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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.

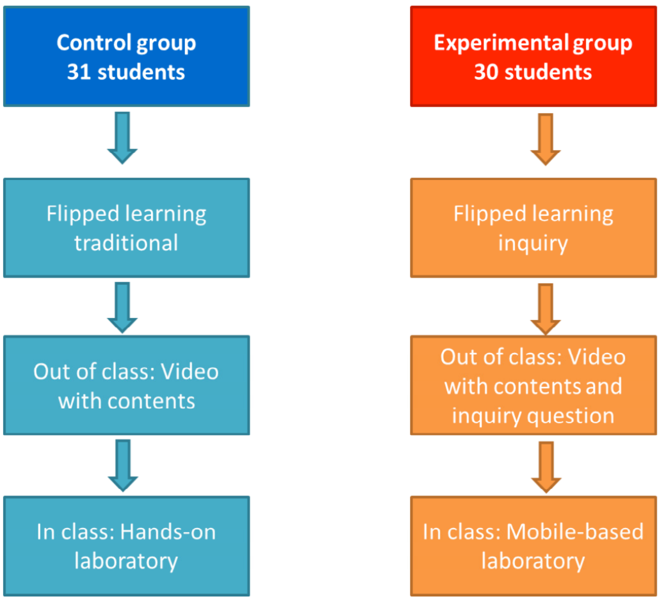


Figure 1. Diagram of participants and learning environment

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.

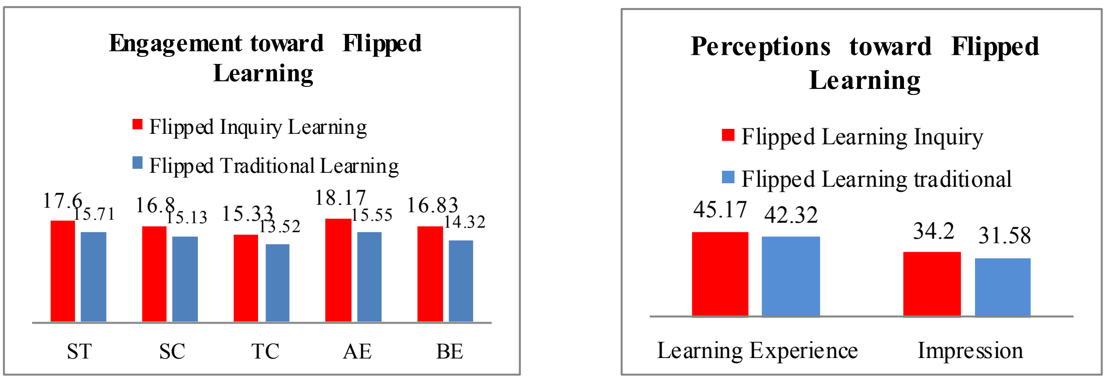


Figure 3. Illustrated arithmetic mean graphics of students’ engagement (Left) and perceptions (Right) toward Flipped Learning

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.

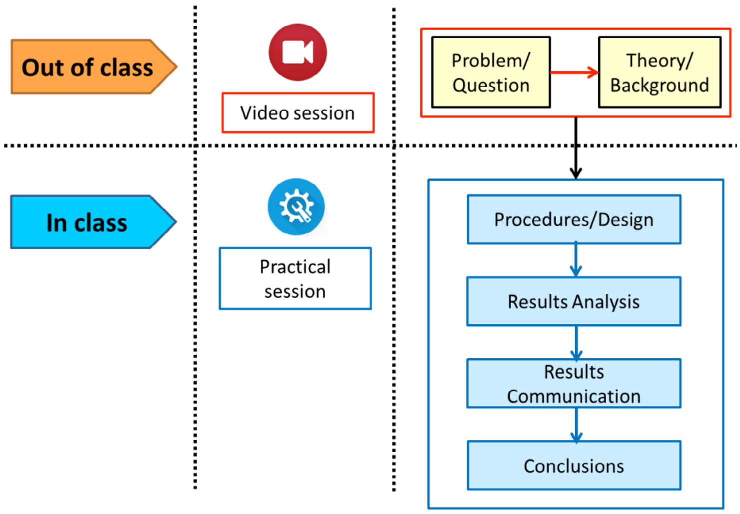
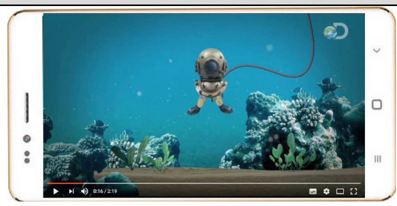
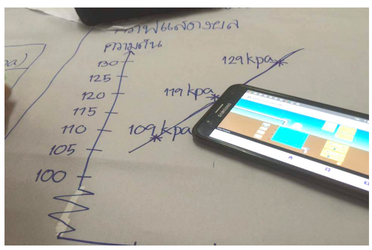


Figure 4. The Flipped Learning with Open Inquiry adapted from Buck et al. (2008)

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	• 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.	
1.Problem/Question		
2. Theory/Background		
Learning material: Virtual mobile –based experimentation		
In Class	• 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.	
3. Procedure/Design		
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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