Using Problem-based Gaming Environment supported Conceptual Physics of Electric Current: A Result on Students' Perceptions

Tawat DONTRISANOR[a], Niwat SRISAWASDI[b*] & Issara KANJAK[c]
[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*
[c]*Department of Educational Technology, Faculty of Education, Khon Kaen University, Khon Kaen, Thailand*
*niwsri@kku.ac.th

Abstract: Educational problem-based gaming, which is one of emerging pedagogies, could promote students' perception. In this study, the educational digital game was specially designed for learning physics based on problem situation. To investigate the effect of perception toward physics lesson and to evaluate the developed problem-based gaming, 82 eleventh grade student were recruited to participate in the developed problem-based gaming. A Likert-scale perception questionnaire was administered to the students before starting learning activity as pre-test. After completing the learning activity, the students were asked to response the perception questionnaire as post-test. The repeated-measures MANOVA results indicated that there was no significant main effect on gender and interaction effect between gender and time (pre-test/post-test), but there were significant main effect on time. That is, there was no effect of gender difference on students' perception towards physics learning through the developed problem-based gaming

Keywords: Problem-based gaming, digital game-based learning, physics learning, interactive experience

1. Introduction

Nowadays, innovative technologies in learning and science teaching are growing continuously. Game is one of technologies that are important to promote science learning. In recent years, several researchers have paid attention to a new research trend that focused on using digital game for teaching physics concepts and other science concepts. There were several studies revealed that the use of game-based learning technology in the instruction could promote motivation and perception of students. For example, Farrokhnia and Esmailpour (2010) showed that the game have significant effect in fostering the students' perceptions. Meesuk and Srisawasdi (2014), Natthida & Srisawasdi (2014), Lokayuth & Srisawasdi (2014) implemented the student-associated game-based open inquiry in chemistry education and found that the students' perceptions and motivations were triggered. Generally, to study about the impact of real, virtual and comprehensive experimenting on students' conceptual understanding of DC electric circuits and their skill in undergraduate electricity laboratory, it has used computer simulations in learning. It was found that the computer simulations could promote students' learning. With technological features, the development of interactive computer-based learning materials for science teaching and learning provides opportunities to help students understand the concepts better by visualizing abstract science concepts into concrete experience to change students' alternative conceptions to scientific conceptual understanding (Srisawasdi, Kerdcharooen, and Suits, 2008; Suits and Srisawasdi, 2013). Moreover, teaching-learning process by integrating computer technologies such as digital game, simulation and others could be a novel pedagogy to promote meaningful learning and students' motivation better than traditional teaching-learning process. Physics, which is the one of most important discipline, explains daily life natural phenomena. Physics concept related to other concepts in science such as the biology, chemistry and materials science. However, it is difficult to understanding and learning when teaching by textbook led to low motivation in learning. Because the nature of Physics is abstract content which need to use imagination for connecting to real life situation (Turgut, 2011).

Therefore, with the abovementioned reasons, the digital game attributes may be help students increase learning interest in physics, motivation and attitude towards physics learning. Therefore, this study aims to create educational computer game as an inquiry tool to learn physics in concepts of electric current. Consequently, the goals of this study were to investigate students' perceptions towards Problem-based gaming in physics after interacting with the Problem-based gaming in physics. Specifically, the following questions were answered:

1) Do the student engaged in the developed problem-based gaming in physics perform significantly better by perceive learning, perceive ease of use, flow, perceived playfulness, enjoyment, and satisfaction?
2) Do genders effect on students' perceptions through the developed game?

2. Literature Review

2.1 Digital game-based Learning

Currently, digital technology and digital gaming are all around. Digital games consist of dazzling and sophisticated images and sounds, alongside textual communication. Players get engagement, which is both pleasurable and challenging. The educational digital games keep players immersed in digital worlds, knowledge, information, and skill development become increasingly accessible outside confines of formal education (Castell, Jenson and Taylor, 2007). In recent years, educators employed digital game combined with content of subject matter or information for educational purpose. Several researches presented empirical evidences that the educational digital games have positive effect on student learning (Farrokhnia & Esmailpour, 2010; Meesuk & Srisawasdi, 2014; Dorji, Panjaburee, & Srisawasdi, 2014).

In the past, game was produced only for entertainment but recently educational researchers have attempted to adapt games for learning which call educational games or serious game and use to study in classroom (Sorensen and Meyer 2007; Stone 2009). The game that composed of challenge, control, curiosity and fantasy can motivate persistence and enjoyment (Toro-Troconis and Partridge, 2010). The educators have developed games for three goals including : (i) student can learn from playing the game; (ii) the component of game can support learning; (ii) the component of game can support learning; and (iii) students have motivation to learn when they learning by playing the game (McNamara, Jackson, & Graesser, 2010). Game-based learning is a king of constructivist-based active learning. Based on the learning research, Watson, Mong and Harris (2011) found that using game in classroom made a shift of teaching from teacher-centered learning environment to student-centered learning environment.

2.2 Problem-based Gaming (PBG)

Problem-based gaming focuses on the meaning of authentic learning tasks, experiential learning and collaboration. Because games usually allow players to creatively test their hypotheses and reflect on outcomes in the game world, experiential learning theory provides an appropriate basis for PBG. In fact, a game includes a major problem, which is caused minor problem (Kiili, 2005). On the other hand, the authenticity of learning situations and tasks is assumed to be a very important factor in facilitating higher order learning (Brown, Collins & Duguid, 1989), at least in higher education. The basic idea is to anchor the learning of knowledge and skills into meaningful problem-solving situations encountered in everyday life. The situated learning theory supports this view by stressing that learning is a context-dependent activity (Brown et al, 1989). Such approach supports the transferability of learned knowledge and skills into the practice (Savery & Duffy, 1995). In games, the storyline and the game world can be used to contextualize the provided problems. Furthermore, the collaborative nature of problem solving is emphasized.

2.3 Problem solving

Problem-solving is a 21st century skill that is essential for learning, work, and daily life (Anneta, 2008). Problem solving can be defined as the ability to find causes, find solutions, and avoid problem (Chan & Wu, 2007). In evaluating problem solving ability, both flexibility and effectiveness should be considered. Whereas flexibility results in a variety of unique responses to a problem, effectiveness ensures that the solutions are practical and thoroughly considered.

3. Method

3.1 Participants

A total of 82 eleventh-grade student (female = 58, male =24), age ranging from 16-17 years, in a local public school at the northeastern region of Thailand participated in this study. They were attending a physics course for basic education level. Regarding to prior learning experience, they have no experience yet using problem-based gaming learning in physics.

3.2 Instructional materials

This section describes the design of problem-based gaming in conceptual physics of electric current. The researcher designed the game as a model problem situation in order to improve problem-solving skill in physics about electric current solution. When the player starts the game, they will assume themselves as characters in the game in order to perform various missions as shown in Figure 1. Figure 1 shows problem-situation about electricity shortages in kingdom: The leader of kingdom say that "How will kingdom have electricity?".

Figure 1. An example of screen interface of the digital game

Moreover, Figure 3 and 4 show problem-based gaming about electricity how to electrons move to the positive pole. Player can use left and right arrow to control electrons through possible obstacles in order to move on to positive pole.

Figure2. An example of a problematic situation in the digital game

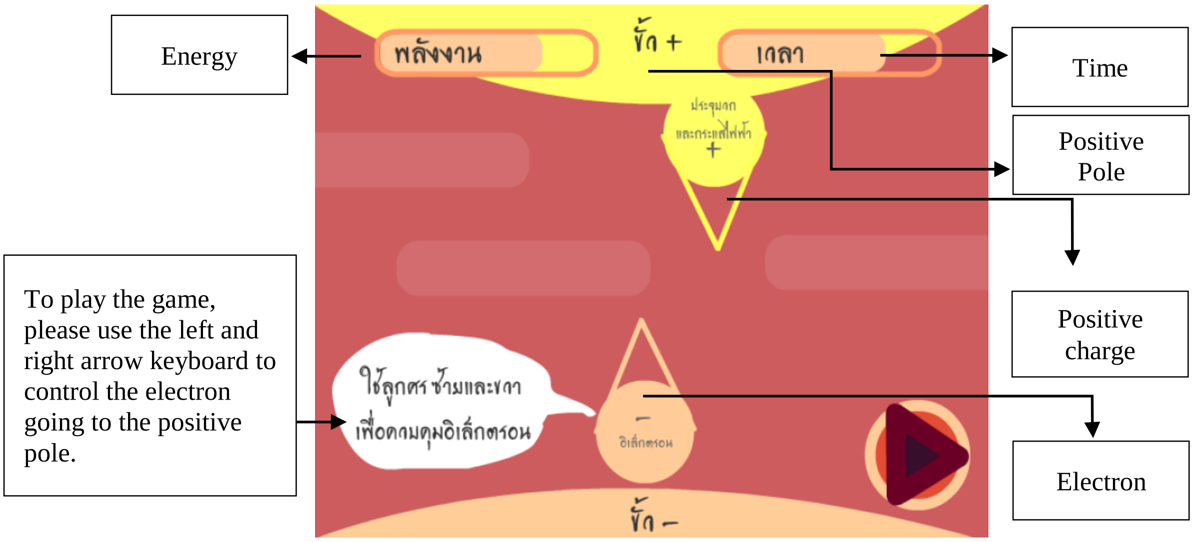

Figure3. An illustration of components in the game

3.3 Research instrument

A 18-item Likert-scale questionnaire was adapted to employ in this study for examining students' perceptions towards the developed game-based learning in physics on six subscales: perceived learning, Perceive ease of use, Flow, Perceived playfulness, Enjoyment, Perceived Satisfaction as shown in Table 1. All of these 5-point Likert-scale item obtained from (Cheng, 2014). From the English version, an identical version in Thai was constructed, and one expert was recruited to identify communication validity of the items.

3.4 Data Collection and Analysis

The participants were asked to complete the perception questionnaire, to measure their pre-perceptions towards the problem-based gaming on electric current for 15 minutes. After completing the instrument, they were exposed to interact dependently with the experiment for 25 minutes. After completing the experiment, the students' post-perceptions were examined by the same questionnaire for 10 minutes. The statistical data techniques selected for analyzing students' science motivation was repeated-measures MANOVA in SPSS to compare effect of intervention considering gender (female/male) and time(pre-test/post-test).

Table1: Example items of perception questionnaire for each construct.

Dimension	Sample items
Perceive learning	The game will help me understand the things I learned. The games increase my learning efficiency. The games allow me to complete my studies faster.
Perceived ease of use	The games are easy to use. Using the games to complete course related tasks are easy.
Flow	I was very involved in the game. I lost track of time when I played. When I played I did not think of anything else.
Perceived playfulness	It is interesting to use games. I feel like exploring more information when I use games. I was totally immersed in the game.
Enjoyment	I had fun playing the game for learning science. I feel relaxed to use games for learning science.
Perceived Satisfaction	The use of the system makes this learning activity more interesting I like to learn new skills by using business simulation games. I would like to learn with the system in the future. I would like to know if the innovative approach could be applied to other courses to improve my learning performance. I would recommend this learning system to others.

Table 2: The students' subscale means of perceptions by time and univariate MANOVA

Dimension	Gender	Time		F (Total)	Sig. (Total)	$\eta 2$ (Total)
		Pre-test Mean (SD)	Post-test Mean (SD)			
Perceive learning (PL)	Male	9.92 (2.977)	11.79 (2.654)	20.856	.000***	0.995
	Female	10.91 (2.452)	12.71 (2.209)			
	Total	10.62 (2.637)	12.44 (2.368)			
Perceive eased of use (PE)	Male	7.50 (1.719)	8.00 (1.615)	10.743	.002**	0.899
	Female	7.57 (1.798)	8.76 (1.329)			
	Total	7.55 (1.765)	8.54 (1.450)			
Flow (Fl)	Male	9.88 (2.542)	11.54 (2.604)	19.009	.000***	0.991
	Female	10.67 (2.612)	12.52 (2.234)			
	Total	10.44 (2.602)	12.23 (2.374)			
Perceive of playfulness (PP)	Male	10.33 (2.408)	11.79 (2.322)	14.098	.000***	0.960
	Female	11.21 (2.419)	12.64 (2.330)			
	Total	10.95 (2.434)	12.39 (2.345)			
Enjoyment (Ej)	Male	7.54 (1.587)	7.96 (1.706)	6.622	.012*	0.720
	Female	7.98 (1.681)	8.79 (1.448)			
	Total	7.85 (1.656)	8.55 (1.565)			
Perceive satisfaction (PS)	Male	18.04 (4.123)	20.08 (3.623)	16.336	.000***	0.979
	Female	18.90 (4.012)	21.66 (3.343)			
	Total	18.65 (4.038)	21.20 (3.480)			

Note. $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

4. Results

The results for the repeated-measures MANOVA was conducted to determine students' perceptions scores. The assumption of homogeneity of variance-covariance was tested with Box's M Test which was not significant and indicated that homogeneity of variance-covariance was fulfilled (p = .110). The results for the repeated-measures MANOVA indicated significant main effect for gender (Wilks' lambda =0.933, $F_{(6, 75)}$ = .903, p = .497, η^2=0.067) and time (Wilks' lambda = .708, $F_{(6, 75)}$ = 5.160, p = .000, η^2=0.292). Also, there was significant interaction effect between time and genders (Wilks' lambda = .942, $F_{(6, 75)}$ = .774, p = .593, η^2=0.058). Univariate analyses of variances (ANOVA) on each subscale were conducted as follow-up tests to the one-way MANOVA. The results of the univariate test for groups are summarized in Table 2.

Moreover, Figure 5 shows that pre-test and post-test of six perception dimension consist of (1) perceived learning, (2) Perceive ease of use, (3) Flow, (4) Perceived playfulness, (5) Enjoyment, (6) Perceived Satisfaction.

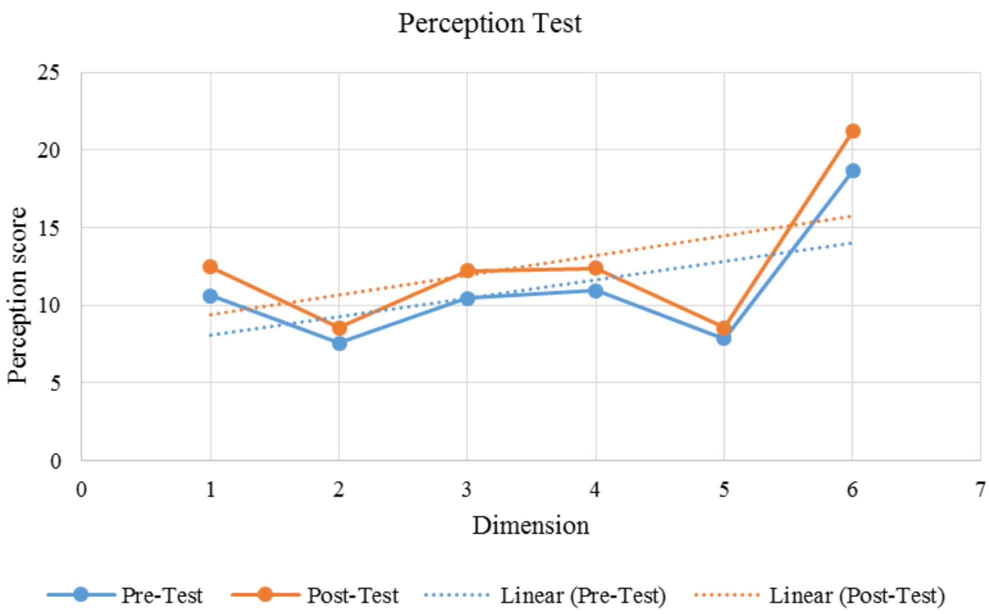

Figure 4. display about perception test score and trend pre-test and post-test of six perception dimension

The trend of this graph indicated that student have positive perception in physics learning by playing the game more than usual after pre-test. As shown in Table 2, the univariate MANOVA on the six dimension scores of perceived towards learning science through the developed problem-based gaming were significant differences across time, from pre-test to post-test. The univariate results revealed a significant effect on PL($F(1,80)$ = 20.856, $p < .05$, partial $\eta2$ = .995), PE($F(1,80)$ = 10.743, $p < .05$, partial $\eta2$ = .899), Fl($F(1,80)$ = 19.009, $p < .05$, partial $\eta2$ = .991), PP($F(1,80)$ = 14.098, $p < .05$, partial $\eta2$ = .960), Ej($F(1,80)$ = 6.622, $p < .05$, partial $\eta2$ = .720) and PS($F(1,80)$ = 16.336, $p < .05$, partial $\eta2$ = .979). According to aforementioned results, the overall result suggested that the increase of perceived towards learning science through the developed problem-based gaming regarding perceive learning, perceive ease of use, flow, perceive of playfulness, enjoyment and perceive satisfaction from the pre-test to post-test was homogeneous both females and males after participating with the developed problem-based gaming. That is, there was no effect of gender difference on perceived towards learning physics, through the developed problem-based gaming.

5. A Proposed Instructional Strategy of Open-Inquiry with problem-based gaming for Promoting problem-based Learning

In pilot study, the researcher aim to explore the effect of gender difference with problem-based gaming and the next study researcher will be using the game to improve problem-solving skill with 11th graders' conceptual understanding, learning attitude, and problem-solving skill, The table 3 shows the example of learning process with Open-inquiry by using the problem-based gaming.

Table 3. An example of open-inquiry learning process using in the next study

Open-Inquiry Process	Description of learning process
1. Open-ended inquiry question	At the beginning of the lesson, teacher will give a question about electric current, such as "How does the electric current travel?"
2. Scientific background	Teacher induces collaborative discussion toward the definitions and pictorial diagram of electric flow; positive charge; negative charge or electron and potential difference.
3. Procedure	Student play the problem-based gaming about electric current to explore the travel of electric flow in the wire; positive charge; negative charge or electron.
4. Data and Result analysis	Student saved the score when they finished the game and bring to analysis "Why they get the score?" and shared with other students.
5. Result Communication	Student have to select the way to present, communicate and discuss the meaning of problem in the game and how to solve the problem to get high score in the game.
6. Conclusion	Teacher using the question to summarized conception about electric current such as "How does the electron move?"; "How does the positive charge move?"

6. Conclusion and implementation

The result of this study provided a more understand on students' perceptions about the problem-based gaming. The finding revealed successful of improving students' perceptions in context of digital game-based learning experience. In addition, gender difference has no effect on students' perceptions towards learning of physics through the developed problem-based gaming. As such, it is obviously found that both females and males increased their perceptions on perceive learning, perceive ease of use, flow, perceived playfulness, enjoyment, and satisfaction.

Acknowledgements

This work was financially supported by the Institute for the Promotion of Teaching Science and Technology (IPST). The author would like to express gratefully acknowledge to Graduate school, Khon Kaen University, for supporting this contribution.

References

Annetta, L. A. (2008). Video games in education: why they should be used and how they ae being used. Theory Into Practice, 47(3), 229-239.

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

Cheng, G. (2014). Exploring students' learning styles in relation to their acceptance and attitudes towards using Second Life in education: A case study in Hong Kong, Computers & Education, 70 (2014),105-115

Chan, S. M., & Wu, W. T. (2007). New problem solving ability test. Taipei, TW: Psychological Publishing Press.

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

Dorji, U., Panjaburee, P., & Srisawasdi, N. (2015). A Learning Cycle Approach to Developing Educational Computer Game for Improving Students' Learning and Awareness in Electric Energy Consumption and Conservation. *Educational Technology & Society, 18*(1), 91–105.

Farrokhnia, M. R., Esmailpour, A. (2010). A study on the impact of real, virtual and comprehensive experimenting on students' conceptual understanding of DC electric circuits and their skills in undergraduate electricity laboratory. *Procedia Social and Behavioral Sciences*, 2, 5474-5482

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.

Lokayut, J., & Srisawasdi, N. (2014). Designing Educational Computer Game for Human Circulatory System:a Pilot Study. 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

Mcnamara, D. S., Jackson, G. T., & Graesser. (2010). Intelligent Tutoring and Games (ItaG). *Gaming for Classroom-Based Learning: Digital Role Playing as a Motivator of Study*,44-57. Doi: 10.4018/978-1-61520-713-8.ch003

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

Savery, J. & Duffy, T. (1995). Problem-based learning: an instructional model and its constructivist framework. *Educational Technology*, *35*, 31–38.

Srisawasdi, N., Kerdcharoen, T., & Suits, J.P. (2008). Turning scientific laboratory research into innovative instructional material for science education: Case studies from practical experience. *International Journal of Learning*, *5*(15), 201–210.

Suits, J. P., & Srisawasdi, N. (2013). 'Use of an interactive computer-simulated experiment to enhance students' mental models of hydrogen bonding phenomena', in Suits, J.P. and Sanger, M.J. (Eds): *Pedagogic Roles of Animations and Simulations in Chemistry Courses*, ACS Symposium Series 1142, American Chemical Society, Washington, DC.

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.

Toro-Troconis,M.& Partrigde, M. (2010). Designing Game-based learning activities in virtual worlds: Experiences from undergraduate medicine. Gaming for Classroom-Based Learning: use of gaming in virtual worlds, 207-289. doi: 10.4018/978-1-61520-713-8.ch016.

Turgut, U., Gürbüz, F., Turgut, G. (2011). An investigation 10 th grade students' misconceptions about electric current. Procedia Social and Behaviroral Sciences 15 ,1965-1971.

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.