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An Approach to Design Educational Digital Game to Improve Students' Conceptual Development in Physics of Static Electricity

Chanvit JUNNGAM[a], **Niwat SRISAWASDI**[b*]
[a]*Science and Technology Education Program, Faculty of Education, Khon Kaen University, Khon Kaen,Thailand*
[b]*Division of Science, Mathematics, and Technology Education, Faculty of Education, Khon Kaen University, Khon Kaen, Thailand*
[*]niwsri@kku.ac.th

Abstract: Nowadays, students are very familiar with digital games. So, it would be nice if we put the knowledge into the digital game. For developing educational digital games, the games do not raise and contain all the content, but it just delivers core or essential concepts for learning. In this paper, we present a developmental approach to design educational digital game and then discuss how to design digital game for learning with regarding learners' existing understanding of scientific concepts. For the proposed approach, we need to investigate student' initial conceptions on particular target of science concepts, and this study involved 74 eleventh-grade students, age ranging from 16 to 18 years old, in this first step. To explore their prior conceptions, selected items of the Three Tier Diagnostic Static Electricity Test (TTDSET) focusing the concept of electric charge, electrostatic force, electric field, energy and electric potential, and capacitor. The result showed that vast majority student hold misconceptions on the target scientific concepts about static electricity. After that, the second step is design of digital game for learning emphasizing the elimination of their misconceptions. As such, the proposed digital game, named "Electrilism War", has been designed to not only transform the core scientific concepts into challenge and fun scenario, but also simplify the concept and connect everyday life action to the game. In addition, the game has been designed using role-playing game style with a story of fantasy novels. We believed that this developmental approach would particularly affect a process of conceptual change using the context of digital game-based learning.

Keywords: Digital game, inquiry-based gaming, game-based learning, conceptual change, physics concept

1. Introduction

The use of digital games to integrate in the teaching of physics. It helps to promote the potential of students as well. It promotes student-centered learning. This is a good way to learn from the mistakes in the classroom. Apart from that, the main goal of digital game creation is to enable the game to be a medium for the player to feel part of the group. And it stimulates the imagination and creativity of the players. It also helps players relax and enjoy playing (Boston, 2009) and these games can promote learning in context outside the classroom. It also promotes distance learning and lifelong learning (Freitas, 2006).

Therefore, digital game-based learning is a very interesting method because the instructor gives the learner the opportunity to learn effectively. Happy and positive attitude toward learning, it will help students succeed in their studies (Tychsen, Hitchens, & Brolund, 2008). Digital games can improve student's perception and gender difference has no effect on student's perceptions (Dontrisanor, Srisawasdi & Kanjak, 2015) and digital game-based learning can improve perception motivation of students (Meesuk & Srisawasdi, 2014; Nantakaew & Srisawasdi, 2014)., and playing a computer game shifted representation styles from verbal descriptions to iconic representations (Greenfield et al., 1994)

As such, this study aims to developing digital game as an inquiry tool to learn physics in concepts of static electricity. Consequently, the goal of this study is investigation of the prior knowledge of static electricity concepts and then developing a digital game to supporting conceptual improvement in static electricity. This study presents a preliminary result on investigating secondary school students' existing conception about static electricity, and then a design of educational digital game for promoting their conceptual improvement on physics concepts related to static electricity.

2. Literature Review

2.1 Digital Game-based Learning

Nowadays, digital gaming is very famous. Digital games consist of bright and wonderful 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).

In the past, digital games were created for entertainment purposes, but recently, researchers have adopted the game for educational purposes and use to study in the classroom (Sorenson & Mayer, 2007; Stone, 2009). Researchers mentioned that the digital games for educational purposes could provide positive effects for students both cognitive and affective domains of learning. Resulted in this, students get a positive learning attitude and create a learning curve in the meantime (Giannakos, 2013). When using a game in the classroom can shift teaching to student-centered learning environment from a teacher-centered environment (Watson, Mong & Harris, 2011). Digital games can challenge the player, but it is 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)

2.2 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. In fact, the game environment itself is a large problem, which has smaller causally linked problems embedded in it (Kiili, 2005). In another word, the authenticity of learning situation and tasks is granted to be a very important component in facilitating higher order learning. (Brown, Collin, & Dunguid, 1989). In games, storyline and the game environment can be used to contextualize the provided problems.

3. Method

3.1 Participants

From investigate prior knowledge on the topic, the participant in this study was of 75 eleventh grade student, age ranging from 16 – 17 years, in local public school in the Northeastern region of Thailand. A program which is science and technology. Regarding prior learning, they have no experience yet using digital game-based learning in physics.

3.2 Research Instrument

The instrument in this study is Three Tier Diagnostic Static Electricity Test (TTDSET) 9 item from Suma, Sadia, and Pujana (2018). That is modified from D.P. Maloney et al. (2001) and E. Bilal & M.

Erol (2009). By has selected some item from this test, electric charge 2 items, electrostatic force 2 items, electric field 2 items, energy and electric Potential 2 items and Capacitor 1 item. From the Indonesia version, an identical version in Thai was constructed, and one expert was recruited to identify communication validity of the items.

3.3 Procedures and Data Analysis

All participants took 30 minutes to complete the three-tier test to identify the student prior knowledge of static electricity concepts. This consist of three level. Firstly, level was a multiple choice that that asked the student to choose a correct answer from the alternative options answers. Secondly level was a multiple-choice test that asked the students to choose an alternative reason for support first level answer. The last level consisted of two alternatives, i.e., sure and not sure. This research analysis students' prior knowledge follows the method of Suma et al. (2018), the students' prior knowledge was categorized into four categories i.e. scientific knowledge (SK), misconception (M), Lack knowledge (LK), and Error (E). Table 1 shows the distribution of test items in static electricity subtopic. The categorization was based on the merger of the student's responses in TTDSET in first, second and third levels as in Table 2. The prior knowledge category for this study was use in the development of digital games to support conceptual improvement in static electricity.

Table 1

Distribution of test item in static electricity concepts

Static Electricity Concepts	No item
1. Electric charge	1, 2
2. Electrostatic force	3, 4
3. Electric field	5, 6
4. Energy and Electric Potential	7, 8
5. Capacitor	9

Table 2

Categorization of the types of students answer

Answer level 1	Answer level 2	Answer level 3	Prior knowledge category
True	True	Sure	Scientific Knowledge (SK)
True	True	Not sure	Lack Knowledge (Lk)
True	Wrong	Not sure	Lack Knowledge (Lk)
Wrong	True	Not sure	Lack Knowledge (Lk)
Wrong	Wrong	Not sure	Lack Knowledge (Lk)
Wrong	True	Sure	Error (E)
True	Wrong	Sure	Misconception (M)
Wrong	Wrong	Sure	Misconception (M)

4. Results and Discussion

The results displayed that there are many types of students' prior knowledge of static electricity concepts, as illustrates in Figure 1-5.

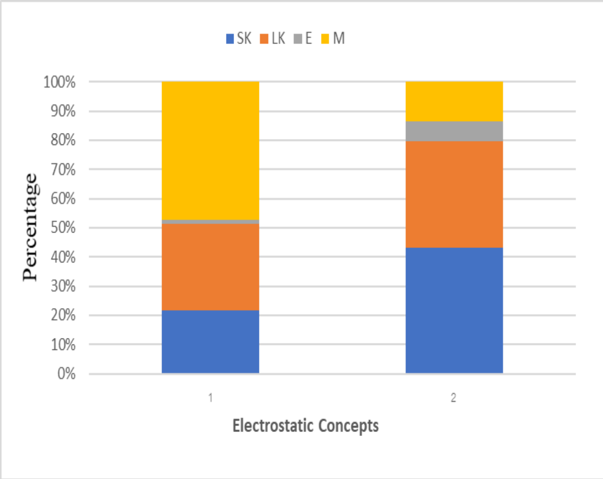

Figure 1. Distribution of students' prior knowledge on electric charge concepts.

Figure 1 was displayed with item number 1 and 2, the percentages for scientific knowledge was 21.62% and 43.24% respectively. The percentage for misconception was 47.30% and 13.51% respectively. The percentages for lack knowledge was 29.73% and 36.49% respectively. The percentage of error was 1.35% and 1.76% respectively. In other words, vast students hold misconception of electric charge concepts.

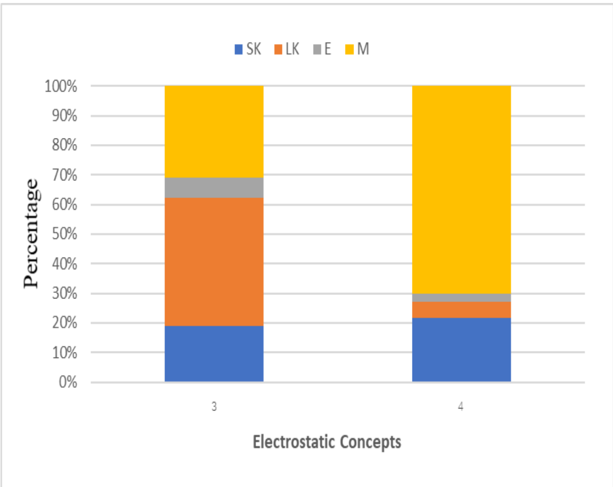

Figure 2. Distribution of students' prior knowledge on electrostatic force concepts.

According to figure 2, present item number 3 and 4, the percentages for scientific knowledge was 18.92% and 21.62% respectively. The percentage for misconception was 31.08% and 70.27% respectively. The percentages for lack knowledge were 43.24% and 5.41% respectively. The percentage for error was 6.76% and 2.70% respectively. In other words, vast students hold misconception of an electrostatic force concepts.

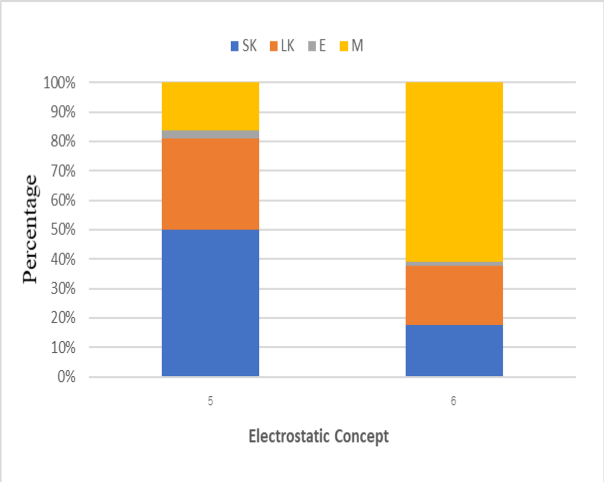

Figure 3. Distribution of students' prior knowledge on electric field concepts.

As seen in figure 3, present item number 5 and 6, the percentages for scientific knowledge was 50.00% and 17.57% respectively. The percentage for misconception was 16.22% and 60.81% respectively. The percentages for lack knowledge was 31.08% and 20.27% respectively. The percentage of error was 2.70% and 1.35% respectively. In other words, vast students hold misconception of electric field concepts.

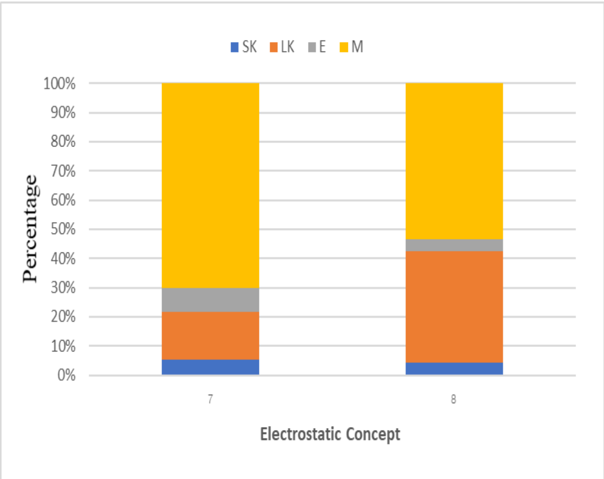

Figure 4. Distribution of students' prior knowledge on energy and electric potential concepts.

According to figure 4, present item number 3 and 4, the percentages for scientific knowledge were 5.41% and 4.05% respectively. The percentage for misconception was 70.27% and 52.70% respectively. The percentages for lack knowledge was 16.22% and 37.84% respectively. The percentage of error was 8.11% and 4.05% respectively. In other words, vast students hold misconception of on energy and electric potential concepts.

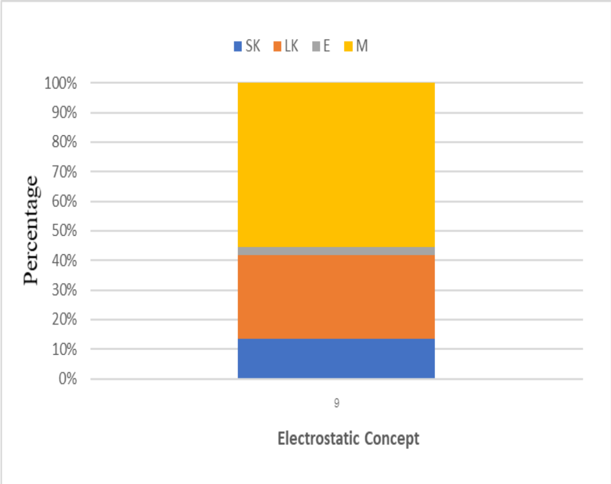

Figure 5. Distribution of students' prior knowledge on capacitor concepts.

According to figure 5, present only item number 9, the percentages for scientific knowledge was 13.51%. The percentage for misconception was 55.41%. The percentages for lack of knowledge was 28.38%. The percentage of error was 2.70%. However, vast students hold misconception about capacitor concepts.

5. The Proposed Design of Digital Games about Static Electricity

From this study results, we know that most participants lack knowledge. Therefore, in the design of the game from the researcher mentioned above that want to put some concept in this game i.e. the same charge will push the same, so in design, we designed a prototype game called "Electrilism War" theme of the game is a war between two cities. Players will be the hero to end this war. The game will control the character to overcome obstacles, fight against the enemy to collect money, unlock the item to make the game easier. Figure 6 displays examples of the main screen of the Electrilism War game.

Figure 6. An example of the Electrilism War game: start screen of the digital game (Left) and playing screen for players (Right).

As seen in figure 6, displayed start screen of the digital game in this screen the map is full of flames instead of war, which is designed to capture the attention of players. When the game starts on the tutorials, players will learn about the various controls in the game. level 1related to a concept of electric charge and electrostatic force. For example, when a player uses a positively charged sword to attack a positive enemy, the enemy splashes out, when players can collect enough points and money, they can pass this level.

In level 2 related to a concept of electrostatic force. In this level, the game environment will change from action RPG to puzzle game. The player must use a hook attached to the item on the island to jump to the other side.

Level 3 is related to a concept of electric field, energy, and electric potential, game environment in this level will change to a maze game. The players must use their previous knowledge is related to this level to escape the maze.

When the player reaches the third level, there is an option for the player to return to play to collect extra money or to fight the boss. If the player chooses to fight the boss, the player will have the option to buy a legendary weapon to fight the boss. In the battle with the boss, the player must use the knowledge level before. If the winner will clear the game, if it loses, it must start to fight with the boss again. Figure 7 displays a flow chart of the game mechanics.

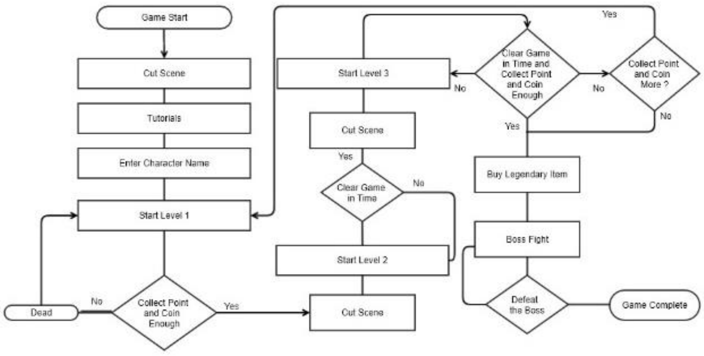

Figure 7. An illustration of the game mechanics.

6. Conclusion

In this study, an educational digital game was developed to support students' conceptual development of physics of static electricity with an inquiry-based learning approach. A developmental approach of digital game environment has been proposed specifically to facilitate students' conceptual learning in science regarding their existing conceptions. As such, a preliminary survey was conducted to identify the need to remedial misconceptions. From the survey results, it was found that students hold a various kind of conceptual status. Therefore, the development of educational digital game should be paid more attention and concern on the status of student' conceptions or understanding. The proposed approach can be applied to other development of digital learning materials and strategies. Therefore, one of our future research plans is to apply the approach to the development of other kinds of digital materials, such as simulation, augmented reality and web-based environment. For the future study, we will use collaborative open inquiry pedagogy, called Student-associated Game-Based open Inquiry (SAGOI) (Meesuk & Srisawasdi, 2014) to promote students' conceptual in static electricity, and to remedial students' misconception. The goal of this work is to resolve the misconception of static electricity, but since the number of participants is not very large. This game limit may not cover all misconception.

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References

Bilal, E. & Erol, M. (2009). Investigating students' conceptions of some electricity concepts. *Lat. Am. J. Phys. Educ, 3*, 193-201.

Boston, B. (2009). Player motivations: A psychological perspective. *Computers in Entertainment*. 7(2). https://doi.org/10.1145/1541895.1541902

Brown, J., Collins, A. & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18,* 32–41.

De Castell, S., Jenson, J., & Taylor, N. (2007). Digital game for education: When meanings play. Intermedialities, 9, 45-54.

Dontrisanor, T., Srisawasdi, N., & Kanjak, I. (2015). Using Problem-based Gaming Environment supported Conceptual Physics of Electric Current: A Result on Students' Perceptions. *Proceedings of the 23rd International Conference on Computers in Education*. 550-557. China: Asia-Pacific Society for Computers in Education

Freitas, S. D. (2006). *Learning in immersive worlds: a review of game-based learning*. Bristol.

Gee, J. P. (2005). *Why video games are good for your soul*: Pleasure and learning. Champaign, IL: Common Ground Publishing.

Greenfield, P.M., Camaioni, L.E., Ercolani, P., Weiss, L., Lauber, B.A., & Perucchini P. (1994). Cognitive socialization by computer games in two cultures: Inductive discovery or mastery of an iconic code?. Journal of Applied Developmental Psychology, 15(1), pp. 59-85.

Kiili, K. (2005). On educational game design: building blocks of flow experience. (Doctoral thesis, Publications
of Tampere University of Technology, Tampere University of Technology, Finland.

Maloney, D. P., O'Kuma, T. L., Hieggelke, C. J., & Heuvelen, A. V. (2001). Surveying students' conceptual knowledge of electricity and magnetism. *Am. J. Phys. Suppl, 3*, 69-71. https://doi.org/10.1119/1.1371296

Meesuk, K., & Srisawasdi, N. (2014). Implementation of Student-associated Game-based Open Inquiry in Chemistry Education : Results on Students' Perception and Motivation. Liu, C.-C. et al. (Eds.), *Proceedings of the 22nd International Conference on Computers in Education*. 219-226. Japan: Asia-Pacific Society for Computer in Education

Nantakaew, N., & Srisawasdi, N. (2014). Investigating Correlation between Attitude toward Chemistry and Motivation within Educational Digital Game-based learning. Liu, C.-C. et al. (Eds.), *Proceedings of the 22nd International Conference on Computers in Education*. 219-226. Japan: Asia-Pacific Society for Computer in Education

Sorense, B., & Meyer, B. (2007). Serious Games in language learning and teaching-a theoretical perspective, 559-566.

Stone, R. (2009). Serious games: virtual reality's second coming?. *Virtual Reality*, *13*(1), 1-2.

Suma, K., & W Sadia, I. & M Pujani, N. (2018). Investigating 12th-Grade Students' Prior Knowledge of Static Electricity Concepts. *International journal of environmental & science education. 13*(2), 163-172.

Sung, H., & Hwang, G. (2012). A collaborative game-based learning approach to improving students learning performance in science courses. *Computers & Education, 63* (2013), 43-51.

Tychsen, A., Hitchens, M., & Brolund, T. (2008). Motivations for Play in Computer Role-Playing Games. *Paper presented at the 2008 Conference on Future Play Research Play Share.* 57-64.

Watson, W.R., Mong, C.J., & Harris, C. (2011). A case study of the in-class use of a video game for teaching high school history. *Computers & Education, 56*(2), 466-474.

Wu, W., Chiou, W., Kao, H., Hu,C. A., & Huang, S. (2012). Re-exploring game-assisted learning research: The perspective of learning theoretical base. *Computers & Education*, 59(2012), 1153– 1161.