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Electricity's in Visible: Thai Middle School Students' Perceptions toward Inquiry-based Science Learning with Visualized Simulation

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Abstract: Computers have been used in education in many ways from the very beginning of their history and computer simulations which contain visualizing features for representing authentic system or phenomenon and it has been recognized as an effective tool for teaching and learning in science. This pilot study investigated an effect of simulation-based inquiry learning on students' perceptions. A total of 18 middle school students in an urban public school at Northeastern region of Thailand were recruited in this study. They interacted with a physical science lesson of simulation-based inquiry learning on light refraction and then they were administered 21 items of 5-points rating scale questionnaire measuring perceived learning (PL), flow (FL), enjoyment (E), perceived ease of use (PEU), perceive of usefulness (PU), and perceive of satisfaction (PS), after the interaction. The result showed that the highest percentage of their perceptions were E, PS, PL, PU, PEU, and FL, respectively. The finding revealed that they prevalently have positive perception towards the simulation-based inquiry learning. However, the simulation-based inquiry learning experience is needed to be improved for the flow of learning and to assisting them to learn with the simulation.

Keywords: Visualization, computer simulation, inquiry, science education, electricity, perception

1. Introduction

In the fast changing world of the early 21st century, digital technologies have become important tool in improving and advancing the practice of science education because of their potential of bringing about change in ways of teaching and learning (Srisawasdi, 2012). Several researchers mentioned, in the past decades, that digital learning environments are important in improving quality of education and preparing new generation workforce to gain essential skills in this 21st century society (Srisawasdi & Panjaburee, 2015; Vreman-de Olde et al. 2013). Those researchers have concluded pedagogic potential of digital technologies that students could improve their learning performance, skills, and attitudes through digital learning activity with digital game, augmented reality, computer simulation, web-based environment, and so on.

In case of computer simulation, shortly called simulation, it is an effective digital technology which assists to visualize abstract, complex, and unobservable phenomena for students learning (Srisawasdi, 2015). The simulations have a number of features that has been recognized as an effective tool for teaching and learning method in science (Blake & Scanlon 2007; Wellington 2004). In science-based education, the physical science area of electricity is complex phenomena and the development of theoretical understanding of the electrical phenomena through practical manipulation could be problematic (Hennessy et al., 2006; Jaakkola & Nurmi, 2008). In the domain of electricity, there is a large body of research evidence that shows that students in all school levels have severe difficulties and misconceptions in their understanding of electric circuits even after formal instruction has taken place (Cohen & Ganiel, 1983; Osborne, 1983; Shipstone, 1984; McDermott & Shaffer, 1992; Shepardson & Moje, 1999). The learning difficulty of electricity was that students were unable to grasp the underlying processes and mechanisms that are invisible in natural systems and important for theoretical understanding (e.g. current flow), and they can only see what is happening on the surface level of the electrical phenomena (Jaakkola & Nurmi, 2008). Therefore, the learning of electricity often requires not only acquisition of new knowledge, but changes in students' deeply entrenched intuitive conceptions as well (Limon & Mason, 2002). According to the aforementioned, the aim of this study was to explore students' perceptions toward simulation-based inquiry learning in electricity, before developing a physical science module of electricity to enhance their learning performance of electricity in secondary school education.

Based on the aforementioned, this study investigates an effect of inquiry-based science learning with visualized simulation on middle school students' perceptions on degree of perceived learning, flow, enjoyment, perceived ease of use, perceive of usefulness, and perceive of satisfaction. The proposed question of this study is "Do the middle school students who learn with simulation-based inquiry learning in electricity show positive perceptions towards the learning experience?".

2. Literature Reviews

2.1 Computer Simulation

Computer simulation or simulation has been used extensively as a visual representation tool to simplify dynamic and theoretical models of real world phenomena or processes (Srisawasdi et al., 2016). Learners can formulate hypotheses about the simulated environment and test the hypotheses by changing parameters in the simulation and observing the way in which the simulation responds to these changes (Lee, Plass, & Homer, 2006). Computer simulations support activities of observation, and reflection help in facilitating the learning of abstract concepts (Chen et al., 2011; Colella, 2000; Bell & Trundle, 2008), that it works with remedial by producing change to student's misconceptions. Computer simulations also improve scientific process skills (Geban, Askar, & Ozkan, 1992), performance of gaining more qualitative knowledge (Staggers & Norcio, 1993), coherent understanding of the concepts (Russell et al. 1997), and advanced mental model (Carlsen & Andre, 1992).

2.2 Simulation-based Inquiry Learning in Science

Computer simulation is currently considered as a cognitive visualized tool for effective support of student learning in science by presenting dynamic theoretical or simplified models of real-world components, phenomena or processes, enlarging students to observe, explore, recreate and receive immediate feedback about real objects, phenomena and processes (Srisawasdi, 2015). Inquiry-based learning with computer simulation is generally seen as a promising area for science ideas. In addition, visualization features of computer simulation facilitated cognitive process of new knowledge and existing knowledge, and improve conceptual understanding in science phenomena (Cook, 2006; Srisawasdi and Sornkhatha, 2014). Moreover, simulation-based inquiry has been becoming a pedagogical approach for enhancing student's conceptual learning in the school science. By interacting with this approach, students practice scientific knowledge of the concept modeled by the simulation (de Jong et al, 2013; Lazonder et al., 2010; Vreman-de Olde et al., 2013; Srisawassdi & Kroothkeaw, 2014).

2.3 Perception toward Learning Technology

Perception toward learning technology is an important factor which refers to the quality of teaching or learning environment. It could be used to indicate the significant of learning and the significance refers to making learning meaningful and important to learners, drawing connections with prior knowledge and contexts outside of the classroom and facilitating multiple ways of knowing cultural perspectives (Xu & Moloney, 2011). Currently, there are many perceptual constructs that researchers employ in educational research and development. Caspi and Blau (2008) mentioned to the perceived learning that it refers to a set of beliefs and feelings one has regarding the learning that has happened. Flow is a perceptual construct that describes a state of deep concentration in which thoughts, intentions, feelings, and all of the senses are focused on the same goal and it happens when learners engage with challenging activities (Csilszentmihalyi, 1990). Enjoyment could be another perceptual construct which happened in the process of interacting with new learning environment and refers to conditional effect of positive reactions toward media and its contents (Fang & Zhao, 2010). Cheng (2014) mentioned that there are another two key factors in determining acceptance of using new technology for a specific purpose. Firstly, perceived ease of use is a person believes degree that using a particular system would be free of effort (Davis, 1989). Another construct is perceived usefulness that is defined as a degree of a person believes that using a particular system would enhance job performance (Fang and Zhao, 2010). In addition, perceived satisfaction is the individual awareness of how well a learning environment supports academic success, and it has been defined as the pleasure or contentment one feels when person performs a required or desired action and experiences the result (Shee & Wang, 2008).

3. The Context of Simulation-based Guided-inquiry Learning in Electricity

To enhance middle school students' scientific understanding and inquiry-based practice of science, a scientific laboratory activity of guided-inquiry learning (Buck et al., 2008) was employed into the context of electricity learning activity in this study. This simulation-based guided-inquiry learning was aimed to afford students' active conceptual learning in the concept of electricity. In this study, a physical science lesson of electric circuit has been designed regarding the simulation-based guided-inquiry learning process that they have never experienced in science classes before. To promote their learning with simulation, an interactive computer-simulated experimentation on "Circuit Construction Kit" obtained from Physics Education Technology (PhET) research group at University of Colorado, Boulder, was used as inquiry tool for the students. Previous researches showed that students who used this simulation demonstrated higher mastery of electrical concepts than students who did not use the simulation, and they were also able to perform better on challenge learning task of electricity (Finkelstein et al. 2005). Figure 1 displays an example of the PhET Circuit Construction Kit simulation.

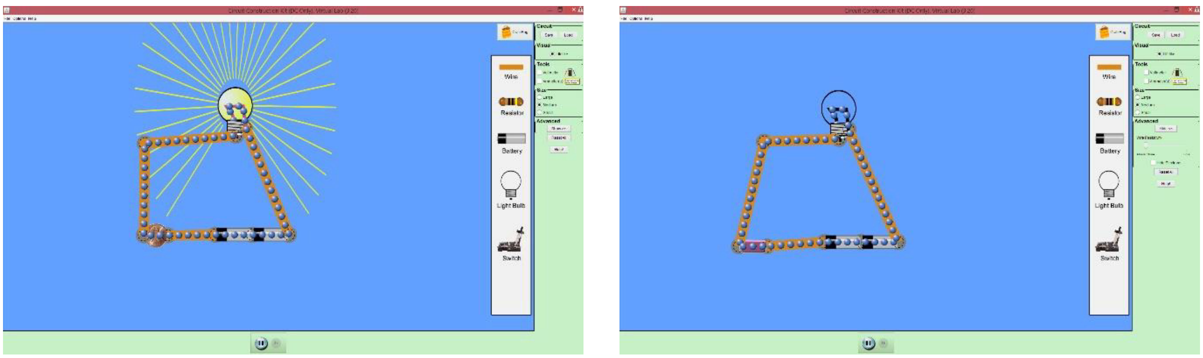

Figure 1. An illustrative interface example of the Circuit Construction Kit simulation by PhET: visualizing scientific concept of conductor (Left) and insulator (Right)

This learning activity begins with an open-ended driving question targeted to alternative conceptions commonly found in conceptual physics of electricity. To assist the process of hypothesis generation addressed the driving question, essential scientific backgrounds or information was provided to the learners. Then, a series of testable hypotheses were presented to them activating their prior experience and supporting a conceptual connection between preconception and the new-coming information. To create a space for their thinking, they were required to design an investigative experiment with simulation; analyzing the data, communicating results of experiment, and drawing a conclusion based on evidence for testing their own selected hypotheses (see Table 1.)

Table 1. Components of simulation-based guided-inquiry learning and examples of learning process

Components of simulation-based guided-inquiry learning	Examples of learning process
Pre-lab	
Question/Problem	Teacher provided an open-ended inquiry question: "What will happen to the light bulb if we replace a penny with a rubber?"
Theory/Background	Teacher induced an open forum discussion about definition of conductor and insulator, and pattern of electron flow in electric circuit.
Lab	
Procedures/Design	Teacher presented a series of experimental hypotheses, the simulation, and then introduces the experimental procedure to students. Moreover, teacher also explained what kinds of the experimental data that the students should collect from the simulation.
Results analysis	After the interacting with simulation, students make a decision to analyze obtained experimental data from their own design and interpret it into results.
Post-lab	
Results communication	Students have to select the way to present, communicate, and discuss the meaning of data and experimental results to others.
Conclusions	Students have to collaboratively make a relationship between each group results and then draw it into a conclusion as the best answer to the provided inquiry question.

4. Methods

In this study, the researchers conducted an exploration to middle school students' perception toward simulation-based guided-inquiry learning pedagogy. The findings of the exploration provided us as a basis in order to design a novel learning experience for physics learning of electricity.

3.1 Participants

This study was conducted with a total of 18 middle school students who are studying in seventh grade and range of age is between 13-14 years in a local public school at the Northeastern region of Thailand. The participants in this study have not experienced yet with the use of computer simulation in science education, but they have good using experience with computer. In addition, they have not been taught on the concepts of electricity in regular physical science class before participating in this study.

3.2 Research Instrument

After interacting with simulation-based guided-inquiry learning in electricity, the students were administered to complete a 21 items of 5-points Likert scale perception questionnaire. The perception questionnaire was divided into six motivational constructs e.g. perceived learning (4 items), flow (5 items), enjoyment (3 items), perceived ease of use (3 items), perceived usefulness (3 items), and perceived satisfaction (3items), and its reliability on each motivational construct were ranging from 0.737 to 0.842. For each item, respondents were assigned to rate how much the respondent agree of five scale, from 1-strongly disagree to 5-strongly agree. The data was analyzed using SPSS 17.0 to depict their perceptions toward the inquiry learning.

3.3 Data Collection and Analysis

In order to explore the middle school students' perceptions, they were administered the 21 items of perception questionnaire for 30 minutes after their interaction with a lesson of simulation-based learning in physics of electrical conductor and insulator for 60 minutes. The perception questionnaire was classified into six perceptual constructs, and total score for all perceptual constructs was 105 points. To analyze their perception scores, mean, standard deviation, and percentage were used to indicate their perceptual status after interacting with the simulation-based physics learning. Figure 2 shows a pilot implementation of simulation-based learning in physics of electricity. Moreover, eight students participated in individual interview for investigating qualitatively their perceptions toward the learning experience.

Figure 2. Students' participation with simulation-based inquiry learning in physical science class

4. Results and Discussion

To evaluate the middle school students' perceptions toward simulation-based inquiry learning in electricity, six perceptual constructs have been used to frame their perceptions. Table 2 shows the calculation of mean, standard deviation (S.D.), and percentage of their perceptions on perceived learning (PL), flow (FL), enjoyment (E), perceived ease of use (PEU), perceive of usefulness (PU), and perceive of satisfaction (PS). The statistical analyses of the data suggested that they prevalently have positive perceptions toward the simulation-based inquiry learning and there were some degree of difference between their perception scores.

Table 2. Mean, standard deviation (S.D.), and percentage of students' perceptions toward simulation-based inquiry learning of electricity

Statistics	**Perceptual Constructs**					
	PL	**FL**	**E**	**PEU**	**PU**	**PS**
Mean	15.06	16.61	11.83	10.72	11.22	11.61
S.D.	2.48	3.03	2.38	1.90	2.41	2.52
%	75.28	66.44	78.89	71.48	74.81	77.41

A graphical representation of the Table 2 is visualized in Figure 3, which allows to see some degree of difference of their perceptions.

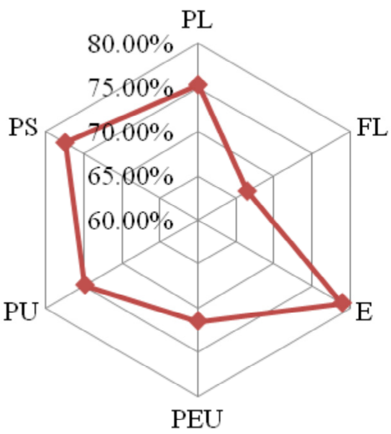

Figure 3. A graphical representation of middle school students' perceptions toward simulation-based inquiry learning of electricity

In Figure 3, the highest percentage of students' perceptions toward simulation-based inquiry learning were enjoyment (E) (78.89%), perceived satisfaction (PS) (77.41%), perceived learning (PL) (75.28%), perceived usefulness (PU) (74.81%), perceived ease of use (PEU) (71.48%), and flow (FL) (66.44%), respectively.

In addition, the qualitative data obtained from individual interview after participating with the simulation-based inquiry learning represented positive degree of their perceptions. The results are presented as synthesized findings addressed each motivational construct. For the flow of learning experience, most of the interviewees mentioned a limited time for performing an experiment with simulation as follow examples:

"We need more time to conduct the experiment with simulation following the provided work sheet. I could not complete the assignment on time."

"There was a limited time for doing experiment. I am still want to do the computer-based experimentation because it is very fun."

For the enjoyment, all of interviewees expressed their positive emotion to the inquiry learning as follow examples:

"Yes, I like it. This activity is a new learning experience that I never have before."

"Yes, I like to do experiment with simulation. It is very fun."

The interviewees suggested that they perceived a new way of learning and they can observe the electricity on screen. This indicated their perception on the motivational construct of perceived learning as shows in the follow examples.

"It is very good. I can see electron flow in electrical circuit and the illumination of light bulbs in computer"

"I can understand how to do experiment on conductor and insulator and I can also see electric current."

For perceived satisfaction, the interviewees revealed their positive perceptions on the learning activity, as display in the following examples.

"I like this class. I like to interact with simulation."

"I like this because I can do experiment by a new way that I never think before."

Moreover, they expressed positive perception on the usefulness of this learning activity that they can learn physical science experiment easier, as display in following examples.

"I can understand electrical conductor and insulator by doing experiment on computer screen."

"I can see electric current and how the light bulb illuminates by the flow of electric current."

Finally, their perceptions on the perceived ease of use towards the inquiry learning activity has been reported by the interviewees as display in following examples.

"Learning with simulation was not difficult. It is fun."

"It seems to be difficult at the first experience. However, I can do experiment via computer by myself after having an interaction with it"

5. Conclusion

This study reported a pilot study investigating an effect of simulation-based inquiry learning of electricity on middle school students' perceptions of perceived learning, flow, enjoyment, perceived ease of use, perceived usefulness, and perceived satisfaction. The findings indicated that they prevalently have positive perceptions after interacting with the simulation-based inquiry learning and the highest percentage of their perceptions were enjoyment, perceived satisfaction, perceived learning, perceived usefulness, perceived ease of use, and flow, respectively. According to the results, the main implications of this study is the redesign of simulation-based inquiry pedagogy for physics teaching of electricity in order to improving middle school students' learning performances both cognitive and affective domain. However, the learning design of simulation-based guided-inquiry approach was perceived positively by students and it could be an effective teaching strategy in physical science course. In future work, the researchers would develop a learning module of the approach and then implement in physical science class for improving the middle school students' learning performances on electricity.

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