Combining Context-aware Ubiquitous Learning and Computer Simulation: A Lesson Learned in Elementary Science Education

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Abstract: Context-aware ubiquitous learning has been recognized as an innovative mobile learning approach that enables students to directly interact with real-world natural phenomena with supports from digital technology. To enhance visualization of the phenomena, computer simulation could be used to simplify the real world using visual representation. These approaches could be used to motivate science-based learning and facilitate inquiry-based learning process in elementary school science. As such, the mobile "Answer Me" application has been created as a cloud-based instructional system to facilitate context-aware ubiquitous learning in science. In this study, the Answer Me was used to facilitate students' investigation of scientific phenomena of sound. To enhance their comprehension about sound wave, a computer simulation, developed by Physics Education Technology research group, was employed to visualize unobservable phenomena of sound. Both technologies were combined to promote science learning experience regarding predict-observe-explain learning process. Moreover, to evaluate its impact on science learning in elementary school, 54 fifth-grade students were recruited to interact with the app and simulation through POE learning activities. They were examined conceptual understanding about sound and science motivation both before and after the intervention. The results showed that students improved their conceptual understanding about sound and the proposed approach had a positive impact on students' science motivation of learning science by the combined learning experience.

Keywords: Blended environment, ubiquitous technology, simulation, science learning, primary education

1. Introduction

Recent development in information and communication technology (ICT) have influenced on teaching practice and learning process in 21st century community. Today, computer and wireless network technologies have greatly affected the delivery of learning and capacitated people to convenient. Minami, Morikawa, and Aoyama (2004) stated that mobile devices, such as tablet PC, PDA, and smart phone, has transformed learning modes from e-learning to m-learning. Mobile technology provides opportunities to support science learning both inside and outside classroom, and the technology provides learning opportunity to anyone, anywhere, and anytime (Nasaro and Srisawasdi, 2014). Consequently, the government of Thailand has been concerned the important of mobile technology that affects educational process and improvement of quality of education.

In 2014, Thailand government has initiated One Tablet Per Child (OTPC) project by administering the OTPC tablet (tablet PC) devices for schools nationwide with the aim for improving quality of education in basic education level. As such, this project initially included some free applications to support learning in the various forms and the government has funded a project to support the development of applications for learning and encourages independent developers by handling the contest application for students. However, the application was developed largely remained focused on the lesson around, which is not different from reading a book.

Due to the abovementioned reason, this study invested an effort to find the way of using national OTPC tablet for students' learning in science. With mobile technology of the tablet, the learning environment can go with the student to outdoor, the laboratory, and other beyond. As such, a combination of ubiquitous learning (u-learning) and computer simulation has been selected by the researchers. This study brings the principle of context-aware u-learning that was designed to provide students authentic science learning in real context. This may be an effective way to enhance construction of conceptual understanding in science for students. In additions, computer-simulated technology were selected to use for facilitating the science teaching and learning through visualizing objects, processes, and interact dynamics models of natural phenomenon, that are normally beyond the user' control in the natural world (Pinatuwong and Srisawasdi, 2014). Kelton et al. (2003) cited in Loagnam (2009), mentioned that the simulation is a compilation of the various methods used to simulate real-life situations or behavior of the system onto a computer by using a computer software program to support science learning of natural phenomena. From these reasons, the researchers produced the combination and emphasized investigation of effects of the combination on elementary school students' conceptual understanding and science motivation.

2. Literature Review

2.1 Context-aware Ubiquitous Learning

Recent progress in wireless and sensor technologies has led to a new development of learning environments, called context-aware ubiquitous learning environment, which is able to sense the situation of learners and provide adaptive supports based on radio-frequency identification (RFID), wireless network, embedded handheld device, and database technologies. (Hwang, Tsai and Yang, 2008). In the past decade, researchers have been widely conducted research concerning mobile and ubiquitous learning and reported the effectiveness of adopting mobile and ubiquitous learning approach in various learning contexts (Hwang and Wong, 2014). Jones and Jo (2004) stated that the concept of adjustment teaching with ubiquitous technology has the potential to revolutionize education, and reduce the physical limits of traditional learning by applied learning to computer at anywhere. Moreover, this innovative practice in the field of education can be realized in the form of individual and learning style of each student as well. (Junqi, Yumei and Zhibin, 2010).

2.2 Computer Simulation

Computer simulations represent the real world by using a computer program. Simulations can be a valuable tool in the science classroom. They can exemplify scientific concepts and situations, thereby allowing students to explore the nature of things. Computer simulations rely heavily on visual representations of the phenomena they model. Currently, computer simulations are powerful tools which can make unobservable phenomena being visible representation and could support students' conceptual learning in science. Regarding the use of computer simulation, 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 simulation can facilitate student reducing alternative conceptions, and improving conceptual understanding of science concepts (Srisawasdi and Kroothkeaw, 2014; Srisawasdi and Sornkhatha, 2014; Suits and Srisawasdi, 2013).

2.3 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, even in Thailand. The inquiry-based learning is one of the primary pedagogy in science learning based on the investigation of scientific questions or problems. (Kuhn, Black, Kesselman and Kaplan, 2000). By the process of investigation and collection of science data, inquiry activities provide a valuable context for learners to acquire, clarify, and apply an understanding of science concepts. (Edelson, Gordin and Pea, 1999). Basically, the learning process of inquiry often begins with an assessment by the teacher of the pre-existing knowledge, understanding and awareness of the learners, and then leads the learners to ask questions when curiosity is provoked by exposure to authentic experiences. After that, learners make discoveries in the search for new understanding upon which they construct meaning and build further connections to understand the world in a way that is unique to them. Predict-Observe-Explain (POE) strategy is an inquiry-based pedagogy and it shows great potential for increasing students' understanding of scientific knowledge and their engagement in science. (Nasaro and Srisawasdi, 2014). This kind of instructional settings may provide a powerful learning environment for students where they have opportunities to construct scientific conceptual understanding that is durable over time. (de Jong, 2005). In addition, researcher reported that incorporation of POE strategy into ubiquitous learning environment affected students' self-efficacy and perceived ease of use in science learning activity. (Nasaro and Srisawasdi, 2014).

3. Method

3.1 Study Participants

The 54 fifth-grade students were divided into a control group (N = 30) and an experimental group (N = 24) in a local public school at the northeastern region of Thailand participated in this study. They came from the same class and ages between 10-12 years old. They have informal experience with the use of OTPC tablet in school but they have no experience in using the Answer Me app before.

3.2 Learning Materials and Activity

To implement the integration of context-aware ubiquitous learning experience and computer simulation in this study, a cloud-based application, named "Answer Me", has been created by the cooperation between science educators and computer engineering at Khon Kaen University. The Answer Me app was installed into wireless OTPC tablets. The app is a ubiquitous-based learning application that allows using for submitting questions or learning tasks by teacher and collecting students' answers and responses via wireless communication, with its built-in visualization and cloud computing features. This app supports high-resolution touch screen feature of tablet which makes it easy and intuitive to read question and to giving answer, as illustrated in Figure 1.

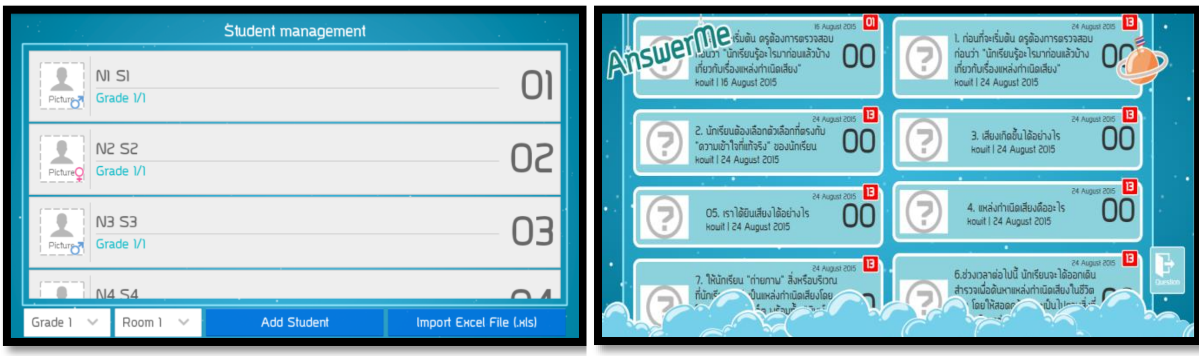

Figure 1. Examples of the Answer Me app's screen user interface: Teacher (Left) and student (Right) interface

Based on the app, students can submit their answers or responses back to teacher immediately from anyplace, which connected the wireless internet. Figure 2 displays an illustration of using the Answer Me app for context-aware u-learning experience. To enhance students' understanding of science concepts on sound, a number of computer simulation obtained from Physics Education Technology (PhET) research group were utilized as visual aid of unobservable phenomena in the class, after completing the ubiquitous learning experience. In an addition, the POE strategy was used as an intervention for their learning activity across four main concepts, including source of sound and its propagation, pitch, tone, and noise pollution.

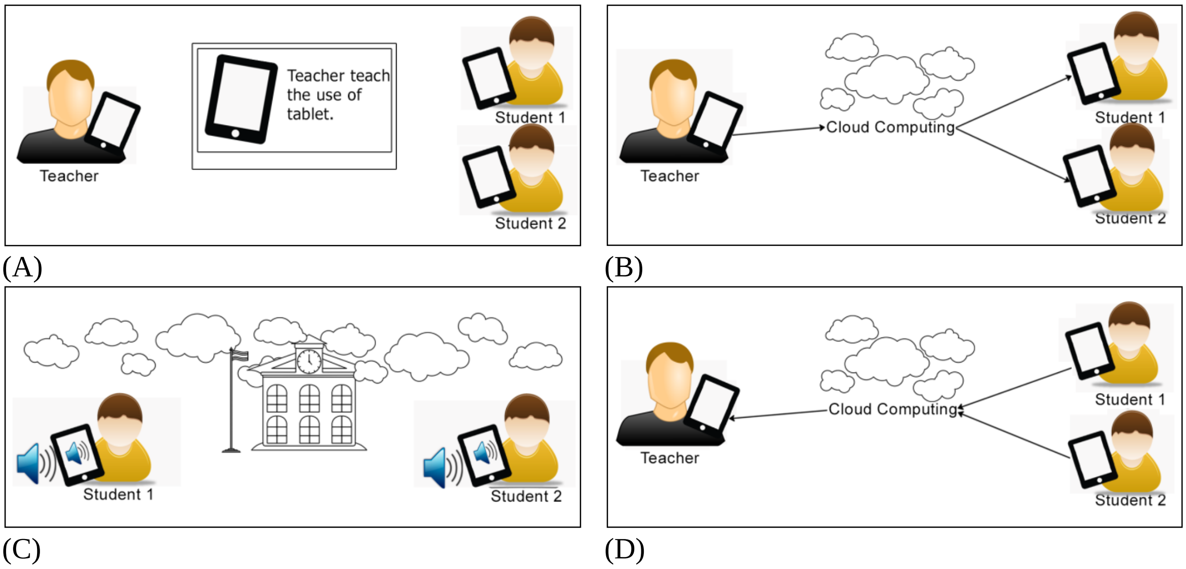

Figure 2. An illustration of u-learning environment by the Answer Me app

For the learning activity, teacher, first of all, introduced students how to use the Answer Me app on OTPC tablet in classroom as seen in Figure 2 (A). Teacher then sent a sample question to students as a demo. Students were assigned to submit their responses to teacher via the cloud-based application. After, teacher sent a series of conceptual questions to students (see Figure 2(B)), and student must find the answers in field, school, or home (see Figure 2(C)). After students found the answers, they sent their answers through the Answer Me's cloud services. Lastly, teacher marked scores for all students as seen in Figure 2(D). According to the proposed pedagogy, Figure 3 displays an example of students' learning scenario through the combination of ubiquitous learning environment and computer simulation.

Figure 3. An illustration of ubiquitous learning activity, outside classroom, by the Answer Me app (Left) and computer simulation in classroom (Right)

3.3 Instruments

To examine the students' conceptual understanding of sound wave, five open-ended conceptual questions were administered to them both pre-test and post-test. In these questions, they were assigned to drawing the sound wave phenomena and explaining their understanding on the sound wave. Draw-A-Sound instrument focuses on four main science concepts consisting (i) source of sound (ii) pitch (iii) tone (iv) noise pollution was used for the evaluation, and its maximum score was 15 points. To probe how much students can learn from each learning activity, POE work sheets were used to measure their conceptual progression along the intervention and their learning performance based on the worksheet were evaluated with the maximum score of 10 points each activity.

3.4 Data collection and Analysis

Figure 4 shows the procedure of the implementation of the learning activity. Before the learning activity, the students took the pre-test of scientific understanding and science motivation. For implementing the ubiquitous learning lesson, they were provided four ubiquitous experiences following POE learning strategy that their learning tasks were encouraged with open-ended inquiry questions and then precede the prediction, observation, and explanation, respectively. After completing all of ubiquitous learning experience, the students were administered the conceptual test again as the post-test. Finally, the science motivation questionnaire was provided to them for evaluating their view towards the ubiquitous learning experience. Figure 4 displays the procedures of the experiment and data collection in this study.

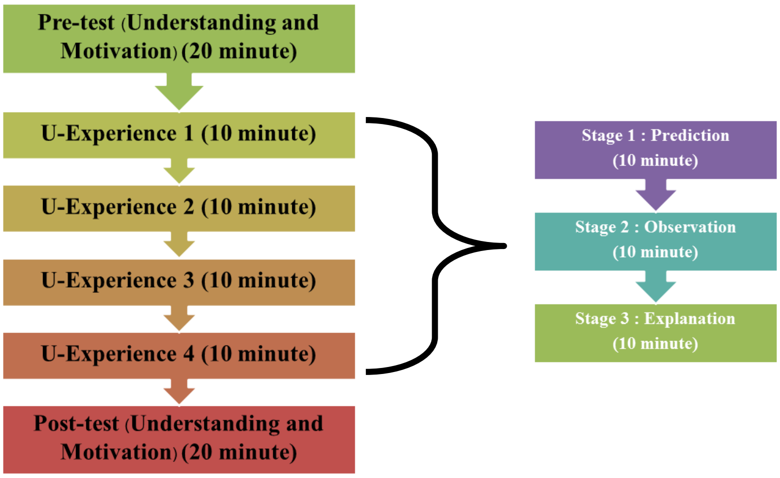

Figure 4. Diagram of experiment design.

To analyze students' conceptual understanding, an item-specific rubric scoring consistent with key concepts of sound wave was used to evaluate conceptual quality of students' understanding. Paired t-test was used to compare a significant difference between pre-test and post-test scores. For evaluating students' science motivation, arithmetic mean and standard deviation were used to describe how do they perceived the ubiquitous learning experience. Moreover, non-parametric statistics of Wilcoxon signed-rank test and Mann-Whitney U test were used to compare the significant change of science motivation.

4. Results and Discussion

In order to explore effects of the context-aware ubiquitous learning experience incorporated computer simulation following POE teaching sequence for science learning of sound wave, Table 1 shows the results on students' conceptual understanding comparing pre-test and post-test scores within group.

Table 1: Statistical results of paired t-test on students' scientific understanding scores of experimental group and control group

Intervention		N	Mean(S.D.)	*t*	*p*
Integrated teaching method of context-aware u-learning and simulation in POE-based inquiry process (Experimental group)	Pre-test Post-test	24 24	1.91(1.44) 12.24(2.41)	16.22	0.000*
Traditional teaching method (Control group)	Pre-test Post-test	30 30	1.37(1.19) 2.50(1.78)	3.26	.003*

*$p < 0.01$

The results show that students' conceptual understanding in experimental group on sound delivered by an integration of context-aware u-learning and computer simulation in POE-based inquiry have significantly increased from pretest to posttest (t = 16.22, p < 0.01), students' conceptual understanding on sound delivered by Traditional teaching have insignificantly increased from pre-test to post-test (t = 3.26, p > 0.01), as seen in Table 1.

According to the abovementioned results, this indicated that the integration of context-aware u-learning, using the Answer Me app., and computer simulation in POE-based inquiry can enhance students' conceptual understanding on sound.

Table 2: Statistical results on nonparametric of the students' science motivation

Scale	Group	Pre - questionnaire	Post - questionnaire	Wilcoxon signed-rank test		Mann-Whitney U Test	
		Mean(SD)	Mean(SD)	z-score	*p*	z-score	*p*
Intrinsic Motivation	EG	18.29(3.62)	18.92(3.32)	-.309	.378	-.279	.390
	CG	18.73(4.19)	18.80(2.89)	-.076	.469		
Career Motivation	EG	16.96(3.56)	18.58(3.92)	-1.727	.042*	-1.642	.510
	CG	18.70(3.81)	18.27(3.52)	-.554	.290		
Self-determination	EG	16.08(4.67)	18.33(3.70)	-2.216	.018*	-1.667	.047*
	CG	18.57(4.07)	18.20(3.43)	-.575	.283		
Self-Efficacy	EG	17.29(4.10)	18.58(4.32)	-1.025	.152	-.925	.177
	CG	17.93(4.19)	17.63(3.11)	-.441	.340		
Grade Motivation	EG	17.29(3.47)	18.88(3.80)	-1.652	.049*	-.595	.276
	CG	18.17(3.66)	18.80(3.30)	-.833	.202		

*$p < 0.01$

The Shapiro-Wilk test of data normality was checked and it showed that the data were not normally distributed, with p-value less than 0.05. Consequently, this study conducted in the nonparametric test (Demircioglu, Ayas and Demircioglu, 2005). The results of statistical analysis using nonparametric Wilcoxon signed-rank test of students in each experimental and control group before and after intervention could examine students' science motivation. The result showed that there was significant mean difference within experimental group in three scales consisted of self-determination (Z (n=24) = -2.216; p <0.05), career motivation (Z (n=24) = -1.727; p <0.05), and grade motivation (Z (n=24) = -1.652; p <0.05). From the results, it indicated that students in experimental group learning with integrated u-learning and simulation in POE-based inquiry improved their science motivation in self-determination, career motivation and grade motivation that's because of this intervention; students interacted with real world learning and precipitated that how importance of science related their daily life (Kamtoom and Srisawasdi, 2015). However, there was no significant mean difference in all scales within control group that studied in the conventional class as shown in Table 2.

Moreover, the results of statistical analysis using nonparametric Mann-Whitney U test of students in both experimental and control group before and after intervention found that there was significant mean difference between two groups from pre-questionnaire and post- questionnaire in the scale of self-determination (Z(n=54) = -1.667; p<0.05), but other scales were found not significantly difference as shown in Table 2.

5. Limitation of the Study

In this research, it should be noted that the students who participated in this study were selected by the researcher. The ratio of females to males was unequal and the number of participants involved was relatively small (N = 24). Therefore, these factors could pose a threat to the results generated from the paired t-test analysis.

6. Conclusions

In this study, the "Answer Me" app was created as an effective instructional tool to facilitate the context-aware ubiquitous learning experience. The results found that only the u-learning experience cannot enhance students' conceptual understanding about sound, especially at the unobservable level of sound phenomena. However, an integration of the u-learning experience and computer simulation in POE-based inquiry can help students to comprehend conceptual understanding about sound both observable and unobservable level of phenomena. After interacting with the intervention, students gain better understanding about sound and they can learn the sound concepts greater than a half of completed scores. In addition, the integrated u-learning and simulation in POE-based inquiry can promote students' career motivation, grade motivation and self-determination. As such, we believed that the proposed approach had a positive impact on students' science learning in promoting their scientific understanding. Last but not least, the Answer Me app. could be used to facilitate students' inquiry-based learning in science effectively.

Acknowledgements

This work was supported by Graduate School, Faculty of Education, Khon Kaen University, Khon Kaen, Thailand. The authors would like to express sincere thanks to Mr. Komkate Meuansechai for his supports in producing the mobile Answer Me application.

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