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Effects of Gender Differences and Learning Performance within Residence Energy Saving Game-based Inquiry Playing

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Abstract: Energy Saving in Residence is one of the important topics in Energy Education, whereby students are required to understand the factors of energy consumption and conservation. Several researchers have studied on how to use digital games to improve understand the topic. However, not every student understands is improved by using these kinds of learning assistance. Therefore, a study on effect of gender differences and learning performance within energy saving games have become a need to address the issue. This paper has attempted to develop a digital game based on inquiry-based learning called Residence Energy Saving Battle (RES-battle). Further, the paper examines the effect of gender difference in students' learning performance and the attitude towards the RES-battle. The result shows that students' learning performances on energy consumption and conservation that significantly improved after they participated in the RES-battle. The result also revealed that the RES-battle can decrease the difference between female and male learning performances reasonably and attitude toward the RES-battle. From the findings, this paper has implication for the development of students' residence energy consumption learning within the digital game.

Keywords: Game-based learning, pedagogy, gender study, energy education

1. Introduction

Electricity, a one of longest-used demand, is widely used for lighting or heating purposes and to make electrical equipment works. Due to widespread use, most of consumers are careless in its management. The amount of electrical energy usage occurs not only from residence budget and size but also from residents' behavior in using electrical equipment (Moll, Noorman, Kok, Engström, Throne-Holst, and Clark, 2005). In the past decade, several researchers attempted to provide the way to decrease the electricity usage in each residence. For example, Abrahamse, Steg, Vlek, and Rothengatter (2005) focused on altering the residents' behavior in the use of electrical equipment in appropriate way. Maharaj-Sharma (2012) suggested that student energy learning is need to apply and link to outside school and daily life. Consequently, learning about energy consumption and conservation in school science has become important in current research.

Although energy consumption and conservation is one of important physics concept in school science. Generally, this topic is a part of physics teaching and learning about electricity. In the conventional physics class, student learned electricity as attribute of electronic and consumption and conservation of energy in a form of employed energy calculation, but not as procedures as it is recognized in contemporary physics. As such, it is an instructional challenge to motivate student learning the concept meaningfully. Several methods and strategies have been used to make the concept of energy consumption and conservation more meaningful for understanding to the students and for encouraging them linking the concept to daily life. For example, Chiu, Chou, and Liu (2002) suggested that although using analogies or metacognition might help the learning process more permanent, but there is no significant conceptual development by these approaches. Slotta and Chi (2006) recommended that students can insight what concepts from their own understanding. Thus, teaching

students to use electric energy efficiently in their daily life to encourage them to construct conceptual understanding of energy consumption and conservation by themselves might be useful way for saving energy in residence. In other words, digital interactive learning could be a useful way for conceptual learning of energy consumption and conservation and for simulating practices of saving energy in residence.

On the other hand, digital interactive learning is generally developed as multimedia learning units with simulations and games in many disciplines such as in mathematics, science, engineering, humanities, and social sciences (Cai, Lu, Zheng, and Li, 2006; Eck, 2006). Recent research attempted to purpose educational computer game which has advantage in students' habits and interests (Gee, 2006; Prensky, 2007) and indicated that the use of digital game is another useful method to improve energy consumption and conservation learning (Yang, Chien, and Liu, 2012). Playing educational computer game requires prior knowledge or pre-existing learning experience that helps students to apply the knowledge to make decision related to realistic situations (Papastergiou, 2009) and can be considered as a learning tool for teaching the factual information as well as worksheet activities (Spraggins and Rowsey, 1986). Therefore, developing a digital learning of energy consumption and conservation that integrates game-based learning technologies and pedagogy into learning of energy consumption and conservation may be a useful way to improve students' learning performance on the topic. However, the successful usage of pedagogy-driven digital game depends on the digital game, the learning strategies, and human factors. Among various human factors, gender difference play an important role when playing digital game affecting on learning performance (Paraskeva, Mysirlaki, and Papagianni, 2010).

In summary, pedagogy-driven digital game, gender differences, and conceptual learning performance are critical to learning saving energy in residence in which students are required to understand the energy consumption and conservation meaningfully. In this vein, the aim of this study is to examine the effects of gender differences on students' conceptual learning performance when playing the *Residence Energy Saving Battle (RES-battle)* digital game and attitudes toward the RES-battle.

2. Background and Motivation

In Bhutanese education system, science subject is introduced from primary level onwards and when it reaches in higher secondary level it is segregated into three disciplines; namely Physics, Chemistry and Biology. The aim of having this is to make the curriculum more relevant to the need of the society or localization and to bring a shift in the teaching style from teacher centered to learner-centered. However, in many schools in Bhutan teacher-centered instruction is a common practice. Most students in Bhutan lack understanding of concepts and they learn by memorization. Many science teachers feel and our personal experiences from the past has found that the answers that students write in the exams are just regurgitation of what they have learnt by memorization. Any twist or rephrasing of the questions made the students difficult or unable to answer the questions.

In recent years, the education system supplied hundreds of computers all over the nation under the project "Chiphen Rigphel Project" (Information Communication Technology-ICT Project) with grant from government of India. The objective of the project is to equip every student with IT literacy and improve science education. Now the system is stressing more on the practical oriented learning that enable students to acquire the skills that can be applied in the practical context. So, the system has observed that digital learning as one of the ways to achieve that goal. Therefore, there is strong need for teachers to change the instructional practices from teacher centeredness to child-centeredness by practicing effective teaching strategies with integration of digital learning like computer games, animations, simulations, and more, particularly in learning abstract concepts in science curriculum, especially on topic energy consumption and conservation.

Energy education has become very important element to educate students on the basic energy concept on daily electrical energy consumption and conservation. It help students to identify basic factors on which energy consumption depend and provide useful ways for reducing daily energy consumption both in and outside of their home and school. Integrating appropriate learning approaches for teaching the concept is very important for any effective learning process. Thus, introducing the concept of energy education into the ways the students understand is crucial for any educator (Gustafson and Branch, 2002). Moreover, one of effective learning strategies for making students as

active leaner is inquiry-based learning approach (Kubicek, 2005). It requires teachers to provide the opportunity for students to observe, gather, analyze, and interpret data which students learn from their findings, explanation, predictions, and communications with peers, which led students to construct their own conceptual knowledge (Krajcik and Blumenfeld, 2006; Kuhn, Black, Keselman, and Kaplan, 2000).

Therefore, in this study, the inquiry-based learning approach was chosen to drive a digital game-based learning to assist students exploring factors related energy consumption, by simulating using electrical appliances for certain durations led to saving energy in residences. These features of the game might help students to improve conceptual learning performance on the topic of energy consumption and conservation. Moreover, when playing digital game, students' gender difference factors play might effect on their learning performance. Consequently, there is a need to examine how the RES-battle affect students' learning performance, and how gender differences affect students' learning performance of conceptual knowledge on energy consumption and conservation. To this end, this study emphasizes on whether gender differences affect students' learning performance by taking the RES-battle.

3. The Digital Game based on Inquiry-based Learning Approach: Residence Energy Saving Battle (RES-battle)

With the benefit of game-based learning in motivating students learning and inquiry-based learning approach in encouraging students explore and construct conceptual knowledge on energy consumption and conservation, this study developed *Residence Energy Saving Battle (RES-battle)* in which the inquiry-based learning approach drives activities in computer-based game playing. The RES-battle is designed in line with practical situations of energy consumption in our daily life. To save money and minimize energy consumption, these help the students in developing sense of awareness on energy conservation. The procedure of RES-battle is following steps:

- **Step 1:** The objectives of the RES-battle are introduced to the students, such as the students should be able to know how energy consumption is calculated in term of money and also how can they apply those factors in monitoring power bill by playing the RES-battle.
- **Step 2:** The rules and basic functions of the RES-battle are demonstrated to the students, such as the RES-battle is designed with scenarios of home comprising electrical appliances that are commonly operated. It is divided into two different-difficulty levels in which the students can go to the second level by passing the first level. Each level has 30 playing-time second. To get into another level, the students should have enough income/budget earned from current stage. In doing, the students should hunt/collect hidden coins which depend upon wattage of those appliances in that room. The students have to take cautious decisions on selecting/clicking on appliances to get those coins because every time they collect coins, it activates the appliance which consumes energy, and they have to pay at the end.

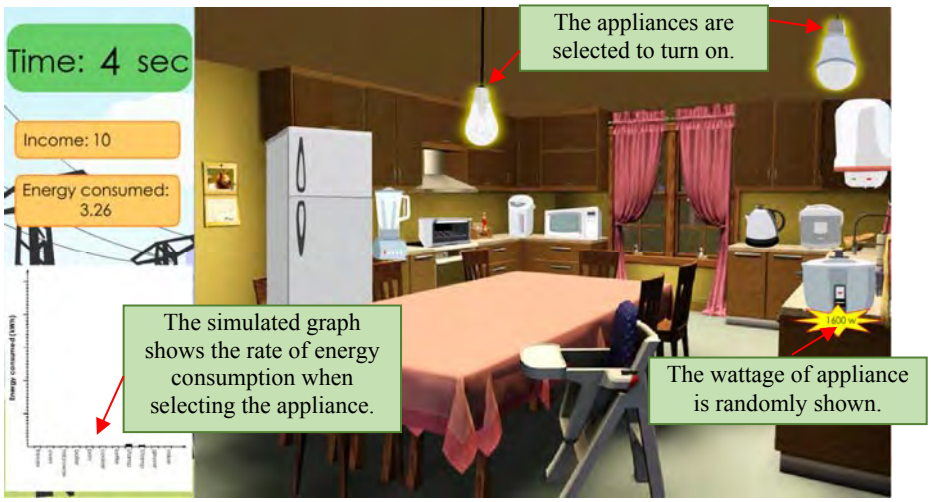

Figure 1. Illustrate playing the Residence Energy Saving Battle (RES-battle) in the first level

- **Step 3:** While playing the RES-battle, whatever coins are accumulated and how much energy has consumed are automatically calculated and displayed in graphical format at the side of the game screen as shown in Figure 1. These help students to apply their theoretical knowledge, skills and strategies to make decisions in their assigned role which promotes the understanding of concept. The wattage of each appliance will be shown randomly at certain interval. The value of hidden coins in each appliance remains constant whether it is chosen at the beginning or at last. In this step, the students are encouraged to inquire factors of energy consumption which are wattage of the appliance and duration of usage.

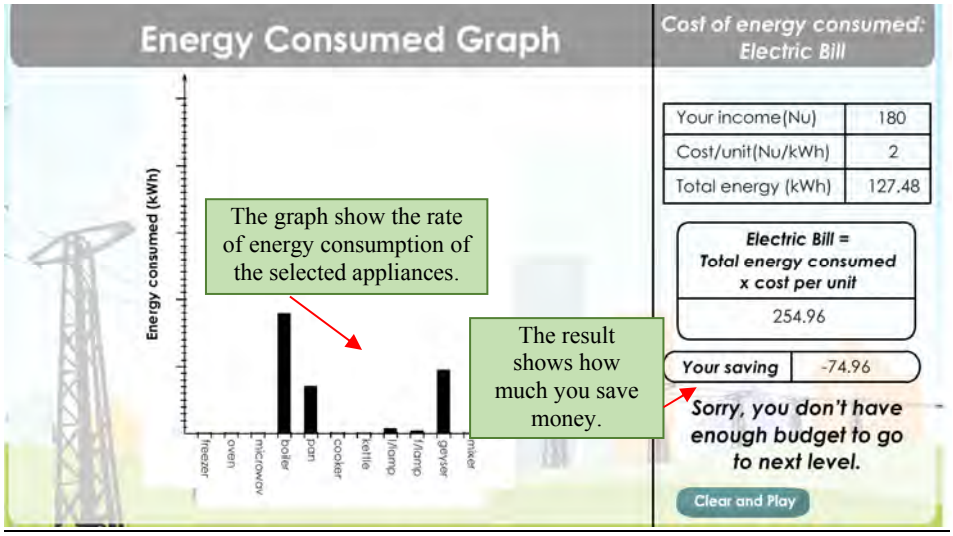

Figure 2. Illustrate results of playing the Residence Energy Saving Battle (RES-battle) in the first level

- **Step 4:** At the end of 30 second, the RES-battle automatically is stopped and displays "Time Up", after that simulated graph for energy consumption will be displayed for those appliances that the students operated during the game as shown in Figure 2. Based on that, cost for energy consumed is calculated and then saving of the students is shown *(your saving = income – cost of energy)*. If the saving is positive, the player can continue the game in the second level with more difficulty as shown in Figure 3, otherwise they cannot go further or can play again as shown in Figure 2.

4. Research Methodology

To investigate the effectiveness of the RES-battle, we investigate whether the RES-battle improve students' learning performance on energy consumption and conservation; result on this will led us to examine whether gender differences affect students' learning performance by taking the RES-battle and whether gender differences affect students' attitudes toward the RES-battle.

This study was designed by one group pre-posttest design. A total of 68 tenth graders of secondary school students in eastern Bhutan were recruited in this study. They participated in the RES-battle individually, and discussed the situations in the RES-battle with their peer to construct their own knowledge of factors of energy consumption and conservation. Before playing in the RES-battle, the students were asked to take pre-conceptual test of the topic. After finishing learning activities on the RES-battle, they were asked to take post-conceptual test. Moreover, they are asked to respond the attitude questionnaire to clarify the degree of their attitude toward the RES-battle.

To examine whether the RES-battle improve students' learning performance on energy consumption and conservation, pre- and post-conceptual tests were used as the research tools. The validity of the tests were determined by three experienced teachers teaching same subject. Each test contained 20 multiple-choice items, and one point was scored for each correct answer; therefore, the total score of the each test was 20.

To investigate students' attitudes toward the RES-battle, the attitude question adopted from Subba (2011) was used in this study. It consisted of 18 items, which were categorized into three categories: interest, participation, and satisfaction. This questionnaire was measuring using a 5-points Likert scale in which for "Interest" and "Participation" category, levels 5 represents for "Strongly agree", 4 for "Agree", 3 for "Neutral", 2 for "Disagree" and 1 for "Strongly disagree"; whereas in "Satisfaction" category, 5 represents for "Extremely Satisfaction", 4 for "High Satisfaction", 3 for "Moderate Satisfaction", 2 for "Low Satisfaction" and 1 for "Least Satisfaction".

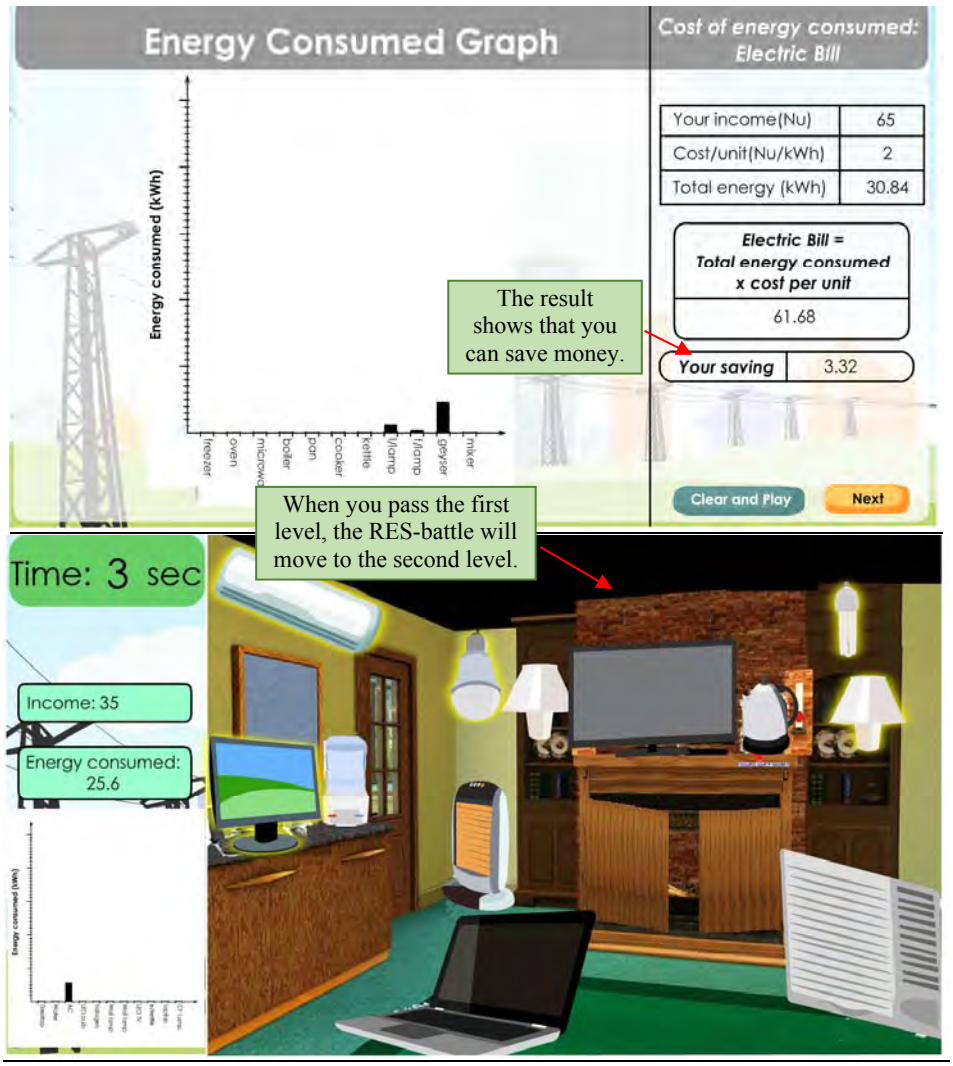

Figure 3. Illustrate success of the first level and move to the second level with more difficulty

5. Results

5.1 Students' conceptual learning performance

5.1.1 Overall conceptual learning performance

Table 1 shows the results of the conceptual test, in term of Mean and Standard Deviation (SD), between pre- and pot-test. The result shows that there was a significant difference between the pre- and post-test on students' conceptual learning of energy consumption and conservation (t = 13.887, p = .000). It indicates that the students performed better in the post-test than in the pre-test; implying that students' conceptual learning were significantly improved after participating in the RES-battle. As shown in Table 1, it seems obviously that the SD in the post-test was little increased from the SD in the pre-test. This result indicates that there is different amount of conceptual knowledge gain after

taking the RES-battle; some student has high gain conceptual knowledge and some student has low gain conceptual knowledge. Thus, another data analysis was conducted to clarify the conceptual knowledge gain in the next section.

Table 1: Conceptual learning performance between pre- and post-test

Test	N	Mean	SD	*t*
Pre-test	68	7.56	2.27	13.887**
Post-test	68	13.35	3.03	

** $p < 0.01$

5.1.2 Conceptual learning progression

To clarify the conceptual knowledge gain of the students after taking the RES-battle, this study employed normalized gain of Hake (1998) which defined the <g> as "High gain, <g> ≥ 0.7", "Medium gain, 0.7 > <g> ≤ 0.3", and "Low gain, <g> < 0.3". From sixty-eight students' conceptual pre- and conceptual post-test scores, the results show that there are 13, 36, and 19 students for high, medium, and low gains respectively. Thus, this results indicates that most of students gains conceptual knowledge of energy consumption and conservation moderately after taking the RES-battle. For overall result, as shown in Table 2, the conceptual score of pre- and post-test, the <g> is 0.47 indicating that the students have conceptual learning progression of their learning by gaining better conceptual knowledge after playing the RES-battle.

Table 2: Conceptual learning progression by the average normalized gain <g>

Conceptual test (Total score = 20)	N	Mean	S.D.
Pre-test	68	7.56	2.27
Post-test	68	13.35	3.03
<g>	0.47		

5.2 Students' attitudes toward the Residence Energy Saving Battle (RES-battle)

Table 3 shows the descriptive statistics of the students' attitude toward the RES-battle. Overall analysis from the questionnaires reveals that the students have rated "High Agree" for the RES-battle for being able to develop interest in learning the concept of energy consumption and conservation in residence. Moreover, the students respond that they were "Highest Agree" towards the RES-battle in which using the inquiry-based learning drives learning activities on the topic. Because the RES-battle encouraged them to explore and construct conceptual knowledge. In addition, the students rated that they have "High Satisfaction" in learning concept of energy consumption and conservation through the RES-battle.

Table 3: Students' attitude degree after taking the RES-battle

Attitude Aspect (N=65)		**Mean**	**SD**	**Interpretation**
Interest	1. I enjoy learning very much with the RES-battle.	4.33	0.63	High Agree
	2. I become more curious and observant in the class when the lesson is integrated with the RES-battle.			
Participation	3. I enjoy participating in class activities when the lessons are taught using the RES-battle.	4.45	0.57	High Agree
	4. The RES-battle make me more attentive in the class.			

Attitude Aspect (N=65)		Mean	SD	Interpretation
	5. Integration of the RES-battle in the lesson promotes better interaction amongst friends and teachers.			
Satisfaction	6. It is easier for me to understand the content with the RES-battle.	4.40	0.42	High Satisfaction
	7. I get learning satisfaction when I learn the lesson with the RES-battle.			
	8. The RES-battle in the lesson helps me to develop confidence in learning electrical energy calculation.			
	9. I found the RES-battle useful in visualizing the concepts.			
	10. The RES-battle in learning helps me to think and analyze the real things in world.			
	11. It helps me to develop the relevance between the course and real world situations.			
	12. The RES-battle allows me to develop skills needed in the real world.			
	13. I like the way the teacher uses the RES-battle to teach energy consumption by various household appliance lesson.			
	14. The use of the RES-battle in the lesson helps me to build confidence in understanding the concept of energy consumption clearly.			
	15. I like the RES-battle in learning electrical energy consumption and conservation sessions because it enables me to learn faster.			
	16. I gain confidence when I learn the lesson using the RES-battle.			
	17. I like electrical energy lessons with the RES-battle because the lessons are interesting, informative and help to visualize the abstract concepts of energy better.			
	18. I like the RES-battle integration in all the subjects to help enhance our critical thinking.			

5.3 Gender Differences

5.3.1 Gender differences in overall conceptual learning performance

Table 4 shows the results of students' conceptual learning performance, in term of mean and Standard Deviation (SD), between females and males for conceptual learning performance. The results of the pre-test and post-test show that there were no significant difference between females and males for their conceptual learning performance. In other words, conceptual learning performance between females and males had no difference in the post-test. It indicates that females and males improved at a faster rate and were not statistically different in the end of the RES-battle.

Table 4: Conceptual learning performance between females and males in the pre- and post-test

Test	Gender	N	Mean	SD	*t*	*p*
Pre-test	Female	38	7.32	2.28	.994	.162
	Male	30	7.87	2.25		
Post-test	Female	38	12.95	2.94	1.249	.108
	Male	30	13.87	3.10		

5.3.2 Gender differences in different sizes of conceptual learning gain

To examine the gender difference for the high, medium, and low gain size of conceptual knowledge, analyzes were undertaken between boys and girls in the pre- and post-test for the three group in different sizes of conceptual learning gain. Table 5 shows the results of these analyzes. The results show that there were no significant difference between females and males in the pre- and post-test of the three gain size groups. These findings reveal that this females and males improved but were not statistically different in the end of the RES-battle.

Table 5: Performance of the high, medium, low gain size between females and males in the pre- and post-test

Size	Test	Gender	N	Mean	SD	*t*	*p*
High	Pre-test	Female	7	5.57	2.99	1.543	.075
		Male	6	8.17	3.06		
	Post-test	Female	7	17.00	.816	1.721	.056
		Male	6	17.67	.516		
Medium	Pre-test	Female	18	7.78	2.102	.156	.438
		Male	18	7.67	2.169		
	Post-test	Female	18	13.61	1.787	.494	.312
		Male	18	13.94	2.235		
Low	Pre-test	Female	13	7.62	1.758	.616	.573
		Male	6	8.17	1.941		
	Post-test	Female	13	9.85	1.068	.023	.491
		Male	6	9.83	1.329		

5.3.3 Gender differences in attitude toward the Residence Energy Saving Battle (RES-battle)

Table 6 shows the results of students' attitude toward the RES-battle, in term of mean and Standard Deviation (SD), between females and males. The results of the three attitude aspects show that there were no significant difference between females and males for their attitude. In other words, attitude toward the RES-battle between females and males were not difference. It indicates that females and males satisfied equally in the end of the RES-battle.

Table 6: Attitudes between females and males after taking the RES-battle

Attitude Aspect	Gender	N	Mean	SD	*t*	*p*
Interest	Female	37	4.38	.57	.655	.256
	Male	29	4.27	.70		
Participation	Female	37	4.50	.55	.748	.223
	Male	29	4.39	.61		
Satisfaction	Female	37	4.33	.40	1.566	.061
	Male	29	4.50	.43		

6. Conclusion and Implications

This study examined the effectiveness of a digital game in which the inquiry-based learning approach drives activities within the game. While playing the game, students were encouraged to explore elements in the game, discuss what they found with their peer, and construct their own knowledge. Although Gee (2007) and Unlusoy, de Haan, Leseman, and van Kruistum (2010) revealed that males interests in digital games is more than females do. But the findings from this study highlighted that there were no difference in the conceptual tests and attitude towards the developed game between females and males. Moreover, when the participants were categorized based on their conceptual knowledge gain size into high, medium, and low gain size, there were also no difference in the

conceptual tests, and attitude toward the developed game between females and males. These findings could imply that the difference between females and males was reduced after taking the developed game. In other words, the developed game enabled the students who gained conceptual knowledge in different size to make significant conceptual learning improvement.

Therefore, to decrease the gap between females and males on conceptual learning performance when using the digital game-based learning, there is a need to develop the game that can provide the opportunities for interaction on game screen and also with other students. The road of game playing needs to accommodate the encoding and decoding of graphics through the game and the elements that promote students inquired evidence for constructing the knowledge.

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