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Using Educational Digital Game to Promote Secondary School Students' Physics Learning Performance in Static Electricity Lessons: A Failure to Learn

Chanvit Junngam[1] and Niwat Srisawasdi[2*]

Science and Technology Education Program, Faculty of Education, Khon Kaen University, Khon Kaen, Thailand[1], Division of Science, Mathematics, and Technology Education, Faculty of Education, Khon Kaen University, Khon Kaen, Thailand[2*]

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Abstract

An important role of educational computer games and pedagogies of game-based learning has been recognized widely in science education research and development. In the context of physics education, very few studies have developed physics learning games and transformed physics concepts into digital games. This research designed an educational digital game for promoting students' learning of the physics concept of static electricity. Moreover, a game-based pedagogy, named student-associate game-based open inquiry (SAGOI), has been used to deliver the physics lesson to 34 eleventh-grade students who had never had a learning experience with the static electricity concept with educational digital games before. In the SAGOI learning process, the student must perform investigative planning and collaboration through an open-inquiry process with the support of a proposed digital game, called Electrilism War game, for 150 minutes. The results showed that the students' post-class conceptual learning scores on static electricity concepts did not significantly increase compared to the pre-class scores. In terms of motivation toward physics, their self-efficacy (SE) in physics learning was significantly higher than before receiving the intervention. However, another four dimensions, i.e., intrinsic motivation (IM), career motivation (CM), self-determination (SD), grade motivation (GM), were not statistically different between pre-and post-test measurements. In addition, the students' learning perceptions were higher than 60 percent, and there was no significant gender difference between female and male perceptions of the intervention. This finding could argue that using educational digital games in school physics education should be carefully considered and implemented for students learning. How to design an educational digital game and apply it with potential pedagogies should be centered for future study regarding the physics concept of static electricity.

Keywords: Digital games, Student-associate game-based open Inquiry, Game-based learning, Conceptual change, Physics concept

*Corresponding author. Tel.: 081 775 9559
Email address: niwsri@kku.ac.th

Introduction

In recent years, everyone has entered the digital age, and digital gaming is a very famous technology for everyone. Digital games consist of bright and beautiful images and sounds alongside textual communication. For digital games, players can get the enjoyment that is both pleasurable and challenging. In addition, digital games comprising elements of challenge, control, curiosity, and fantasy can motivate students' persistence and enjoyment (Toro-Troconis & Partrigde 2010). Educational digital games have been recognized as one model that combines digital technology with traditional instruction, and digital education games keep players immersed in the worlds of digital learning environments. Players who are students can get knowledge, information, and skill in non-traditional education (de Castell, Jenson, & Taylor, 2007). In the context of educational research and development, many studies have used the potential of educational digital games to promote students' attitudes toward learning and increase their learning performance (Srisawasdi & Panjaburee, 2019).

The use of educational digital games in teaching and learning physics could promote students' learning potential. This is an excellent way to learn from the mistakes in the classroom with game playing. Boston (2009) mentioned that learning with digital games stimulates the imagination and creativity of the learner, and it also helps learners feel relaxed and enjoy playing. Besides, this method also promotes distance learning ability and lifelong learning skills in learners (Freitas, 2006). In terms of the principle of learning, digital game-based learning is a type of constructivist-based active learning emerging in this 21st century. Based on teaching and learning research and development, Watson et al. (2011) suggested that using games in the classroom shifts teaching from a teacher-centered to a student-centered learning environment, promoting a student-centered learning mechanism. In terms of game playing, happiness and a positive attitude toward learning with digital games would help students succeed in their studies (Tychsen, Hitchens, & Brolund, 2008). Some research reported that digital games could improve students' learning perception, and gender difference has no effect on their perceptions (Dontrisanor, Srisawasdi & Kanjak, 2015). Meesuk & Srisawasdi (2014) and Nantakaew & Srisawasdi (2014) also reported that digital game-based learning in science could improve students' perception of learning and science motivation. Moreover, learning by playing with digital games shifted knowledge representation styles from verbal descriptions to iconic representations, and this facilitated students' effective learning in a domain of subject-specific area (Greenfield et al., 1994).

According to the above reason, this study aims to develop an educational digital game as a cognitive-oriented inquiry tool to learn the physics concept of static electricity in school science education. An educational digital game regarding the static electricity concepts in physics was developed and aligned to physics learning standards of the Basic Education Core Curriculum of Thailand called Electrilism War game. The game is a two-dimension role-playing game and requires less personal computer power and wireless networking communication. Moreover, the game was used as learning material and a cognitive tool in a game-based pedagogy named student-associate game-based open inquiry (SAGOI) (Meesuk & Srisawasdi, 2014; Nantakaew & Srisawasdi, 2014).

Consequently, this study also investigates the impact of designed digital game-based pedagogy on supporting secondary school students' conceptual improvement in static electricity, their motivation to learn physics, and their perception of learning.

Research Questions

This study was guided by the following research questions:

1. Does educational digital game incorporate into the student-associated game-based open inquiry (SAGOI) approach facilitate secondary school students' better conceptual understanding of the physics concept of static electricity?

2. Does educational digital game incorporated into the SAGOI approach motivate secondary school students' physics learning on static electricity?

3. How did female and male secondary school students perceive the SAGOI approach and an educational digital game of static electricity?

Research Purpose

The primary purpose of this study was the harmonization of an educational computer game and a student-associated game-based open inquiry (SAGOI) approach. In other words, this study applied a process-oriented, inquiry-based active learning approach to a digital physics game. Thus, this study empirically compares secondary school students' conceptual understanding, physics motivation, and learning perception resulting from the SAGOI.

Literature Review

Digital Game-based Learning

In the past, digital games were designed for entertainment purposes, but recently, researchers have adopted the game for educational purposes and used it to study in the classroom (Sorenson & Mayer, 2007; Stone, 2009). The digital game provides excitement, entertainment, and challenge for players while they indulge in the game system explained by rules, which results in a quantifiable outcome (Salen & Zimmerman, 2004). Researchers considered that digital games for educational purposes could positively affect students in both cognitive and affective learning domains. Result: Students get a positive learning attitude and create a learning curve (Giannakos, 2013). Using a game in the classroom can shift teaching from a student-centered learning environment to a teacher-centered environment (Watson, Mong & Harris, 2011). Digital games can challenge the player, but they are not taking any stress. The player can control everything is, not strictly. Moreover, learning with digital games can increase the collaborative process of learning (Gee, 2005; Sung and Hwang, 2013; Wu, Chiou, Kao, Hu, & Huang, 2012).

Nowadays, digital gaming is very famous. Digital games consist of bright and beautiful images and sounds alongside textual communication. Players can get enjoyment which is both pleasurable and challenging. The education digital game keeps players immersed in the worlds of the digital game. Players can get knowledge, information, and skill in the context of non-traditional education (Castell, Jenson, & Taylor, 2007).

Problem-based Gaming

Problem-based gaming focuses on the meaning of a reliable learning task, collaborative learning, and experiential learning. By allowing players to create a hypothesis, problem-based gaming creatively tests their outcome in the game world. The game environment itself is an enormous problem, with smaller causally linked problems embedded in it (Kiili, 2005). In other words, the authenticity of the learning situation and tasks are essential component in facilitating higher-order learning. (Brown, Collin, & Dunguid, 1989). In games, the storyline and the game environment can contextualize the provided problems.

The basic idea is to attach the learning of knowledge and skills to meaningful problem-solving situations encountered in everyday life. In games, the storyline and the game system can contextualize the provided problems. Furthermore, the collaborative nature of problem-solving is highlighted. The situated learning theory helps this view by stressing that education is a context-dependent activity (Brown et al., 1989). This approach encourages the transferability of learned knowledge and skills into practice (Savery & Duffy, 1995).

Student-associated Game-based Open Inquiry

For motivating or engaging students in learning combined in their groups, the learning process is collaborative learning (Kanyapasit & Srisawasdi, 2014). Game-based collaborative education provides players more cooperation and reduces antisocial behavior due to recognizing technology literacy. Game-based is any instructor's methodology to provide the students learning any content in an aspect of the game while exploring and searching for the answer comparable to an inquiry. It encourages students learning, enhances interaction within student groups, and directs students to their goals. The research reported that study results would be better for learning online English to affect players' collaboration and interest than learning English through traditional collaboration (Kuo, Chu, & Huang, 2015). Which is the learning method as focus concerning the cognitive enhancement and constructivist concept of the nature of the science of the pupil (Hofstein & Lunetta, 2004)

The research of Meesuk & Srisawasdi (2014) and Nantakaew & Srisawasdi (2014) used to propose an approach to the learning of student groups through a game-based follow opening inquiry model called "Student-associated Game-based Open Inquiry (SAGOI)." The learning process occurs during the student receives the inquiry questions and scientific background. After that, they must begin playing the game, exploring, observing phenomena, and then answering individually. Besides, they must report the answer and plan collectively for presentation and conclusion when they finish the game.

■ Research Design and Participants

Participant

A university-based secondary education school in the northeastern region of Thailand was used in this study for to study students' learning about the topic of static electricity in a physics course based on the Basic Education Core Curriculum of Thailand. The school implements a technology infrastructure that includes the internet, wireless communication, and personal computers with the support of the public university. A total of 34 eleventh-grade students from one class participated in this study. They do not have prior experience of static electricity and never using digital games in physics learning in the classroom. The same teacher taught the students in the two classes to ensure that the same content was delivered and did not impact the students' outcomes.

Research Instrument

First, there are adapted the instrument from Suma, Sadia, and Pujana (2018), modified from D.P. Maloney et al. (2001) and E. Bilal & M. Erol (2009), which is a test regarding a concept of physics about static electricity, selected only eight items that measure the concept, and then it was translated into the Thai language by the researchers. The test consists of two electric charge items, two electrostatic force items, two electric field items, and two electric potential items, the total score of the tests was eight. The pre- and post-tests were verified by three experienced teachers, and the pre-test aimed to evaluate the students' prior knowledge of the physics concept of static electricity. On the other hand, the post-test aimed to evaluate the students' conceptual understanding after participating in the SAGOI learning activities.

Second, regarding the science motivation questionnaire to investigate motivation from learning experience within the digital game environment, the participant was tested to answer a 25-item survey instrument of Science Motivation Questionnaire II (Glynn et al., 2011). The questionnaire was a Likert scale, including items that presented five motivation factors: Intrinsic Motivation (IM), Career Motivation (CM), Self-determination (SD), Self-efficacy (SE), and Grade Motivation (GM). The participant must answer at both pre-test and post-test on a 5-point scale of agreement varying from "strongly disagree" (1 point) to "strongly agree" (5 points). In this research, the 25-item survey instrument has been translated into Thai language and the 25 Thai language items scored on a five-point Likert scale, in which "5" represents "always," "4" represents “usually,” “3” represents “sometimes,” “2” represents “rarely,” and “1” represents “never.” There are five dimensions of the questions: intrinsic motivation, career motivation, self-determination, self-efficacy, and grade motivation. Intrinsic motivation relies on asks about interesting, curious, relevant, meaningful, and enjoyable learning activity. Career motivation refers to how to get a good job, career promotion, career advantage, use scientific knowledge in one’s career, and related career topics. Self-determination asks how hard it is to learn science, to prepare well, to expend enough effort, to spend time learning, and to use strategies. Self-efficacy refers to earning good scores, feeling confident on tests, gaining knowledge, understanding, and feeling confident to perform scientific tasks. Grade motivation focuses on scoring, high grades, grade concern, grades’ importance, and gaining better grades in chemistry learning. The questionnaire’s internal consistencies of the subscales by Cronbach’s alphas are 0.79, 0.81, 0.81, 0.89, and 0.85, respectively. The Cronbach’s alpha value for the Thai version of the motivation questionnaire is 0.92 (Srisawasdi, 2015), implying good reliability for the survey.

The Final was to pay attention to the perception questionnaire to survey participants' perceptions of being affected by the digital game environment after learning for the first time. The perception questionnaire was promoted by Peng et al. (2009). There are 21 items distributed into two parts: learning experience, 12 items, and overall impression, nine items. Similarly, the participant must choose their agreement on a 5-point scale of agreement varying from "strongly disagree" to "strongly agree" (scored 1 to 5 points). An expert recruited both motivation and perception questionnaires to identify the communication validity of the items.

Instructional Materials

The researcher has developed and designed a digital game combined with the creator as a programmer in this research. The digital game was developed to support the physics conception of static electricity. The name of the digital game is Electrilism War. The digital game focuses on enhancing static electricity's central concept through any phenomena within the digital game. When players start the game, they must role-play by giving a name to a character, whatever they want. The game's story provides the adventure and task, and the problem will appear to assign the mission which the player must do, as display in Figure 1.

Figure 1. An illustration of digital game called "Electrilism War", the scene about the main task to provide the player to challenge

The Electrilism War has offered any component and interface in the digital game to allow the player to control the digital game. The digital game system guides the player when they start the first time. Moreover, the digital game consists of concepts of static electricity. Each concept will be presented at each level to complete a level. For example, in the first level, the player must choose weapons of the same type on the enemy to knock the enemy off the player.

Figure 2 displays the component and interface for a digital game as the player should recognize to defeat an enemy, then complete the digital game. The vital component to realize is health points and the type of electric charge on the weapon because these factors affect adventure and exploration. Another component, also crucial as armor, has affected planning and strategy to defeat an enemy. In addition, the shop serves the player to trade any items for improving themselves.

Figure 2. An illustration of Electilism War describes the component and interface in the digital game which the player must know within the game

Figure 3 shows a mission when the player uses a weapon with the same electric charge as the enemy, attacks the enemy. Defenders will knock the enemy away from the player, which will result in that player not reducing their health points. Then, the player uses a weapon that has an electric charge against the enemy, attacks the enemy, and causes the enemy to be absorbed and hit the player's body, resulting in a decrease in the player's health point. Besides, if the player can defeat the enemy, they will receive money and have a chance to earn cards, which money can be used to buy items that can help players clear the game more efficiently, and collectible cards and collected cards can be used in the third stage.

Figure 3. An illustration of Electilism War displays an event when a player uses the same electric charge weapon against an enemy

Figure 4 shows that the player must find a way to cross another island. Therefore, the player must observe the symbol of the electric charge on each island. Next, a player must select the electric charge symbol in the lower right corner of the screen to display an arrow symbol representing electric field lines. If a player makes the right choice, a player can cross to another island, but the player cannot cross the island if the player chooses incorrectly.

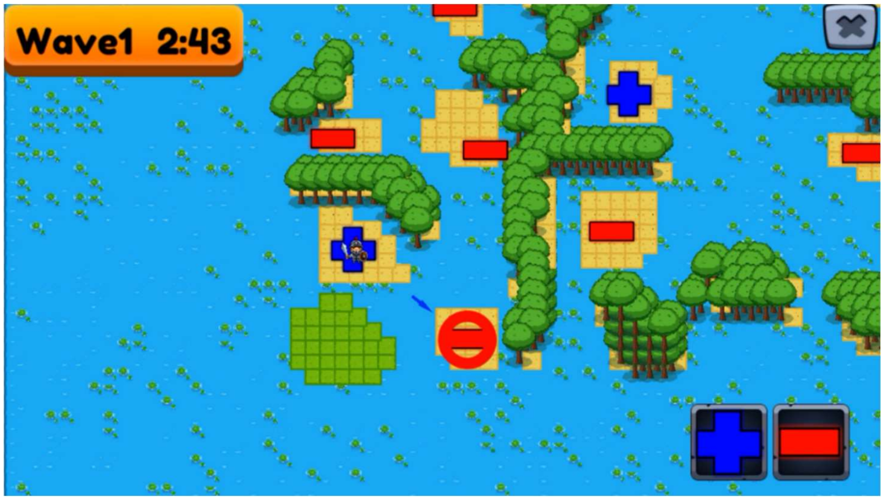

Figure 4. An illustration of Electrilism War in stage 2 in which the player must find a way to cross the island.

In addition, Figure 5 displays that the player decides to use the cards marked with the charge obtained from the first stage according to the path because, in this stage, the player can only choose the direction left or right, the top and bottom directions. It depends on the player's choice of charge cards. Hence, players must observe and find out where in this third stage, the direction of the enemy army based on the game's storyline is to make decisions on their choices. Use a card in which the player's direction of movement up or down represents the electric field, and the player's movement up or down with acceleration represents the electric field.

Figure 5. An illustration of Electilism War in stage three that player must choose a card to show the appropriate electric charge to the electric field

Procedures and Data Analysis

Before the class began, the teacher, who is the first author, provided the participant with 50 minutes to complete the pre-test, divided into two parts, 8-itme static electricity concept test and 25-item physics motivation questionnaire. When completing both, the teacher also guided the participant how to interact with the digital game environment and SAGOI learning process for 30 minutes. After that, took to complete a 21-itmes perception questionnaire, which lasted for 20 minutes. Afterward, over a period of 2 days (a total of 150 minutes), the students learned about the physics concept of static electricity in three lessons. The SAGOI learning activities with the Electrilism War were conducted in regular science classroom in the school. Figure 6 displays students' learning interaction with the SAGOI approach.

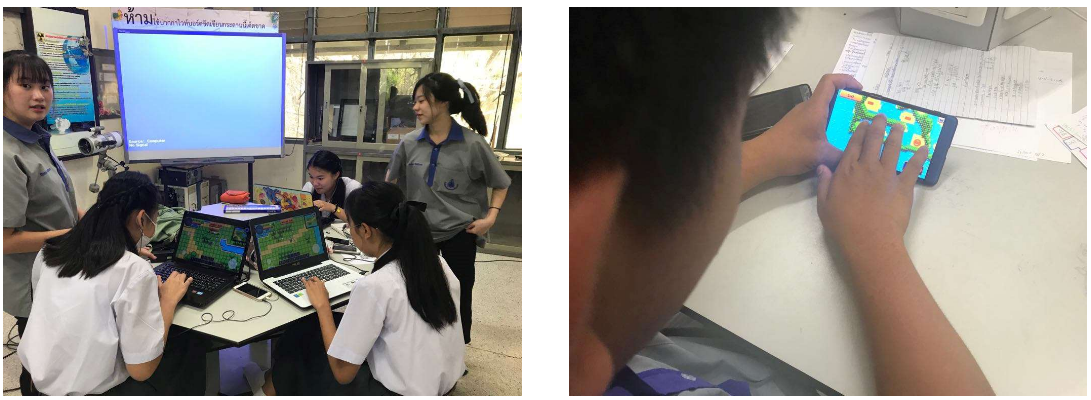

Figure 6. Students' learning interaction with the Electilism War game and in SAGOI approach in regular physics class: learning together in small group through SAGOI (left) and personal interaction with the game (right)

After the class ended, the students took the conceptual post-test to evaluate their conceptual understanding of the static electricity concepts, followed by filling out the post-learning physics motivation questionnaire, which lasted 50 min.

To answer the research questions of this study, Wilcoxon Signed-rank test was used to analyze students' conceptual development. All assumptions were checked, and all analyses were performed in SPSS 21. To compare motivation in learning of physics, the pre- and post-motivation ratings were analyzed with one-way repeated measures MANOVA. Nevertheless, the perception questionnaire differed from the two variables above, and the researcher was analyzed by percentage pattern because incomparable (there are only post-test data) to another variable. Additionally, students' perception was also compared in the dimension of gender difference, which MANOVA analyzed.

Result and Discussion

The results displayed the students' existing conceptions related to static electricity concepts, in table 3 reports the statistic calculation of the Wilcoxon Signed-rank test analysis to compare pre-test and post-test. The analysis indicates that the concept electric charge, electrostatic force, electric field, energy and electric potential was not significant (Z= -1.342, p(pre-post) > 0.05), (Z= -0.258, p(pre-post) <0.05), (Z= -1.528, p(pre-post) > 0.05) and (Z= -1.498, p(pre-post) > 0.05) respectively. In addition, an overall concept also reveals a significant difference in post-test was improved to better than pre-test score (Z= -0.134, p(pre-post) > 0.05). Thus, the statistical analysis results indicate that learning through digital games by the SAGOI technique granted students the concept of developing static electricity with no significant difference in each concept.

Table 1.

Statistical outcomes on Wilcoxon Signed-rank test of the students' conceptual understanding of static electricity

Concept	Test	Mean	Mean Rank	S.D.	Post – Pre-test	N	Z	Sig.
Electric charge	Pre	1.88	3.00	0.17	Post > Pre	1	-1.342	0.180
	Post	1.97	3.00	0.32	Post = Pre	4		
					Post = Pre	29		
					Total	34		
Electrostatic force	Pre	1.24	6.00	0.55	Post > Pre	6	-0.258	0.796
	Post	1.26	7.00	0.61	Post = Pre	6		
					Post = Pre	22		
					Total	34		
Electric field	Pre	0.74	9.00	0.61	Post > Pre	6	-1.528	0.127
	Post	0.94	9.75	0.73	Post = Pre	12		
					Post = Pre	16		
					Total	34		
Energy and Electric Potential	Pre	0.41	6.00	0.55	Post > Pre	5	-1.498	0.134
	Post	0.62	8.33	0.69	Post = Pre	9		
					Post = Pre	20		
					Total	34		

**p = < .05

Table 1 indicated no significant difference between pre-and post-test of conceptual learning. The digital game-based learning approach intervened in a slight increase in the post-test scores, including SAGOI pedagogy. It could be said that the digital learning games, in this research, could not visibly enhance the students' physics conception. However, the observation of this research, which is not similar to other previous research using digital games in learning, is that we should also consider student characteristics and the classroom environment.

In addition, the result of one-way repeated measures MANOVA for comparing motivation in learning physics indicated no significant difference between the pre-physics motivation ratings for the SAGOI learning, except self-efficacy dimension, as shown in Table 2.

Table 2.

Comparisons of subscale mean pre- and post-physics motivation scores on the motivation factors by pre-test and post-test

Subscale	Time		F	Sig.	η^2
	Pre-test	Post-test			
Intrinsic Motivation (IM)	16.38 (3.78)	17.36 (4.65)	0.813	0.371	0.014
Career Motivation (CM)	16.83 (3.93)	18.46 (4.95)	2.231	0.141	0.037
Self-determination (SD)	16.94 (2.98)	17.86 (2.86)	1.473	0.230	0.025
Self-efficacy (SE)	12.66 (3.59)	15.18 (3.80)	4.307	0.042*	0.069
Grade Motivation (GM)	18.41 (2.79)	19.50 (2.39)	1.491	0.227	0.025

*p = < .05

This result indicates that the students were not significantly different in their motivation to learn physics, i.e., intrinsic motivation (IM), career motivation (CM), self-determination (SD), and grade motivation (GM), after participating in the SAGOI learning activities. However, ratings of self-efficacy dimension of students were significantly higher on the post-motivations than on the pre-motivations, (Wilks' lambda = 1.068, F(5,54) = 4.307, p < 0.05, partial h2 = 0.069), as shown in Table 2. This significant difference indicates that the students improved in their self-efficacy in learning physics after interacting with the SAGOI learning approach. This result implied that students were not motivated to learn through digital games. The only dimension that significantly increased was self-efficacy, which is a kind of internal motivation indicating that students have a learning preference for greater confidence in learning through digital games by the SAGOI technique, which helps students communicate and express their thoughts more effectively improve their self-efficacy. Figure 6 displayed the students' physics motivation scores compared between pre-and post-investigation.

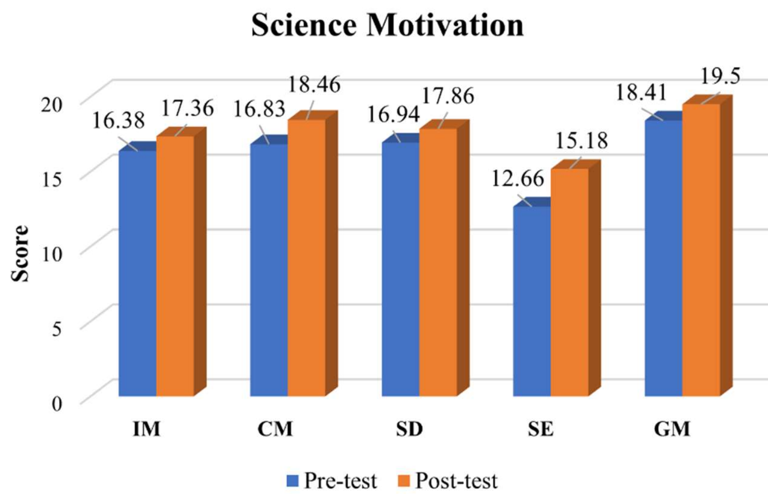

Figure 6. A graphical illustration of the students' science motivation on each measured aspect.

According to Figure 6, the bar graph represents compared information about science motivation in the mean score pattern, as displayed in Table 2. This graph reveals that post-test scores increased slightly in the total dimension. Notice from the height of post-test bar's height was higher than the pre-test bar. It is noteworthy that in the SE dimension of the post-test, more than the pre-test was increased statistically significantly. It shows that the researcher-designed digital games may not yet provide enough incentives in other dimensions. Therefore, the suggestion to develop physics motivation in this research is that digital games should design to be more attractive and focus on designing digital games to be more personally suitable for the learner.

Figure 7 shows a result of students' perception questionnaire percentages regarding their learning experience and overall impression. It was found that after participating in the SAGOI learning activities, the students perceived positively (greater than 65 percent) to their learning experience with SAGOI and overall impression to their interaction with the proposed digital game and learning approach.

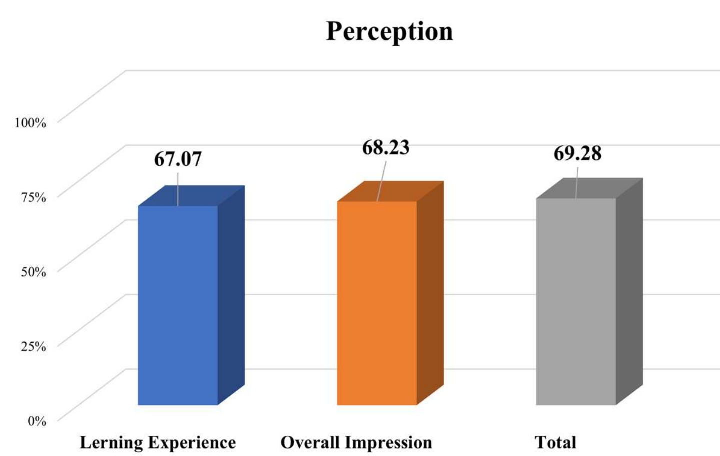

Figure 7. Distribution of percentage students' perception as divide in three parts, learning experience, overall impression and total.

For more details, gender effect based on students' learning perception was also examined, as displayed in Figure 8 and Table 3. Figure 8 compares students' perception scores between females and males after they interacted with the SAGOI learning activities.

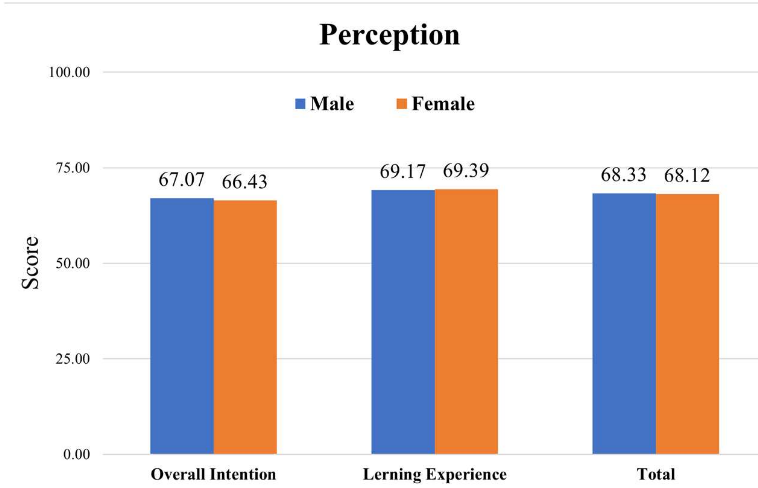

Figure 8. A graphical illustration of the percentage of students' perception was shown in each aspect

The one-way repeated measures MANOVA for comparing female and male students' learning perception indicated no significant difference between both genders based on their pre-physics perception ratings for the SAGOI learning, as shown in Table 3.

Table 3. Descriptive statistic for student's perceptions toward digital game-based SAGOI pedagogy on gender

Subscale	Gender		F	Sig.	η^2
	Male	Female			
Learning Experience	41.50 (7.49)	41.50 (7.62)	0.000	1.000	0.000
Overall Impression	30.25 (4.81)	29.95 (5.94)	0.022	0.883	0.001
Total	71.75 (11.65)	71.45 (12.65)	0.004	0.947	0.000

*p = < .05

Typically, there are differences in gender in every classroom, but that does not the problem in learning and teaching. The students have cooperated with everyone in the class, even unlike gender. The SAGOI pedagogy provides an environment for students in collaborative learning. They can negotiate and transfer their ideas within the group or require the teacher's help when they have a problem. A part of digital games offers students a puzzle, which they must exchange their information or strategy to complete. The teacher's role is only to coach or mentor when they need it, and all students can require support from anyone in the classroom. Hence, both learnings were no different because they supported each other mutually. Likewise, Dontrisanor, Srisawasdi, & Kanjak (2015) report that students' perceptions were raised in males and females but had no significant differential impact on gender. The researcher supposed a course of uniform because in the context of a student currently, males and females have the same skill level in learning and perception through the digital game.

■ Conclusion

There are two features of the present study which make it noteworthy. First, this study demonstrated that an educational digital game was more economical and easier to provide an enjoyable learning experience in a secondary school science education. Moreover, a unique digital game-based inquiry learning approach, called student-associated game-based open inquiry or SAGOI, by integrating the digital game into the open-ended inquiry learning process, can be developed for facilitating physics teaching and learning. The digital game learning environment was incorporated with open-inquiry learning processes, and a role-play digital game to promote students' conceptual development, physics motivation, and learning perceptions. Second, never have researchers investigated the effect of gender difference on students' learning perception of the physics concept of static electricity and progressive development of conceptual learning performance and physics motivation implemented in secondary schools. The findings of this study suggest that gender did not impact learning perception for female and male secondary school students when the same amount of exposure to the SAGOI learning activities was given to them. In other words, when the amount of the experience is controlled, females and males respond equally in terms of learning perception.

In addition, this study evaluated the impact of the SAGOI learning approach on the ability of eleventh-grade students at a secondary school to learn physics concepts of static electricity and their motivation toward physics. The main objective of this study is to compare students' conceptual understanding and physics motivation on the topic of the properties of liquid before and after their usual school setting with an educational computer game. In other words, the study helps in understanding whether the Electilism War game, through open-inquiry learning, contributed to conceptual understanding and chemistry motivations. It was found that the secondary school students did not significantly improve their conceptual post-test scores from conceptual pre-test scores. That is, the characteristics of the educational digital game integrating with the SAGOI pedagogy, such as posing questions, problems, or scenarios rather than simply presenting facts; encouraging investigative procedures and practices regarding the posed questions, problems, or scenarios; and fostering investigative reflection and conclusions in students need to reconsider to facilitate the construction of their conceptual understanding and improve their motivation toward physics. Interestingly, this study indicates that the students who received the SAGOI learning experience and the proposed digital game were significantly better in their motivation to learn physics in terms of self-efficacy. As such, the results of this study verify that educational digital games could serve as critical cognitive tools in enhancing students' self-efficacy in the physics course.

Nevertheless, the results are based on the data collected from a single physics class and school. Therefore, more experiments or implementations on physics courses need to be conducted in further study to ensure the founding results. In addition, there are several concerns to be addressed within further study. For example, it would be challenging to categorize students' learning styles when formatting game interfaces. It is necessary to improve the game by addressing the conceptual difficulty level for students to learn physics concepts in each gaming stage and mission.

Due to the increasing role of the educational digital game for improving the quality of education in all subject areas, there is a large call for the current young generation to be adequately trained on how to learn with the digital game and also on how to teach with the digital game effectively for teachers as well. In the future, the educational digital game will become formal tools to integrate into mainstream basic education curricula as its nature. Government, university, and school bodies should investigate the possibility and collaborate with researchers, educators, or developers to educate pre-university students in physics and other science with the educational digital game.

■ Limitation and Recommendation

Limitation

For the limitation of this research, there are a few factors to affect this work. First, from the effect of the first study, the researcher must create the storyboard and design the digital games based on the student's misconception is consistent with static electricity. The storyboard was sent to the programmer, who does not understand this content. Thus, research must connect and communicate to support the programmer in developing digital games. To develop digital games, researchers spent time monitoring and checking the accuracy of phenomena and puzzles to reduce the effect on a student's misconception. The complete digital games version also could not provide any situation to improve students' conception, and the same phenomenon ceased to confuse. Since the Digital games situation does not cover in daily life events of the student, it was displayed characteristic situations as the creator provides merely. Second, using digital games in the authentic instruction, which teaches following the SAGOI technique, let the student learn and inquire in the section of gaming. Half of the students do not care about the objective to obtain from a teacher. They just spend time on digital games and do not interact with their group. They immerse in the entertainment and challenge of digital games, attempting to find the shortcut to complete the game.

Recommendation

Based on our findings in the current research, the design and development of game technology innovation by creating more visible into scientific phenomena, more challenging and compelling to learning tasks, more addressing of students' learning profiles and characters whether it is appropriate to learn through digital games or not. Moreover, using instruction by SAGOI combined with digital games gives good results, but teachers should find ways to make students more focused on classroom activities when used in the classroom.

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