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Students' Self-efficacy and Acceptance toward Context-Aware Ubiquitous Learning in Biology Education: A Case of Photosynthesis in Plant

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Abstract: Recent progression in wireless and sensor technologies has led to a new development of learning environment, called context-aware ubiquitous learning environment, which is able to transform students' learning experience into more authenticity. With the benefit of the context-aware u-learning environment, this study aims to investigate impact of sensor-based laboratory learning in biology, incorporated with predict-observe-explain (POE) pedagogy on students' perceptions of self-efficacy, perceived usefulness, and perceived ease of use. The 21-item Likert-scale questionnaire was administered to 44 eleventh-grade students both before and after the intervention. The results indicated that the POE-based ubiquitous learning in the real context of plant photosynthesis could promote students' self-efficacy and perceived ease of use on the learning. However, there was no significant effect on perceived usefulness of the intervention. As such, this study also provided the discussion for promoting the students' perceived usefulness after participating in the POE-based tablet.

Keywords: Ubiquitous learning, POE, ubiquitous computing, biology education, wireless networks

1. Introduction

Recent development in science and technology applications have influenced on learning process. In 21st century learning, computer and wireless network technologies have greatly affected the delivery of learning and capacitated people to convenient. The widespread of mobile devices, such as Tablet, PC, PDA and smart phone, has transformed learning modes from e-learning to m-learning (Minami, Morikawa and Aoyama, 2004). These technologies provide learning opportunity to everyone, anywhere and anytime. Mobile technology provides opportunities to support science learning both inside and outside classroom. With mobile technology, the learning environment can go with the student to outdoor, the laboratory and other beyond.

Chen, Chang and Wang (2008) suggested that ubiquitous learning is context sensitive anytime, anywhere learning using ubiquitous devices such as, Tablet, Web, PDA's in indoor, outdoor, individual and groups. Schroerder and Haskell (2011) described u-learning as social media plus mobile learning. Some of these characteristics are applicable to here and now learning (Huang, Chiu, Liu and Chen, 2011): (i) Hastening of learning need (on time suitable) (ii) Initiative of knowledge occupancy (providing information to students immediately) (iii) Situation of learning activity (flow of everyday activities) (iv) Context awareness (interaction controlled by context such as location, time, activity etc) (v) Self-regulated learning (students control their learning process)

Cause many parts of science topics difficult to understanding and learning in many area teaching by textbook which is low motivation and better to learn which should to learn in real phenomena. The prevalence of outdoor education has increased considerably in recent years (Bloom, Holden, Sawey and Weinburgh, 2010). Students can use those outdoor learning experiences to understand and establish new knowledge and concepts regarding the topic being studied (Auer, 2008, Upadhyay and DeFranco, 2008). On the other hand, Teachers can incorporate knowledge regarding ecology that students gained through outdoor learning into formal classroom instruction to improve students perception (Eick, 2012). Thus recent u-learning should be appropriately used to support authentic learning in real phenomena as science subject.

2. Purpose of the Study

Based on the abovementioned rational, this study aims to investigate students' perceptions delivered in sensor-based laboratory learning environment incorporated predict-observe-explain (POE) pedagogy for biology learning of photosynthesis. Specifically, the following questions were answered:

- Do the students engaged in sensor-based laboratory learning environment incorporated predict-observe-explain (POE) perform significantly better by students' perceptions of self-efficacy?
- Do the students engaged in sensor-based laboratory learning environment incorporated predict-observe-explain (POE) perform significantly better by students' perceptions of perceived usefulness?
- Do the students engaged in sensor-based laboratory learning environment incorporated predict-observe-explain (POE) perform significantly better by students' perceptions of perceived ease of use?

3. Literature review

3.1 A Context-aware Ubiquitous Learning

Recent progress in wireless and sensor technologies has lead 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. Many researchers have been investigating the development of such new learning environments. For examples, a context-aware mobile learning system was used as a sensing device for nursing training courses and they found that students' learning outcomes were notably improved by utilizing the mobile learning system (Chen and Huang, 2012). Shih, Chuang and Hwang (2010) study with fifth grade students with the inquiry-based mobile learning system. They investigate by pre- and post-test with observations and interview focus group. The finding showed significant positive results for students' learning. In an addition, e-library activity worksheets were developed by Hung, Lin and Hwang (2010) that helped students focus their outside ecology observation tasks, and results indicated that most students demonstrated substantial improvements and extended their inquiry skill. These evidence indicated potentials of the novel learning environment of context-aware ubiquitous learning in teaching and learning.

3.2 Inquiry- based Learning

Kuhn, Black, Keselman and Kaplan (2000) descript that inquiry-based learning is one of primarily pedagogical based on the investigation of questions. 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). Furthermore, many researchers try to develop learners' investigation skills, data analysis and critical thinking using inquiry-based learning. They adopt activities related to the natural world to allow students to observe events and objects in the physical world from various facets, and to develop an understanding of how scientists explore the natural world (Hmelo-Silver, Duncan and Chinn, 2007). The advantages of inquiry learning are that it can lengthen the retention period of new knowledge, increase problem solving flexibility and creativity, and increase student learning motivation (Lord and Orkwiszewski, 2006). When inquiry learning is used in science subjects, it shows great potential for increasing students' understanding of scientific knowledge and their engagement in science.

POE strategy is a constructivist-based pedagogy and many researchers employed to facilitate learner's conceptual change process in inquiry-based learning. This kind of 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). POE can provide students to work on tasks collaboratively in group. Thus, it encourages a cooperative learning environment where students can share their knowledge and discuss with others in their group (Küçüközer, 2008, Tao and Gunstone, 1999).

4. Method

4.1 Study Participants

A total of 44 student-respondents in their eleventh grade, age ranging from 16 to 17 years in a local public school at the northeastern region of Thailand participated in this study. They were attending a biology course for basic education level. They have no experience yet using sensor-based laboratory in biology learning. This implied that they are heterogeneous before interacting with the experimental study.

4.2 Learning Materials and Activity

To engage student into context-aware ubiquitous learning, this study employed wireless microcomputer-based laboratory by Vernier and software technology. Vernier LabQuest-2 is a standalone interface used to collect sensor data with its built-in graphing and analysis application. The large, high-resolution touch screen makes it easy and intuitive to collect, analyze, and share data from experiments in class, field, and anyplace. Its wireless connectivity encourages students' collaboration and personalized learning. For this study, students were provided opportunity to conduct an investigation of photosynthesis in plant. With wireless features of the Vernier laboratory, the researchers designed students' laboratory experience with measurement of rate of oxygen (O_2) and carbon dioxide (CO_2) released by plants in the real context by gas sensors. The Vernier CO_2 and O_2 gas sensors used to measure gaseous carbon dioxide by monitoring the amount of infrared radiation absorbed by carbon dioxide molecules, and gaseous oxygen levels in a variety of environment, respectively. With the use of wireless LabQuest-2 data logger, experimental data were obtained, processed, and then shared to tablets in classroom via a server, as seen in Figure 1.

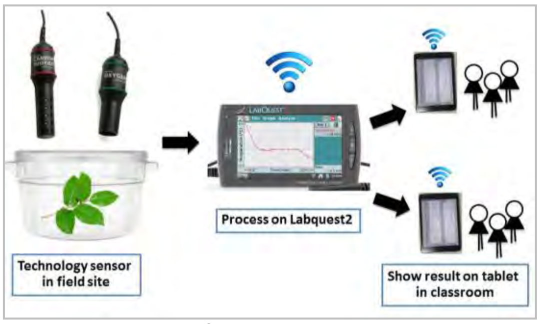

Figure 1. Materials of tablet-based laboratory learning.

To promote students' self-efficacy and acceptance toward the learning intervention, constructivist POE (predict-observe-explain) sequential learning steps were designed to foster biology learning by inquiry. In this study, instructor used 100 minutes class session to provide the u-learning experience for biology class. Student took overall 30 minutes for pre-test and post-test, and another 70 minutes for their POE learning process. Before performing the learning process, the instructor gave an orientation for working with the Vernier laboratory in 5 minutes and then 65 minutes for prediction (5 minutes), observation (30 minutes), and explanation (30 minutes). Figure 2 represented the prediction step based on an open-ended inquiry question provided by instructor, "what will happen if we measure rate of CO_2 and O_2 from plans outside the classroom?''. Then, students predict the graph of rate of O_2

and CO_2 when plant live in light and dark area on a work sheet. This warm-up activity was designed to provide the students with basic knowledge, and stimulate their motivation to learn science.

Figure 2. Prediction Stage. Students drawing graph on work sheet.

In the next learning step, a volunteer group of students was setting up by instructor and assign them to investigate rate of photosynthesis of plants using the Vernier gas sensor and LabQuest-2 data logger at the field for 30 minutes, regarding the variations in amount of carbon dioxide and oxygen. Figure 3 illustrates the observation activity in the real context.

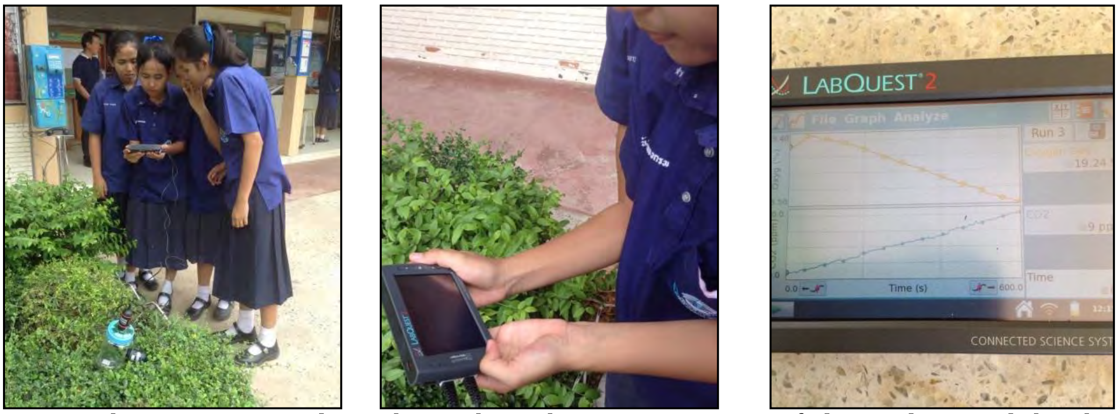

Figure 3. Observe Stage. Students observe by authentic measure rate of plants release and absorb O_2 and CO_2 in real area and process result by Labquest2 and share data on tablet in classroom by wireless connection.

At the same time with the observation, another student viewed the real-time experimental data of rate of plant photosynthesis through tablet connected wireless internet system in classroom. Figure 4 illustrates the use of tablet to monitor results of photosynthesis experimentation.

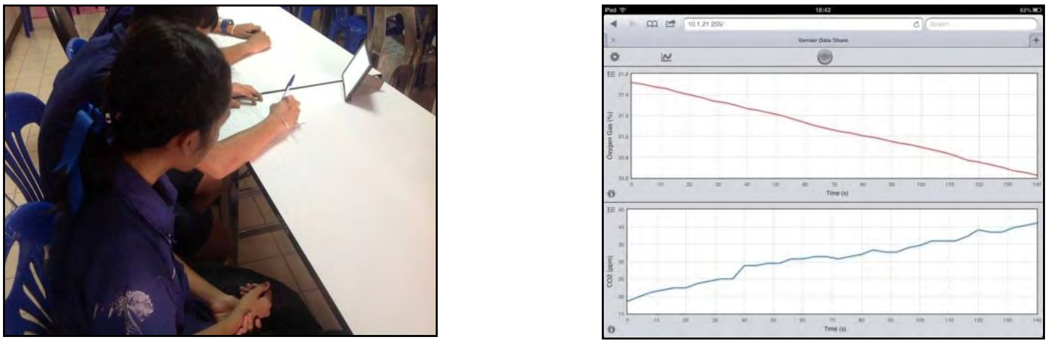

Figure 4. Observe Stage. The results were shared on tablet in classroom by wireless connection. Students compared their predictions and real observe.

For the last learning step of explanation, the volunteer group of students came back to the classroom and then the instructor conducted a forum discussion with peers to collaborative explain the plant photosynthesis phenomenon, emphasizing comparison of their prediction and explanation (See Figure 5).

Figure 5. Explain Stage. Students discuss and explain their prediction and real observe.

4.3 Instruments

A 21-item Likert-scale questionnaire was developed to use in this study for examining students' self-efficacy, perceived usefulness, and perceived ease of use toward the context-aware ubiquitous learning of plant photosynthesis. There were eight items of self-efficacy obtained from Wang and Hwang (2012), and six and seven items of perceived usefulness and perceived ease of use, respectively, from Hwang, Yang and Wang (2013). To develop a Thai version of the questionnaire, the original English version (See Table 1) was translated identically in Thai language. One expert was recruited to identify communication validity of the items. On each item, respondents were assigned to rate how much the respondent agree with into five scale, from 1-strongly disagree to 5-strongly agree). The reliability for self-efficacy, perceived usefulness, perceived ease of use, overall items was 0.76, 0.47, 0.73, and 0.85 (N=40), respectively.

Table 1: Items used to measure Self-efficacy, Perceived Usefulness and Perceived Ease of use.

Scale	Description of the scale	Example of items
Self-efficacy	Self-efficacy, or students' beliefs regarding their capability to execute actions necessary to achieve designated outcomes	• I am confident that I can learn the basic concepts well of this work. • I am confident that I can finish this work well.
Acceptance of the technology or learning approach	To better understand the students' perceptions of tablet-based laboratory learning approach, the students' ratings for the ''perceived usefulness,'' and ''perceived ease of use''	Perceived Usefulness • The learning mechanisms provided by the learning system smoothed the learning process. • The learning approach is more useful than the conventional computer-assisted learning approaches. Perceived Ease of use

		● I felt that the interface of the learning system was easy to use. ● To sum up, the learning system adopted in this learning activity was easy to learn and use.

4.4 Data collection and Analysis

Figure 6 shows the procedure of the experiment. Before the learning activity, the students took the pre-test questionnaire. During the learning activity, stage 1 teacher provide inquiry question ‘‘what will happen if we measure rate of CO_2 and O_2 from plans now?’’ that students predict graph of result on activity sheet in each group (15 minutes). Then stage 2, students observe in field site by material learning (Vernier laboratory). The result will be show on tablet in each group inside classroom (30 minutes). Stage 3 student discuss in their group, compare the result of prediction and observation and explain (30 minutes)

After the learning activity, the students took the post-test questionnaire for comparing the pretest and the improvements learning.

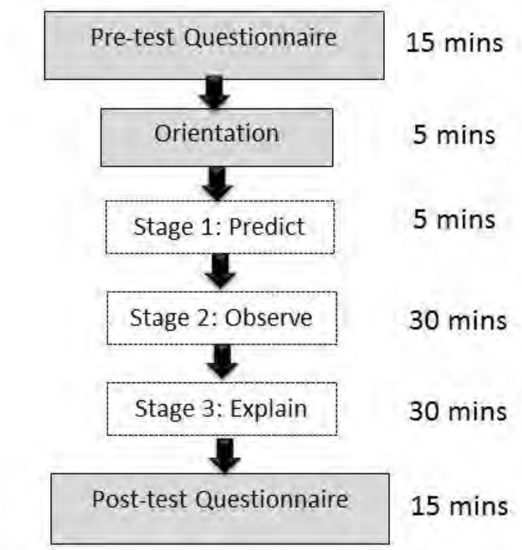

Figure 6. Diagram of experiment design.

The statistical data analysis techniques selected for this study were pair sample t-test. When there are measurement and nominal variables. The paired t-test in SPSS is used to compare the values of means from two related samples in a before and after learning.

5. Results and Discussion

In order to explore effects of the sensor-based laboratory learning environment incorporated predict-observe-explain (POE) for biology learning of photosynthesis, Table 2 shows results on students' self-efficacy, perceived usefulness, and perceived ease of use.

Table 2. Statistical results of paired t-test on students' perception scores.

Variable		N	Mean	SD	t
Self-efficacy	Pre-test	44	27.41	.555	2.846*
	Post-test	44	29.80	.665	

Perceived usefulness	Pre-test	44	21.93	.358	1.335
	Post-test	44	22.75	.512	
Perceived ease of use	Pre-test	44	23.68	.426	4.310*
	Post-test	44	26.39	.535	

*$p < 0.05$

The results show that student' self-efficacy and perceived ease of use delivered in the context-aware u-learning were statistically significant difference between pretest and posttest (t = 2.846, p<0.05 and t = 4.310, p<0.05, respectively). The result indicated also that the students' perceptions on self-efficacy and perceived ease of use showed significant improvement after participating with the context-aware u-learning. These means that learning with the sensor-based laboratory learning in biology, incorporated with predict-observe-explain (POE) pedagogy was not difficult and they were able to perform the investigation of plant photosynthesis with peers to accomplish the predetermined learning task in biology class. The result is consistent with the research findings that students with a strong sense of efficacy are more likely to challenge themselves with difficult tasks and be intrinsically motivated (Margolis and McCabe, 2006). In an addition, this finding consistent with Shih, Chuang and Hwang (2010), which reports that students felt more liberating and relaxing than learning in the classroom with the inquiry-based learning experience in field trip. Also, Hwang, Yang and Wang (2013) reported that students showed positive feedback after participating with the context-aware u-learning. However, the result indicated that there was no significant difference on students' perceived usefulness between pretest and posttest (t = 1.335, p<0.05). This result expressed that the students did not perceived the usefulness of the sensor-based laboratory learning incorporated with predict-observe-explain (POE) pedagogy for their biology learning. The reason might be that they did not familiar with the use of tablet technology in science learning and never use sensor-based laboratory learning for doing science before. Therefore, they might have no idea how this kind of learning environment would be benefits to them. According with Hwang, Tsai and Yang, (2008) descript that there are several levels of individualized guidance, to support learning with a context-aware u-learning environment, for naive learners, adaptive supports and guidance for real-world operations or observations should be provided for learners who have different backgrounds and experiences.

6. Conclusions

Although ubiquitous learning or context-aware learning environments is still available in Thailand. this paper is an effort to design, develop, and implement context-aware ubiquitous learning experience for biology learning in school science. This study demonstrates how instructions using context-aware ubiquitous learning with a sequential learning process of predict-observe-explain promoted students' perceptions on self-efficacy and perceived ease of use in teaching and learning about photosynthesis of plant phenomena. The results suggested that student can perform science investigation with sensor-based learning technology effectively. However, to promote students' perceived usefulness of the ubiquitous learning experience, the intervention in this study may need a revise to contribute fostering their perception of usefulness following Tsai, Tsai and Hwang (2011), which explored students' conceptions of context-aware ubiquitous learning and they found that students perceived the learning environment as followings: application of technology in the learning process; a convenient way to attain information to achieve their goals; a timely guide to apply the mobile devices to provide directions for learning; increase of knowledge; and a way of allowing them to engage in inquiry practices, such as allowing open-ended exploration for the learning topic.

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