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A Flipped Classroom Model with Gamified Inquiry-based Process-Concept Relationship

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Abstract: In recent years, flipped learning has received increasing emphasis because of its impact on learning enhancement. Nowadays, gamification plays an important role in promoting students' motivation and attitude toward learning. A gamified flipped inquiry-oriented laboratory learning is proposed for promoting students' science learning performance in this study. To examine the effectiveness of the proposed approach, an experiment was conducted in physics learning activity of a secondary school. The participants were two classes of 62 tenth graders, and they were assigned into one experimental group and one control group. Those learning in the experimental group used the proposed learning mode, while those in the control group learned with the conventional learning mode. The results indicated that the integration of gamification into flipped inquiry-oriented laboratory learning produced a better progression of students' understanding of scientific concepts and process than without gamification. However, there was no significant difference on science motivation between students who learned through the proposed learning mode and who learned through the conventional learning mode. This finding suggests that the gamified flipped inquiry-oriented laboratory learning can be used to effectively support construction of comprehensive understanding of both science concepts and processes in the natural setting of school science learning.

Keywords: Gamification, flipped learning, inquiry-based learning, scientific understanding, science motivation

1. Introduction

Concept of applying game elements to increase the attracting non-game context process called gamification (Deterding et al., 2011). Gamification can be motivated the audiences to manipulate the challenge missions with game elements. Furthermore, an interesting application of gamification is it can be modified and applied in several knowledge areas include Education, Entertainment, Health, Business, and Marketing (Muangsrinoon & Boonbrahm, 2019). Moreover, many researchers studied the impact of gamification in numerous areas. Johnson et al. (2016) studied the impact of gamification on health, the results indicated that gamification had the positive impact on health behavior. In addition, Dicheva et al. (2015) suggested that research should be more seriously study the affectation of gamification on motivation to the audiences.

In education, one highlight of the emerging technologies is flipped classroom, it can be a standard of teaching and learning to promote student's learning (Hamdan et al., 2013), flipped classroom was created and introduced in 2007 by two chemistry teachers Bergmann and Sams (Tucker, 2012). For this learning pedagogical method, it will be available possibilities choice for contemporary instruction method, and flipped classroom is a trend that is currently popular in education (O'Flaherty & Phillips, 2015). The main idea of this instruction is based on students leaning by themselves (Sams & Bergmann, 2013). Flipped classroom was separated in to two sessions of classroom; Out-class and In-class parts. Out-class, students need to study the contents that will learn in class by themselves through lecture video watching before attending class (Zainuddin, 2018). In-class part, students will learn with new things as an interactive activity which regarding with the contents in an out-class video (Keengwe et al., 2014). Since, flipped classroom has received several researches attention, Berrett

(2012) resulted that conceptual understanding, thinking process, and self-directed learning were increased by the flipped classroom.

From previous study, we found that most of students were classified in incomplete conception and misconception in concept of energy consisting of six concepts of energy; kinetic energy, spring potential energy, gravitational potential energy, energy principle, transformation of energy, and conservation of energy (Panomrerngsak & Srisawasdi, 2018). Therefore, this research mixed gamification with flipped classroom we defined as Gamified Flipped-classroom to eliminate incomplete conception and misconception in these above energy concepts except energy principle, and to improve student's Pro-Cept of energy. In this study, two terminologies "gamified flipped learning and gamified flipped inquiry-based classroom" are not strictly distinguished. The research questions were addressed: Do the students who learn with gamified flipped inquiry-based classroom improve Pro-Cept of energy than those who learn with traditional flipped classroom? Do the students who learn with gamified flipped inquiry-based classroom approach have science motivation and perception better than those who learn with traditional flipped classroom?

2. Literature review

2.1 Foundation of Pro-Cept and Relevant Study

Pro-Cept is a conceptual framework to combine concept and process. To make we are on the same page, we will clearly discuss more about concept and process definitions in this work. Concept is important conclusions, ideas or fact that illustrates the important common characteristics of various factors from the concept group (Termtachatipongsa, 2007). Furthermore, we discussed to distinguish two terms of process and procedure to realize what actually process is. Process is using in the common sense of addition, deletion, multiplication, and division (Gray & Tall, 1994). Vice versa, procedure refers to implementation of process or procedure carry out the process to solve an equation (Davis, 1983). Thus, in this study process is not same as procedure. For a relevant study, Gray & Tall (1994) claimed that successful mathematicians use mental structure that merge together between concept and process which is called Pro-Cept.

2.2 Flipped Classroom and Gamification

The design of instruction is extremely significant to students or learners. Flipped-classroom is a choice of teaching activity or pedagogy which is rapidly spread around the world and becomes trend in current (Mzoughi, 2014). In addition, four reasons that support flipped classroom were proposed by Hwang et al. (2015). First of all, limitations of learning from time and space were eliminated by technology, for example students can learn anywhere and anytime from multimedia which teacher provides before come to class. Secondly, this pedagogy gave students prepare themselves to have prior knowledge. Third, from the second reason if students have prior knowledge, they could achieve higher level learning. The last one is gap between teachers and students will closer due to interactive activities in classroom, these activities will make pleasant atmosphere to classroom, it is probably increase students' learning motivation. There are numerous positive educational researches about Flipped classroom, Chaipidech & Srisawasdi (2016) found that students who have learned with the mobile flipped inquiry learning have better perceptions and engagements than students who have not learned with the same method. Chaipidech & Srisawasdi (2017) showed that learning performance of students who have learned with flipped-inquiry based was better than students who have learned with traditional method and hand-on open inquiry. Vice versa, there are researches also reported negative results from flipped classroom, Boevé et al. (2017) reported there are no learning behavior difference between students from flipped classroom and a non-flipped-classroom. Tse et al. (2017) published that students in the flipped class have lower motivation than students in the traditional class for reading subject. From abovementioned researches, Zainuddin (2018) increased performance of this pedagogical method by merging flipped classroom with gamification concept that is called gamified flipped-class. His results reveal that the gamified flipped-class made students have better motivation and engagement. Gamification is the process that uses game elements to motivate audiences (Zichermann & Cunningham, 2011).

3. Methods

3.1 Participants

The participants of this work were separated into two groups. There were 32 students for experimental group, who learn with gamified flipped classroom, and the other group was control group include 30 students, who learn with traditional flipped classroom; both of two groups were tenth-grade students who had age about 15 to 16 years old. The participants were selected from students who had attended an additional physics in an extra-large public school in Kalasin province, Thailand.

3.2 Research Instrument

There were two types of instruments in this work. The first one was the Pro-Cept test of energy concept, Energy Concept Assessment (ECA) that is developed by Lin Ding (Ding, 2007) and Energy Concept Inventory (Swackhamer, 2003) were modified that from one tier multiple choices to two-tier and translated them to Thai version. We used only 10 items that regarding five main concepts of energy: kinetic energy, gravitational potential energy, spring potential energy, energy transformation, and conservation of energy. We had got the reliability of our test that is 0.708. The second one was the science motivation and perception questionnaires toward learning approaches that are likert scale, Science motivation validated by Glynn et al. (2011) consisting of 25 items, included the following scales, each with 5 items: intrinsic motivation, self-determination, self-efficacy, career motivation, and grade motivation. Science motivation developed by Peng et al. (2009) comprises 21 items, includes two parts, learning experience (12 items) and overall impression (9 items), respectively. Both of them were transforming to Thai language. We recruited one expert to verify communication validity of the test.

3.3 Data Collection and Analysis

The activity implementation had procedure as follow; all participants had to complete the entire test before starting learning activities. Then, students learning toward four activities, kinetic energy, gravitational potential energy, spring potential energy, and energy transformation and conservation of energy were merged into one activity, each with 100 minutes. After that, students had to complete the entire test as the post-test. Thus, the total duration of the research process is about three weeks included pre-test and pro-test (teach twice a week). In order to answer the research questions, One-way Multivariate Analysis of Variance (MANOVA) was conducted to compare two groups of students in term of perception. In addition, multivariate analysis of covariance (MANCOVA) was used to determine the science motivation between experimental group and traditional control group. We used Mann-Whitney U test to investigate students' Pro-Cept.

3.4 Learning Materials and Activity

3.4.1 Traditional Flipped-classroom for Control Group

For traditional flipped-classroom, the conventional lecture is frequently changed to be in the form of a video (Sams & Bergmann, 2013). Students are obliged to watch video-recorded for understanding contents before attending class and learning through activity in classroom (Zainuddin, 2018). Therefore, we designed traditional flipped-class learning process for control group as followed these steps; first of all, students interacted with lecture video that teacher provided before attending class, which video we retrieved and modified from OPTCHELP.com, these videos were created from the cooperation of a regular teacher and Ministry of Education of Thailand. Next, this is a practical session or in-class students handed on traditional laboratory regarding with content in video. For in-class, teachers had prepared all major laboratory equipment for students. After students finished laboratory, the teacher explained, discussed, and concluded about content and consistency between laboratory and content, as shown in Figure 1.

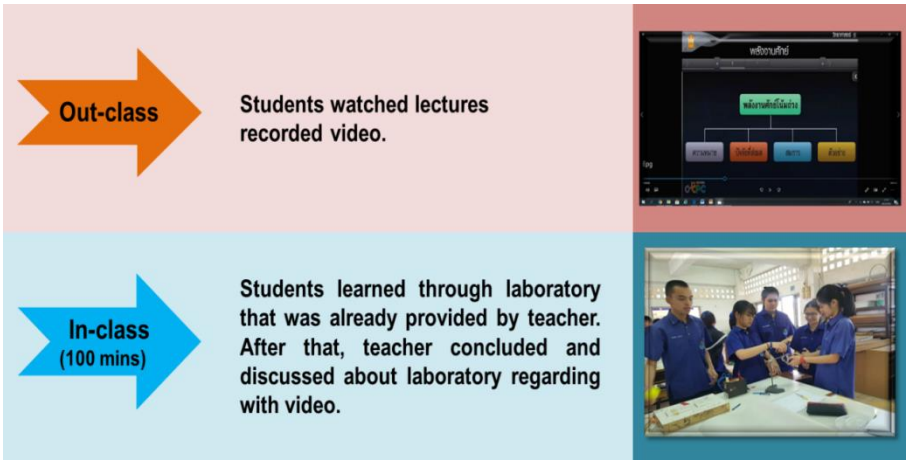

Figure 1. Implementation of traditional flipped classroom.

3.4.2 Gamified Flipped-class Inquiry Learning for Experimental Group

Inquiry teaching is a crucial pedagogy for science (Chaipidech & Srisawasdi, 2016), thus in this work we followed inquiry process according to Buck et al. (2008), there were six characteristics for undergraduate laboratory; (1) Problem/Question, (2) Background/Theory, (3) Procedure/Design, (4) Results Analysis, (5) Results communication, and (6) Conclusions. We used opened-inquiry to design our gamified flipped-class inquiry classroom; question and theory were provided but the others one was not provided to students. We inserted game mechanic into the learning activities. Game mechanic or game elements in this work consisted of badges, leaderboards, points, and team components from a total of fifteen game element terms (Werbach & Hunter, 2012). For abovementioned, in out-class session, we constructed interactive video including inquiry question and theory about energy, the video was filled with elements of game. Figure 2 illustrated an example of an interactive video screen, in the screen had two choices and timer to motivate player for responsiveness and concentrate with the video. Moreover, each responsiveness will affect the score and the next scene, each scene is related to the physical phenomena resulting from the relevant variables. In addition, in-class session, first students bought the equipment for laboratory that they thought that are necessary buy using points from the video instead of money. Then, students in each group helped each other to design experiment or laboratory for answering inquiry question in the video. To made the classroom more fun in the game activity, we made classroom life by input agitated cards into class, such as adding scored cards, deleting scored cards, stop working cards, and listen to music cards. In the procedure, a group volunteer randomly selected a card then followed the commands on the card. In every process teacher gave students group score for group progression, these scores had shown real time on board in front of classroom. If any group of students received the most points, they will obtain special privileges to arrange of the experimental presentation of each group. Then, the inquiry question was answered by students with a teacher who was an assistant. After class, students assessed their own learning and understanding by using student response system called poll everywhere.

Figure 2. An interactive video screen example.

4. Results and Discussion

4.1 Students' Pro-Cept of Energy Concepts

To investigate the influence of two instructions on students' Pro-Cept, Mann-Whitney U test was used as statistical data analysis technique to compared progressive score (different score between pre-test and post-test) of two groups. Results of Mann-Whitney U test indicated that there were significantly differences between experimental and control groups in two concepts; spring potential energy and conservation of energy, Z (n = 62) = -3.357; p = 0.001 and Z (n = 62) = -3.577; p < 0.001, respectively. Although, there were no significant difference between both groups in three concepts include kinetic energy, Z (n = 62) = -1.642; p = 0.113, gravitational potential energy, Z (n = 62) = -1.537; p = 0.113, and transformation of energy, Z (n = 62) = -1.026; p = 0.355. The Mann-Whitney U test results are summarized in Table 1.

Table 1

Mann-Whitney U test results for the progressive score of experimental and control groups

Subscale	Groups	N	Mean	Mean Rank	U	Z	Sig
kinetic energy	Control	30	1.00	27.77	368.00	-1.642	0.113
	Experimental	32	1.59	35.00			
spring potential energy	Control	30	0.70	23.68	245.50	-3.357	**0.001****
	Experimental	32	2.06	38.83			
gravitational potential energy	Control	30	1.43	27.97	374.00	-1.537	0.113
	Experimental	32	1.97	34.81			
conservation of energy	Control	30	0.67	23.23	232.00	-3.577	**0.000****
	Experimental	32	1.97	39.25			
transformation of energy	Control	30	1.47	33.87	409.00	-1.026	0.355
	Experimental	32	1.19	29.28			

Note. **p <.01

Moreover, we fabricated a rubric scoring for interpreting students' Pro-Cept of energy concepts, at two presentation levels; concept and process levels. For each concept and process, (+) symbol was present the status of scientific concept or process, in the other hand, alternative concept or process was represented by (-) symbol. A (0) symbol (zero point) was used for either no responsible or no reasonable to indicate no conception. Thus, maximum scores of each level was equal to ten, likewise, minimum scores of each level was equal to ten. After that, we plotted mean center and standard deviational ellipse of students' score to clearly illustrate the increase of students' Pro-Cept in Figure 3. We assign x axis as concept and y axis as process of energy concepts. Moreover, we invited five first year master degree students of Khon Kaen university in department of physics to participant this study as expert. Visually, Figure 3 showed that both of two groups have different prior Pro-Cept, control group was in scientific process but alternative concept, experimental group was in both alternative concept and process. However, control group and experimental group were in scientific concept and process after their action with instructions. This means both instructions of gamified flipped classroom and traditional flipped classroom effectively encouraged to eliminated alternative concept and process of students and increased students' scientific concept and process. In addition, results presented all students in experimental group cannot reach to expert levels, while a few students in control group can reach to expert levels. However, Zainuddin (2018), he founded the students' post-test indicated that students' learning performance scores in the gamified flipped class were higher than that of students in the non-gamified flipped class. In addition, Chaipidech & Srisawasdi (2017) showed that students'

learning performance on liquid pressure was superior in the flipped inquiry-based learning with mobility as compared to hands-on inquiry-based learning and traditional learning.

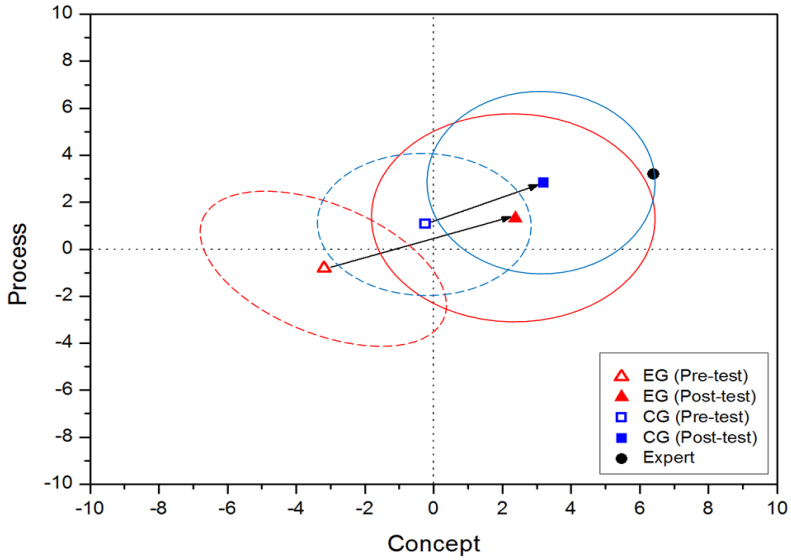

Figure 3. Mean center (MC) and Standard deviational ellipse (SDE) of Experimental group and Control group in Students' Pro-Cept compared with expert).

4.2 Students' Science Motivation and Perception toward learning strategies

In this subsection separated into two parts; science motivation and perception. First, one-way multivariate analysis of covariance (MANCOVA) was conducted to explore students' science motivation for experimental group and control group. The results indicated that there was no significantly difference in science motivation between experimental group and control group (Wilks' Lambda = 0.903, $F(5,52) = 1.114$, $p = 0.364$, partial $\eta^2 = 0.097$) after intervention. The results in each component of science motivation are summarized in Table 2. The MANCOVA results displayed a no significant effect on IM, CM, SDT, SEC, and GM. This implied that both flipped classrooms have the same effect on science motivation. These results make this study noteworthy because of small among of teachers actually use gamification in their classes, although gamification is interested by numerous academic reports. This research demonstrated that using gamification in courses does not decrease students' science motivation, nonetheless students' science motivation who learn with gamification instruction is approximately equal to students' science motivation who learn with regular instruction. Second part, perception was investigated by one-way multivariate analysis of variance (MANOVA) the results for one-way MANOVA showed that there was no significantly difference in perception for both groups (Wilks' Lambda = 0.959, $F(2,59) = 1.267$, $p = 0.289$, partial $\eta^2 = 0.041$) after intervention. MANOVA results for students' perception in two groups are illustrated in Table 3. Consider to subscales of students' perception; learning experiences and overall impressions both of them were no significantly difference in each subscale. In this subsection, according to these results, students' science motivation and perception of experimental group and control group were no significantly difference. From MANCOVA and MANOVA results notice that the mean of science motivation and perception in both groups were in favorable criteria (average mean was four out of five of Likert scale) Therefore, gamified flipped classroom and traditional flipped classroom effectively encouraged to enhance science motivation and perception. Accordingly, González-Gómez et al. (2016) showed that most students had a favorable perception about the flipped classroom as well as increased individualized learning. Jeong et al. (2016) displayed that the students have the overall positive perceptions to a flipped classroom pedagogy. There were no significantly difference in both science motivation and perception due to all participants were classified into high achiever students from school criteria, they were classified in the group of Gifted students. Likupe & Mwale (2016) proposed that students attribute success and failure to many components such as ability, effort, task difficulty and luck, and they found that high achievers attributed their success and failure mostly to effort and ability. This means high achievers can learn well

in all pedagogies of teaching and learning because they have effort and ability for learning to their success. Thus, this is a hypothesis which suggest that why there were no significantly difference in both science motivation and perception in control group and experimental group.

Table 2

MANCOVA results of students' science motivation

Subscale	Groups		F	df	Sig.	η^2
	Control	Experimental				
Covariate	19.01		0.950	5, 52	0.457	0.084
Intrinsic Motivation (IM)	19.14 (0.47)	19.62 (0.44)	0.489	1, 56	0.487	0.009
Self-Determination (SDT)	17.74 (0.37)	18.15 (0.35)	0.781	1, 56	0.381	0.014
Self-Efficacy (SEC)	16.27 (0.58)	14.94 (0.55)	0.649	1, 56	0.424	0.011
Career Motivation (CM)	20.69 (0.64)	19.61 (0.61)	1.434	1, 56	0.236	0.025
Grade Motivation (GM)	19.92 (0.40)	20.12 (0.38)	0.098	1, 56	0.755	0.002

Note. Pre-test of Career Motivation was entered as a Covariate,

Table 3

MANOVA results for students' perception in two groups

Subscale	Groups		F	Sig.	η^2
	Control	Experimental			
Learning Experiences	43.78 (5.59)	45.66 (5.88)	1.659	0.203	0.27
Overall Impressions	32.92 (4.15)	34.61 (4.38)	2.457	0.122	0.39

5. Results and Discussion

This research, gamified flipped classroom was constructed by combining together of gamification, technology, and flipped classroom. The research aimed to investigate students' learning performance and attitude in the gamified flipped classroom, comparing the results with traditional flipped classroom. The finding of this study demonstrated two noteworthy key points for integrating of gamification, technology, and flipped classroom. First, there were three concepts of energy have no significant difference between progressive score of experimental group and control group. In contrast, the other two concepts were significant difference in term of progressive score. This significantly means the students who learn with gamified flipped inquiry-based classroom do not improve Pro-Cept of energy than those who learn with traditional flipped classroom. Second, students in both groups had no significant difference on science motivation and perception. This means the students who learn with

gamified flipped inquiry-based classroom approach do not have science motivation and perception better than those who learn with traditional flipped classroom. From this study, perhaps the significant implication was: based on research results, the researcher believed that the use of gamification and technology to integrate with learning strategy does not negatively affect the students' learning performance and attitude. Conversely, this integration of these had similar impact as traditional flipped classroom. Therefore, this research suggested the challenge to develop this instruction for making students have progressive learning performance and attitude than traditional flipped classroom.

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