Introduction

Programming is a complex activity and Jenkins (Jenkins, 2002) analyzed a number of factors that could contribute to the difficulty of programming. Some of the issues contributed to this obstacle such as : the teaching methods employed by the instructor, the difficult nature of computer programming (Matthíasdóttir, 2006), the study methods, abilities and attitudes employed by the student (Gomes & Mendes, 2007), the nature of the art of programming, the lack of prior knowledge of novice students, and the psychological influence that the student suffered from society (Jenkins, 2002). From past studies, the learning benefits of student question generation (SQG) have been well recognized and also attached with peer-comment feature (Denny, Luxton-Reilly, & Hamer, 2008; Denny, Luxton-Reilly, Tempero, & Hendrickx, 2011; Funabiki, Korenaga, Nakanishi, & Watanabe, 2013; Rhind & Pettigrew, 2012; Fu-Yun Yu, Liu, & Chan, 2005). There are many advantages of SQG based system, such as enhancing learning motivation, achievement, etc.

However, to the best of our knowledge, most of the existing researches have not yet focused on, or few to apply SQG and also peer comment in the support programming learning. Denny and Luxton-Reilly created CodeWrite (Denny et al., 2011) and StudySieve (Luxton-Reilly, Denny, Plimmer, & Bertinshaw, 2011) which is aimed at helping students learning to programming by using question posing and peer comment. Both CodeWrite and StudySieve have a significant effect in support students learn programming (Denny et al., 2011; Luxton-Reilly et al., 2011) but only focus on free-response domain which limit students who wanted to create other types of questions. In addition, only after the solution compiles and passes all the test cases are the solutions submitted by other students revealed (Denny et al., 2011) makes normal students harder to solve the difficult questions without any hints or supports.

That is, there are research gap for apply SQG for supporting its use in programming classes with more types of question and support mechanism to make students more convenience in questioning and answering in the system. Therefore, this study aims to develop a system to fulfill the gaps which remain in previous research.

2. Question generation and learning programming

Question generation is the activity in which students generate exam questions based on the reading content. The question types included multiple choice, matching, short answer, true-false, and fill-in-the-blank formats or word puzzles (Barak & Rafaeli, 2004; Wilson, 2004; F. Y. Yu, 2011). When students generate questions, students need to concentrate on the important information in their texts, and then provide correct answers and distracters (Yu, Liu & Chan, 2002). Students' abilities to explain why the answer options they create are correct or incorrect, reveal whether students really understand the reading materials or not (Fellenz, 2004). And through question generation, teachers could identify students' reading problems and thus provided adaptive instruction (Lan & Lin, 2011; Yeh & Lai, 2012).

A number of web-based learning systems with a focus on student question-generation have been developed such as QPPA (F.-Y. Yu, Liu, & Chan, 2002), POP-B and POP-C (Nakano, Hirashima, & Takeuchi, 2002), Question Sharing, Information and Assessment system (QSIA) (Barak & Rafaeli, 2004), Multiple Choice Items Development Assignment (MCIDA) (Fellenz, 2004), Asking a Good Question (AGQ) (Chang, Huang, Tung, & Chan, 2005), Questionbank (Draaijer & Boter, 2005), ExamNet (Wilson, 2004), Concerto (Hazeyama & Hirai, 2007), PeerWise (Denny et al., 2008), Question-Authoring and Reasoning Knowledge System (QuARKS) (F. Y. Yu, 2009), CodeWrite (Denny et al., 2011), Question-Posing Indicators Service (QPIS) (Lan & Lin, 2011), StudySieve (Luxton-Reilly et al., 2011) and Active S-Quiz (Hayashi et al., 2015). While most such systems are domain-independent, allow students to generate different types of questions with multimedia, and support anonymous interactions, but few are geared toward supporting its use in programming classes. Denny et al. presented and evaluated a Web based on tool providing drill and practice supports for Java programming called CodeWrite (Denny et al., 2011), where students are responsible for developing exercises that are shared among classmates. Students develop associated test cases for the exercises they author, and receive immediate feedback on their own code when solving exercises created by their peers. CodeWrite and StudySieve (Luxton-Reilly et al., 2011) are actually extended version of PeerWise (Denny et al., 2008) which only allows students to generate multiple choice questions. Both developed to extend student-generated questions to the free-response domain and helped students to write, solve and assess computer programming codes with regard to the difficulty of multiple choice questions in addressing higher-order cognitive skills. StudySieve is now discontinued but CodeWrite is still being used in some Computer Science courses.

As we described in the introduction, very little research has been done on SQG in the area of programming. Current systems typically support a limited number of question types, are hard to interact with, and are not effective in helping students learn by themselves. Besides, they lack support for student anonymity. Ballantyne suggested that students should remain anonymous to alleviate student concerns over bias and unfair marking (Ballantyne, Hughes, & Mylonas, 2002). In some institutions, anonymity may be a statutory requirement (Bhalerao & Ward, 2001) when working with student information.

On the other hand, teachers need to use the systems with other e-learning systems to manage learning resources, grade students exercise, which are heavy work for teachers.

3. Description of the system

Peer-Interaction Programming Learning System (PIPLS) is a web-based system based on the open source Question2Answer system (Greenspan & Contributors, 2016) with further development and customization. PIPLS is designed aiming at fill some gaps which are remains from previous systems:

- Allow students to choose to use their real name, their nickname or anonymous.
- Support more question types: multiple choice, short answer, true-false, fill-in-the-blank, coding and essay with automatic judge or semi-automatic which is significant benefit for staff.
- Make the peer-interactive process more accurate and easy for students whom nowadays familiar with many social networking sites.
- Allow learning content to be integrated into courses.

PIPLS supports student-generated multiple types of questions, included free-response, multiple-choices, fill in the blanks, and true-false questions. In this system, the students can discuss with each other by asking and answering the questions. The teachers can set questions, share the resources of learning and develop effectiveness of class management.

After logging in, the main menu (Fig. 1) is divided into some sections entitled: "Class register", "Your questions", "Answered questions", "Unanswered questions", "Your exercises", "Leader board", "FAQ" and "Chatroom". On the main page, students can find some quick statistic information about their progress: courses they are following, contributed questions, answered questions, unanswered questions, and and remaining exercises..

Besides those sections, there are many features and functions that we developed to help students and teachers. The system was developed on the basis of the Question2Answer system, so it has inherited all features of Question2Answer (Greenspan & Contributors, 2016). Due to the limit of this paper, the role of some of these sections is described next.

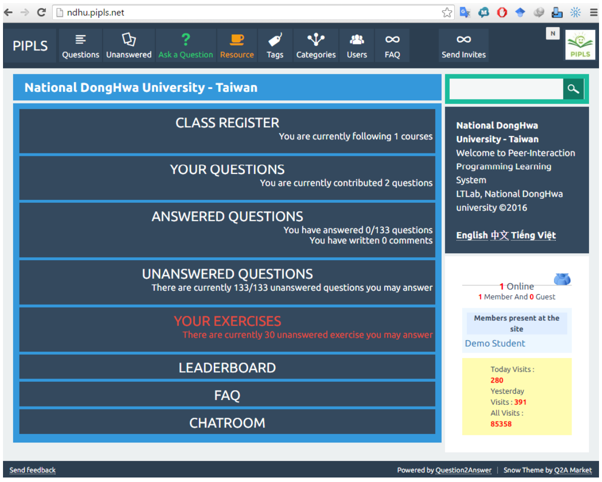

Figure 1. The main page of PIPLS.

3.1 Composing a question

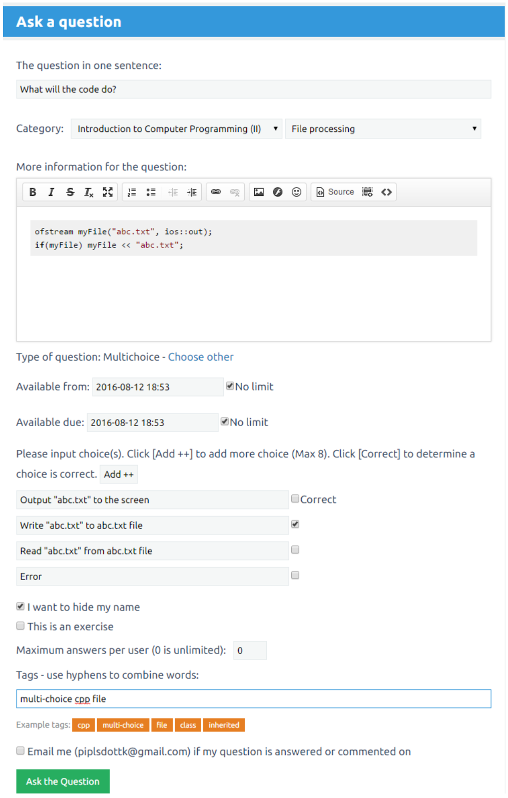

Figure 2. Composing a new question in PIPLS.

This section (fig. 2) allows a student to compose a question. The student was asked to chose the type of question before they can reach this section. PIPLS is designed to support multiple question types, including free-response, multiple-choices, fill in the blanks, and true-false questions.

Inherited from Question2Answer (Greenspan & Contributors, 2016), the question title must be provided with detailed information and embed multimedia, links, … To help students find and organize relevant questions, the questions may be tagged with appropriate topics by the author.

Original Question2Answer only provided free-response question so we developed additional fields applied for different types of question. Fig.2 illustrates how a multiple-choice question is defined.

Besides important information come with types of question, we also developed available time for the question, anonymous feature, mark question as exercise specifically for teacher, and the maximum answer per user allowed for the question.

3.2 Viewing all questions in course

Figure 3 shows how the list of questions in the course is displayed to students. The design is inherited from Question2Answer, the questions contained in the course are displayed in a single paginated list that can be sorted and filtered by various criteria: Recent, hot, most votes, most answers, most views, and our extended filter include exercises, your contributed questions, difficulty (based on peer evaluations), unanswered or answered questions.

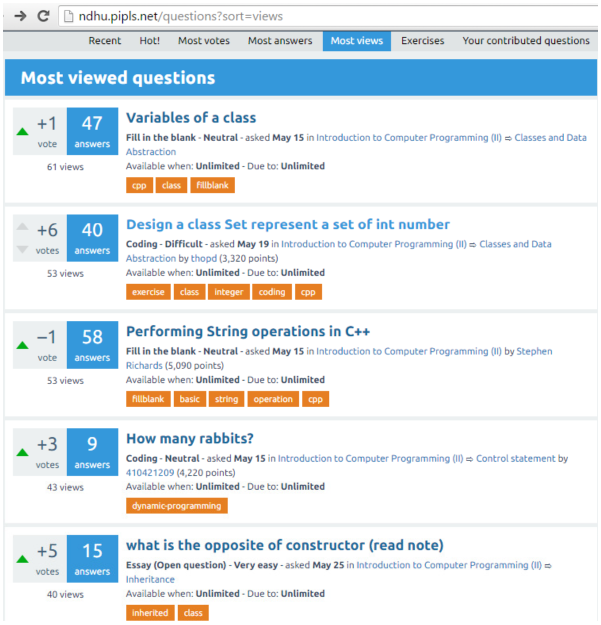

Figure 3. The All Questions List (Sorted by Views) in PIPLS.

3.3 Answering questions and viewing peer answers

In question-generation systems designed for educational purposes, students can use the questions for drilling and practicing, and as such, any answers should remain hidden until the student attempts to answer the question (Luxton-Reilly et al., 2011). In PIPLS, answers are revealed only after the student submitted the correct answer for automatically judged questions, or the answer for an essay question.

We enhanced PIPLS by including many functions of traditional SQG systems, include “call for help” function. When student cannot figure out the answer, they don’t need to give up or require help by giving some comment and wait. They can keep thinking straight without losing time by “call for help”. This function will allow student reading the answers from other classmates. Then the student need to decide which answer is correct and complete their own answer.

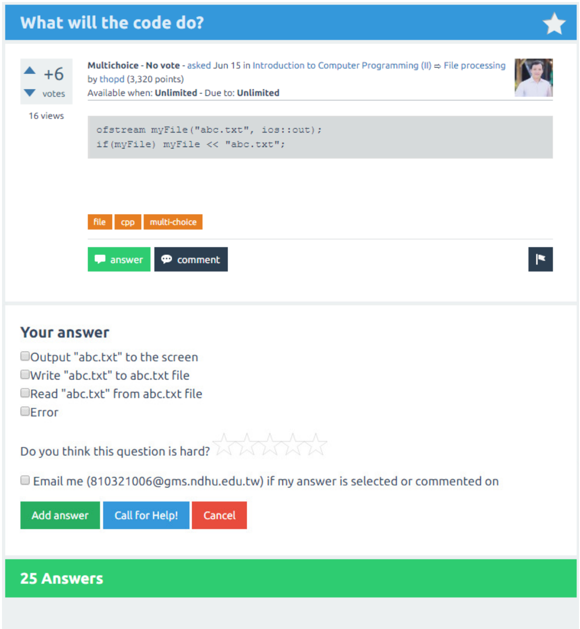

Figure 4. The Questions Answer interface (Multiple-choices type) in PIPLS.

3.4 Evaluating questions and answer

PIPLS support multiple-choice, true/false, fill in the blanks, and coding questions so it can automatically generate feedback for students who answer questions, by reporting whether the answer is correct (by percentage) or not. The student needs to submit the correct answer in order to see other answers. And numbers of answer are limited by author (or not) in the question composing interface (Fig. 2).

In the PIPLS, we have two types of free-response question: essay questions and coding question. Essay questions needs author or teacher to judge but coding question is automatically judged. PIPLS now supporting C, C++, Java and Pascal in auto-judge function. Coding questions are not only judged automatically, teacher also can re-judge the answer in case the machine cannot or if teacher want to give some bonus points for the good solution.

Currently, whenever a student submits an answer to a question, they can evaluate the question by assigning a rating (on a 1–5 scale) to the difficulty level of the question (Fig. 4).

Students also have the opportunity to write formative feedback to the question author, thanks to the comment feature of original Question2Answer which is visible to all users, and can agree or disagree with other feedback provided by their peers by voting feature. When the others' answer is visible, students can give comment and also voting in others' answer.

4. Conclusion and future work

We developed the system based on previous research, and focused on supporting students to learn Programming. We also extended the type of question generation (multiple-choice, true/false, fill in the blanks, essay and coding) and developed many additional feature. We hope to give more support to students when comparing with other systems which also support programming learning.

In future, we will plan to enhance the existed systems' functions and evaluate the impact of the tool on students' performance. We also intend to study the nature and quality of the artefacts (questions, answers and feedback) produced by students.

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Basic Framework for Learning by Constructing Cognitive Models Based on Problem-Solving Processes

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Abstract: Construction of models is promising as a learning activity. However, it can be a difficult activity which imposes heavy load on learners because it requires eminent skills. This study proposes a basic framework for learning by constructing models of a production system in the domain of cognitive science. In this framework, a model abstractly describing human problem-solving processes and its computer model implemented on the production system is prepared by an instructor in advance. A learner is given the abstract model and problem-solving processes produced by executing the implementation model, and then engaged in instantiating the abstract model into an implementation model. This activity is expected to deepen learner understanding of cognitive processes embedded in the abstract model. We implemented a support system for the framework.

Keywords: Learning by construction, cognitive model, production system, problem solving

1. Introduction

Science in recent decades has used two approaches to understand the natures of targets: an analytical approach through observation of targets, and a constructive approach through construction and simulation of target models. For example, within cognitive science research, running computational models has been adopted in understanding human mind in addition to empirical studies of human behaviors (Schunn, Crowley and Okada, 1998).

Construction is also promising as a learning activity. However, it can be a difficult activity which imposes heavy load on learners because it requires eminent skills such as implementation of a model with a programming language. Therefore, several studies addressed support for learning by constructing models (e.g., Basu, Dukeman, Kinnebrew, Biswas and Sengupta, 2014; Hirashima, Imai, Horiguchi and Toumoto, 2009). Support by the studies allow learners to construct and simulate models by designing models abstractly describing the attributes or behaviors of targets. Instantiation of the models into computer-executable models is left to support systems. Here, the former models of abstract description of targets are referred to as *abstract models*, and the latter as *implementation models*.

Basically, abstract models are critical in learning by construction because they are externalized products in understanding of targets. On the other hand, implementation of models also plays a critical role in deepening understanding as demonstrated in history of cognitive science. One of the central keys in learning by construction is to receive feedback from actual or virtual worlds through instantiation of abstract models into implementation models (Nakashima, 2008). Moreover, it is difficult to adapt learning by design of abstract models described with objects, agents and their attributes to some domains. Mental processes in problem solving by a person, for example, are not properly represented with interactions of objects and agents. Therefore, learning of such targets must require a different approach.

This study proposes a basic framework for learning by constructing models in the domain of cognitive science. This framework provides learners an abstract model and allows them to experience instantiate it into an implementation model with moderate load.

2. A Framework for Learning by Constructing Cognitive Models

This study adopts human problem-solving processes as learning targets and a production system as an architecture of implementation models. Production systems are one representative architecture in cognitive science. We proposes a framework for learning of cognitive processes by constructing production models.

The overview of this framework is illustrated in Figure 1. In this framework, an abstract model and its implementation model is prepared by an instructor in advance. A learner is given the abstract model and problem-solving processes produced by executing the implementation model. He or she is then engaged in instantiating it into an implementation model by himself/herself with production rules according to the processes. Our previous study confirmed that such an activity to reproduce a target based on its construction processes facilitates understanding of the target structure (Kojima, Miwa and Matsui, 2013). Thus, this activity is expected to deepen learner understanding of cognitive processes embedded in the abstract model (e.g., sophisticating a mental model of learners about a phenomenon the abstract model represents).

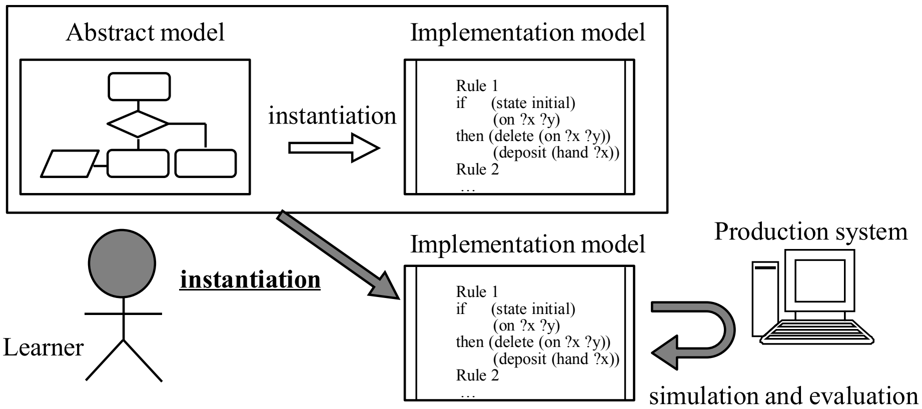

Figure 1. Framework for learning by constructing cognitive models

3. A Support System for the Framework

We implemented a support system for the framework described in the previous section. It uses DoCoPro (Nakaike, Miwa, Morita and Terai, 2009), a production system designed for learning by constructing models by novice learners, as the architecture of implantation models. Before the system is given to learners, an instructor implements a cognitive model for an abstract model of human problem solving on DoCoPro. The system executes the model and extracts its processes. It then creates information indicating steps involved in the processes of model execution. This information includes explanation of a production rule fired and two states before/after the rule firing for each step of the processes. Figure 2 illustrates an example of structure of the information.

A learner is then given the abstract model and instantiates it with the support system shown in Figure 3. As the left side of the figure indicates, the system provides information of each step in processes from the implemented model by the instructor. For every step of the model processes, the learner composes a production rule which can change the before-state to the after-state with the editor of the right side. The learner can check his/her rule on each step through comparison between the after-state and the result from firing the rule. Construction of the implementation model is completed through composition of rules for all steps. Although learners cannot experience design of problem representation in this framework, it enables the learners who are not familiar with coding skill to experience instantiation of an abstract model and receiving of feedback from the instantiation. We are now working on an empirical study to test the effectiveness of learning by constructing a cognitive model with the system.

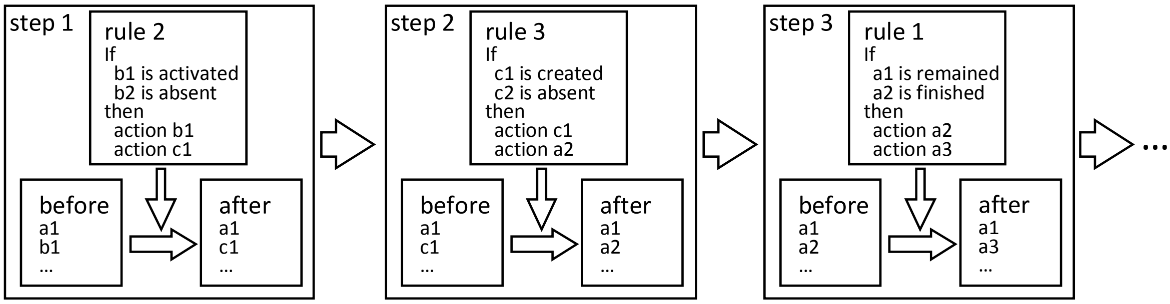

Figure 2. Structure of information of processes from model execution

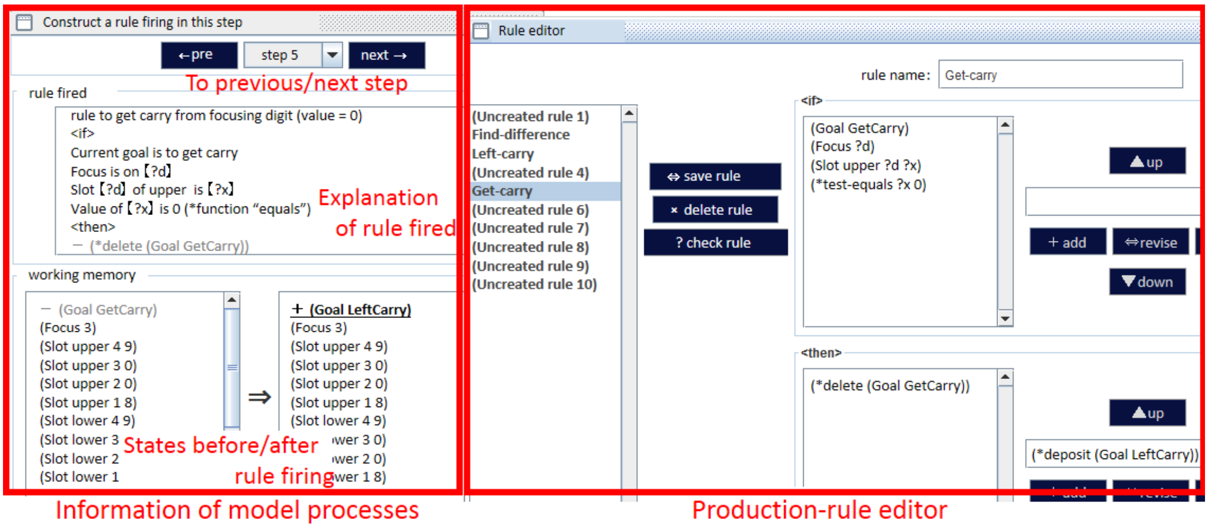

Figure 3. Screenshot of support system

Acknowledgements

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A Case Study of Interactive Environment for Learning by Problem-posing Targeting Junior High School Students with Reading Disability

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Abstract: In this paper, we describe a case study of learning environment for problem-posing targeted as learners with reading disability. We have developed a learning environment for problem-posing as sentence integration that is different from usual problem-posing targeted as arithmetic word problem. In this exercise, a learner is required to select and arrange given simple sentence cards for posing problems. On the other hands, learners write problems from scratch in usual problem-posing. Because it is very difficult for learners with reading disability to write a sentence, they cannot exercise by usual problem-posing virtually even though a teacher would like to teach the arithmetic word problems to them through problem-posing exercise. However, several learners with reading disability are able to read a simple sentence. So, we assumed that these learners realize to exercise problem-posing by the problem-posing as sentence integration. Analysis of its practical use confirmed that it is possible for them not only to pose a problem but also to learn a structure of arithmetic word problem by using our learning environment.

Keywords: Problem-posing as sentence integration, arithmetic word problem, special classroom, reading disability

1. Introduction

A special classroom is dedicated to the education of students with special needs. This classroom often includes a small group of students with special needs. The special needs include learning disabilities, communication disorders, emotional and behavioral disorders, physical disabilities, and developmental disabilities. Teacher provides them an education that addresses their individual differences and needs. Many learner with learning disability includes one of learning disability called reading disability. It is very difficult for them to read and write a sentence. A teacher and several researchers teach them how to solve the arithmetic word problem as easily as possible (William, 2007; Jitendra and Hoff, 1996; Xin et al, 2005). For example, they explain a meaning of each sentence or divide a complex sentence into some simple sentences when they are solving the arithmetic word problem. Additionally, if the learner difficult to read the simple sentence, the teacher often explains the arithmetic word problem by using some picture in several school. Thus, it is hard for a teacher to teach the arithmetic word problems in special classroom.

Problem-posing is suggested as an effective way for improving learner's understanding of mathematical concepts and the development of mathematical thinking (English, 1998; Silver, 1997; Singer and Moscovici, 2008). In this exercise, a learner is given an assignment, and then, he/she is required to pose a problem by writing it from scratch. The teacher of special classroom would like to teach the arithmetic word problem by problem-posing if the learner can do it. However, learner with reading disability is not able to pose an arithmetic word problem because of their disability.

We have designed and developed a learning environment for posing an arithmetic word problem (Hirashima et al, 2007; Yamamoto et al, 2012, 2013, 2014). In this problem-posing, the learner is required to select and arrange a few sentences in order to pose the problem. These sentences are designed by structuralizing targeted problem. We call this exercise problem-posing as sentence integration. Its learning environment can assess the posed problem automatically and feedback the result of problem-posing in real-time. By using this learning environment, the learner can understand a problem structure to pose the problem. Actually, we have confirmed that the learner improved their understanding of problem structure after they have learned the arithmetic word problem by using our environment in regular class.

We assumed that the learner with reading disability can pose an arithmetic word problem and understands a structure of arithmetic word problem by using our learning environment if he/she is able to understand a simple sentence. The purpose of this research is to realize the learning of problem-posing in special classroom by using our learning environment. Previously, a teacher in special classroom requested us to use our learning environment in his class because he has same assumption. A result of this experimental use has suggested that the learners with reading disability who cannot exercise usual problem-posing could exercise the problem-posing by using our learning environment (Yamamoto et al, 2016). We don't find a research that the learner with reading disability realized to exercise problem-posing. However, there are only two subjects in this experimental use.

In this paper, we report a case study of our learning environment for a sixteen learners with intellectual disability who belongs to special classroom at junior high school in Hiroshima. A purpose of this paper is to verify an assumption that our learning environment realizes that the learner with reading disability can exercise problem-posing and understand the problem structure. A relation between the problem-posing as sentence integration and reading disability are explained in next section. Subsequently, we have described an error of problem-posing, kind of problems and a developed learning environment by problem posing called MONSAKUN Touch. Lastly, a procedure of case study of learning environment and its result are reported.

2. Problem-posing and Reading Disability

2.1 Problem-posing

We focused on an arithmetic word problem that can be solved by one-step addition or subtraction in this research. Figure 1 shows usual problem-posing of the arithmetic word problem. In this exercise, leaners are required to pose the problem that is satisfied a given assignment like calculation. Then, they pose the problem from scratch by writing sentence.

On the other hands, we have defined the problem-posing as sentence integration that required learners to pose the problem by selecting and arranging a three simple sentences from a given simple sentences in Figure 2. In this exercise, they need to read and understand each given sentences that consist of quantity, object and attribute. For example, in the first sentence of Figure 2, the quantity is "five". The object is "apple". The attribute is "There are" that expresses existence of quantity. We call this simple sentence the independent quantity sentence. The third sentence of Figure 2 has the attribute that is "altogether". This attribute expresses the relation between the quantity of apple and orange. This simple sentence called the relative quantity sentence. These simple sentences show the quantitative . concepts. In our research, the arithmetic word problem is expressed by three quantity sentences because the arithmetic word problem that can be solved one-step addition or subtraction consists of three quantities: operand, operant and result quantity. We call this model as triplet structure model (Hirashima et al, 2014). Therefore, if a learner is able to read and understand this concept, he/she can exercise the problem-posing as sentence integration.

Assignment: Pose problem that can be solved by "8-5".
Answer: There is one big tree. Tree has five apples and there are several oranges on other tree. A number of apples and oranges are eight. How many oranges are there?

Figure 1. Usual Problem Posing.

Assignment: Pose a problem that can be solved by "8-5" .

Answer:
- There are 5 apples.
- There are ? oranges.
- There are 8 apples and oranges altogether.

Dummy:
- There are 7 apples.
- There are ? bananas.
- 8 apples are eaten.

(Answer and Dummy together: **Given simple sentences**)

Figure 2. Problem-posing as Sentence Integration.

2.2 Relation between targeted reading disability and problem-posing as sentence integration

There are several learners with reading disability in special classroom. They need a long time to recognize each word more than regular learners. Moreover, it is known that most learners with reading disability cannot write a sentence correctly. Thus, they cannot exercise by usual problem-posing because of their disability.

So, the learner with reading disability often finds difficulty in reading sentence but several learners are able to read the simple quantity sentence. They are our targeting learner because the arithmetic word problem composed of three simple quantity sentences in triplet structure model. In other words, the problem-posing as sentence integration may provide a scaffold that provides the each simple sentence for learning by problem-posing. However, it is difficult for teacher to assess posed problems in real-time even if teacher use our method. Our learning environment solved this difficulty so that teacher and learner realize the problem-posing of arithmetic word problem by using information technology. We have already performed an experimental use in special classroom in which there are two targeted learners at elementary school. The results of the experimental use suggested that they are able to pose the problem and improve their ability for posing the arithmetic word problem that can be solved by one-step addition or subtraction. However, there are a few subjects in this experimental use. Therefore, we verify the realization of problem-posing as sentence integration for our targeted learners as additional experimental use so that anyone who understands the quantitative concepts are learn by problem-posing as sentence integration in special classroom.

3. Learning environment for problem posing as sentence integration

3.1 Exercise on Learning Environment

Functions for exercising the problem-posing as sentence integration targeted as the arithmetic word problem are implemented on a learning environment called MONSAKUN Touch (Yamamoto et al, 2016). MONSAKUN Touch runs on Android tablet. In this learning environment, the learner can select a level of assignment after login. If the level is selected, MONSAKUN Touch displays the main interface for problem posing that is shown in Figure 3. This interface presents an assignment of posing problem in upper right area, the group of given simple sentence cards in right area and the three blanks for setting selected sentence cards in center left area. The assignment shows the calculation and story. The learner poses the problem by selecting three simple sentence cards from given cards and arranging them in proper order. Given sentence cards are consists of both correct and dummy cards that leading to errors. If three blank is filled with three sentence cards, diagnosis button will be active. After the learner taps this button, MONSAKUN Touch diagnoses and generate a feedback his/her posed problem in real-time. Feedback consists of Flag Feedback that replies correct or incorrect and Pointing Hint that replies points of error (Vanlehn et al, 2005). The feedbacks are displayed by a sentence. If the learner finishes answering all assignment in selected level correctly, the interface for posing problem changes to the interface for selecting level.

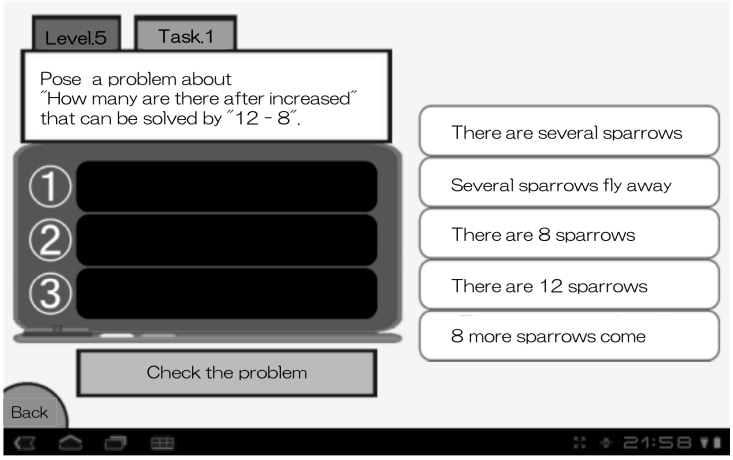

Figure 3. Main interface of MONSAKUN Touch.

3.2 Level of Assignment and Kind of Error

Table 1 shows a level of assignment on MONSAKUN Touch. A different of each level is a kind of posed problem, a given calculation and a given story. The story is divided into addition story and subtraction story. Addition story is usually expressed by increase story or combine story. Subtraction story is usually expressed by decrease story or comparison story. For example, the following story is decrease story.

{There are "?" apples. 2 apples are eaten. There are 3 apples.}

We are able to solve this problem by "3+2". We call this calculation for solving problems the calculation numerical relation. And then, the numerical relation of this problem expresses as the subtraction story that is "?-2=3". We call this calculation based on story the story numerical relation.

In above problem, story numerical relation and calculation numerical relation are deferent. We call this type of problem "reverse thinking problem". If story numerical relation and calculation numerical relation are same, then such problems are called "Forward thinking problem". Reverse thinking problem is much harder than forward thinking problem. The level of assignment is designed to be the step by step based on these definitions. The level one is easiest assignment in MONSAKUN Touch. The level two and three of assignment are difficult secondly because the learner is required to pose reverse thinking problem but indicated calculation is story numerical relation. The level four and five of assignment is most difficult assignment because the learning environment shows the learner to calculation numerical relation and the learner poses reverse thinking problem.

Table 1: Level of Assignment.

Level	Kind of posed problem	Given calculation	Given Story
1	Forward thinking problem	Story numerical relation	Combine, Increase, Decrease, Comparison
2	Reverse thinking problem	Story numerical relation	Combine, Increase
3	Reverse thinking problem	Story numerical relation	Decrease, Comparison
4	Reverse thinking problem	Calculation numerical relation	Combine, Increase
5	Reverse thinking problem	Calculation numerical relation	Decrease, Comparison
6	Random	Random	Random

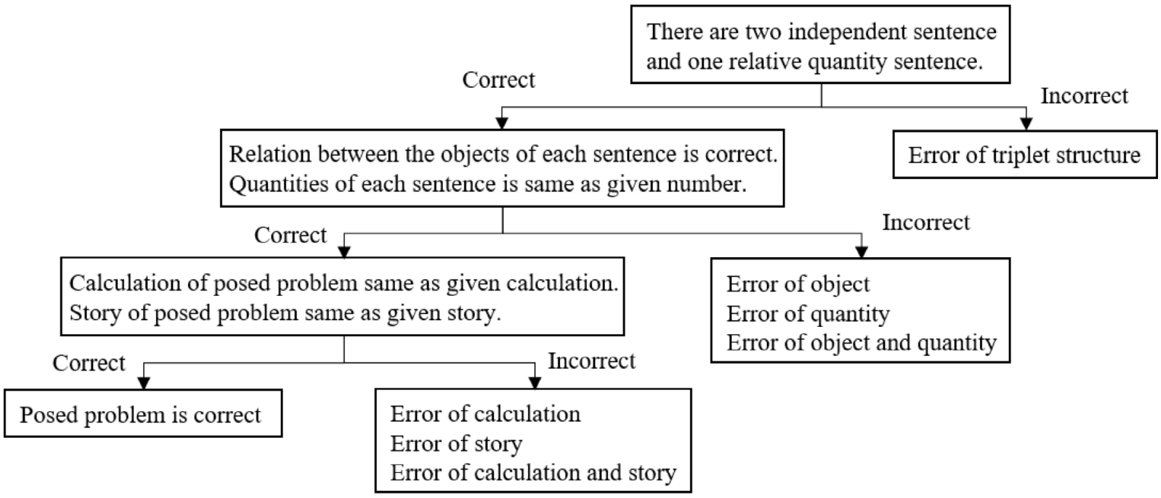

Figure 4. Diagnosis of Posed Problem by MONSAKUN Touch (Yamamoto et al, 2016).

The errors of posed problem are shown in Figure 4. First, MONSAKUN Touch diagnoses that pose problem composes of two independent quantity sentences and one relative quantity sentence. If the posed problem doesn't satisfy this restriction, the posed problem has the error called the error of triplet structure. Second, the correspondence relation between each quantity of posed problem and given quantities in assignment and the correspondence relation between each object in posed problem are diagnosed. These errors call the error of quantity and the error of object. Third, the calculation and story of posed problem correspond to the assignment is diagnosed. If the calculation of posed problem doesn't correspond to given one, the problem has the error of calculation. If the story of posed problem is not corresponded to given one, the problem has the error of story. We analyzed these errors in the experimental use.

4. Experimental Use

4.1 Method

The subjects were sixteen students in special classroom at junior high school in Hiroshima. These subjects joined from three special classrooms. They have already finished learning the arithmetic word problems. They were divided into three groups. First, nine subjects has our targeted reading disability (targeted subjects). Second, six subjects doesn't have reading disability (non-targeted subjects). Third, one subject has massive reading disability. All subjects are mild or medium intellectual disability. Intellectual disability is known as general learning disability and mental retardation but it is defined by an IQ score under 70. Because third group subject cannot read a word, the teacher read for her a given sentence cards, assignment and feedback on MONSAKUN Touch. In this experimental use, we were examined these assumption: (a) If the subjects can read the simple quantity sentence, they can exercise by the problem-posing as sentence integration, (b) subjects improve their ability for problem-posing, (c) subjects improve their problem solving and understanding of problem structure performances, (d) MONSAKUN Touch is useful for teacher to realize the lesson by problem-posing.

This experimental use has been performed during seven lessons. (Step.1) Subjects work on a pretest that consists of usual problem-solving test, extraneous problem-solving test (Muth, 1992) and problem-posing test in one lesson (forty-five minutes per one lesson). The full mark of usual problem-solving test is sixteen. The full mark of extraneous problem-solving test is sixteen. Usual problem-solving test is same as problem-solving test in arithmetic textbook. The extraneous problem-solving test includes extraneous information that is not necessary to solve the word problem. It is more difficult for learner to solve the extraneous problem than to solve the usual problem. In problem-posing test, the subjects are required to pose problems that can be solved by one-step addition or subtraction in time. (Step.2) The subjects work on a pre-problem-posing by using MONSAKUN Touch in one lesson. In this exercise, teacher didn't support subjects for posing problem. (Step.3) Lectures of arithmetic word problem by using MONSAKUN Touch are performed in three lessons. First lesson is composed of teacher's lecture about triplet structure and exercising by MONSAKUN Touch (level one) with teacher's support. One teacher taught in this lesson. Other lessons are only exercising by MONSAKUN Touch with teacher's support. In this time, the teacher uses a monitoring system for observing the learners learning data. Second lesson deals with level two and three. Third lesson deals with level four and five. Four teachers taught in these lessons. If subject finish to exercise the targeted level, they are repeat to exercise the targeted level and previous level. (Step.4) Post-problem-posing by using MONSAKUN Touch is performed in one lesson. (Step.5) The subjects work on a posttest. The teachers answered a questionnaire and an interview after all lessons finished. Four teachers who joined its experimental use answered its interview. The problems of posttest are same as pretest but its order is changed.

4.2 Results

4.2.1 Analysis of Log Data in Pre and Post Problem-posing

Average number of posed problem per minutes is 3.1 problems in all subjects. Average number of posed problem by targeted subjects is 3.96 problems. In regular classroom at elementary school, students posed 2.8 problems per minutes (Yamamoto et al, 2012). Thus, the subjects in special classroom are posed problem same as the subjects in regular class by MONSAKUN Touch.

Next, we categorized this analysis based on kind of posed problem and given calculation. If the subject cannot finish the all assignment in each level, its data is excluded. Here, a log data of non-targeted subjects is analyzed. This log data is shown in Table 2. In the analysis of level one, there was no significant difference in each error between pre-problem-posing and post-problem-posing because these learners don't have reading disability and there is few number of their error in pre-problem-posing. In the analysis of level two and three, there was only a significant difference in the error of triplet structure between pre-problem-posing and post-problem-posing (Paired t-test, p=.03), and effect size is large ($|d|$=1.72). There was no significant difference in each error of level four and five between pre-problem-posing and post-problem-posing but the assignments of level four and five are very difficult for a learner in regular class as well as these subjects.

The analysis of log data of targeted subjects is described. This log data is presented in Table 3. In the analysis of level one, there was a significant difference in the error of triplet structure between pre-problem-posing and post-problem-posing (Paired t-test, p=.04), and effect size is large ($|d|$=1.7). Also, there was a significant difference in the error of quantity and object between pre-problem-posing and post-problem-posing (Paired t-test, p=.02), and effect size is large ($|d|$=1.5). In the analysis of level two and three, there was a significant difference in the error of triplet structure between pre-problem-posing and post-problem-posing (Paired t-test, p=.002), and effect size is large ($|d|$=2.3). There was no significant difference in each error of level four and five between pre-problem-posing and post-problem-posing. The reason of this result is same as the case of non-targeted subjects.

Table 2: Number of Each Error in Non-targeted Subjects.

		Pre-problem-posing		Post-problem-posing		
Level	Type of error	M	SD	M	SD	
1 (N=5)	Story, Calculation	1.4	1.95	0.4	0.89	n.s.
	Object, Quantity	0.8	0.84	0	0	n.s.
	Triplet structure	8.6	12.03	2.6	5.27	n.s.
2, 3 (N=5)	Story, Calculation	6	4.06	1.6	2.07	n.s.
	Object, Quantity	15	13.61	1.8	1.92	n.s.
	Triplet structure	20.2	12.81	3.6	4.83	*
4, 5 (N=5)	Story, Calculation	14.2	10.92	14.8	6.38	n.s.
	Object, Quantity	11.8	7.56	10.2	8.17	n.s.
	Triplet structure	48.4	65.36	71.2	59.83	n.s.

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

Table 3: Number of Each Error in Targeted Subjects.

		Pre-problem-posing		Post-problem-posing		
Level	Type of error	M	SD	M	SD	
1 (N=7)	Story, Calculation	4.14	3.48	1.86	2.34	n.s.
	Object, Quantity	16.71	12.89	2.57	2.23	*
	Triplet structure	59.14	30.43	17.86	14.62	*
2, 3 (N=4)	Story, Calculation	6.50	4.51	6.00	3.92	n.s.
	Object, Quantity	18.75	5.56	7.50	4.04	**
	Triplet structure	44.25	17.39	35.00	20.52	n.s.
4, 5 (N=4)	Story, Calculation	27.50	43.94	13.75	8.96	n.s.
	Object, Quantity	13.25	10.87	12.50	4.43	n.s.
	Triplet structure	83.75	125.77	83.75	68.96	n.s.

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

Table 4: Number of Subjects who finished Each Level.

		Lv.1	Lv.2	Lv.3	Lv.4	Lv.5
Non-targeted Subjects (N=5)	Pre-problem-posing	5	5	5	1	0
	Post-problem-posing	5	5	5	2	1
Targeted Subjects (N=7)	Pre-problem-posing	7	4	4	0	0
	Post-problem-posing	7	7	7	2	2

In addition to these results, one subject with massive reading disability has caused the one error of triplet structure in post-problem-posing exercise, first. However, she didn't cause the error of triplet structure from twice to fourteen times diagnosis. This result suggested that the problem-posing as sentence integration is effective method for massive reading disability student. Table 4 shows the number of subjects who finished each level. From the results of Table 4, all subjects learned the method of posing problem because their reached levels are improved.

The results of log data pointed out that the student with reading disability can exercise by problem-posing if they use MONSAKUN Touch. Also, this results of log data shows that MONSAKUN Touch improves all subject's problem-posing ability without the level four and five that required them to pose the reverse thinking problem based on given calculation numerical relation. From mentioned above, we demonstrate the assumption (a). However, they couldn't improve their ability of problem-posing in level four and five. For improving these results, we need to sophisticate the level of assignment more gradually.

4.2.2 Analysis of Pretest and Posttest

A score of each pretest and posttest is presented in Table 5. One student absent from the posttest in usual problem-solving test. Additionally, one student couldn't work on extraneous problem-solving test because of time. There is no significant difference between pretest and posttest in usual problem-solving test. About this reason, we thought that it is difficult for several subjects to concentrate to solve problems. Actually, a score of two subjects in pretest and posttest are zero. There is also no significant difference between pretest and posttest in extraneous problem-solving test. We thought that the reason of this result is same as usual problem-solving test. A score of five subjects in pretest and posttest are zero. So, it is difficult for them to solve the general problem solving test.

Only eight subjects described problems in problem-posing test. There is no significant difference between the number of posed correct problem in pretest and posttest but this number is increased from 2.5 to 4. Moreover, one subjects posed one reverse thinking problem in posttest. The results of problem-posing test and log data are suggested the assumption (b) but we didn't confirm that assumption (c). The tests for examining the performance of problem-solving and understanding of problem structure have to be improved.

Table 5: Score of Each Pretest and Posttest.

	Pretest		Posttest		
	M	SD	M	SD	
Usual Problem-solving test (N=15, Max score=16)	7.60	4.67	7.40	5.36	n.s.
Extraneous Problem-solving test (N=14, Max score=16)	3.64	5.37	4.29	5.30	n.s.
Problem-posing test (N=8)	2.50	2.07	3.50	2.67	n.s.

4.2.3 Analysis of Questionnaire and Interview

The result of questionnaire for teacher is shown in Table 6. From the question (1), they find it is very hard for them to teach problem-posing without MONSAKUN Touch in special classroom. They also said that teachers need to have enough experience in order to teach problem-posing. And it is difficult to design a lecture of problem-posing because teachers let students pose few problems in one lesson generally. However, if they apply MONSAKUN Touch to their lecture, the students with reading disability can pose many problems. Here, one teacher answered "neutral" in question (1) because she has never taught problem-posing. Therefore, these teachers consider that MONSAKUN Touch is useful software to teach the arithmetic word problem that can be solved by one-step addition or subtraction by problem-posing in special classroom if a learner with reading disability can read and understand the simple quantity sentence. So, three teachers answered question (2) "neutral" but they would like to use MONSAKUN Touch continually.

In the results of interview, these teachers suspected that subjects are able to pose problem by using MONSAKUN Touch but most subjects have difficulty in exercising by problem-posing and they cannot concentrate on a problem-posing for a long time. These teachers also suspected that some subjects can learn the arithmetic word problem by using MONSAKUN Touch before experimental use but many subjects cannot learn because of their disability. However, all subjects concentrated on a problem-posing during lesson and the number of error was decreased. Besides, most subjects answered that the problem-posing as sentence integration is difficult exercise but they enjoy learning by problem-posing and want to learn again. These results are better than the results that the teachers suspected. These results also demonstrate the assumption (d).

Table 6: Result of Questionnaire for Teacher (N=4).

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
(1) Is it easy to teach problem-posing without MONSAKUN Touch?	0	0	1	0	3
(2) Is it effective to use problem-posing as sentence integration for reading disability leaner?	0	0	3	0	1
(3) Is it easy for you to use MONSAKUN Touch in your class?	1	2	1	0	0
(4) Would you like to use MONSAKUN Touch in your class continually?	3	1	0	0	0

5. Conclusions

We designed and developed the learning environment for problem-posing as sentence integration. On this learning environment, learners pose the arithmetic word problem as selecting and arranging given simple sentence cards. In usual problem-posing, learners need to write an arithmetic word problem with some sentences. So, learners with reading disability cannot exercise problem-posing because they feel difficulty in writing a sentence and reading long sentence. Therefore, it is virtually impossible for them to learn by problem-posing. However, we assumed that these learners exercise the problem-posing by using our learning environment if they can read the simple sentence. Through the experimental use of the system, it was confirmed that the learners could pose the problem. Moreover, the teachers accepted that our learning environment is effective for targeted learner. These results are better than the results that the teachers suspected. It is believed that the leaner with reading disability who can read the simple sentence could learn by problem-posing for our learning environment. However, it is not sufficient to confirm the learning effect like problem-solving performance and several functions of our system have to be improved.

As our future works, we have to sophisticate the level of assignment and analyze the results of this experimental use in more detail. Furthermore, we are going to perform the experimental use continually for confirming the effect of our learning environment.

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