A Two-phase Study of Investigating Lao PDR Preservice Physics Teachers' Perceptions toward the Use of Computer Simulation in Physics Education

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Abstract: The teaching of physics in Lao People's Democratic Republic (Lao PDR), generally, offers conceptual ideas to students by using mathematical equations, rather than core ideas of physics. Many researchers reported that this way of instruction made students memorization of scientific facts, rather than understand its concepts, and they may have no motivation to learn physics. According to the mentioned problem, this paper reported a two-phase study investigating preservice physics teachers' prior conceptual understanding and physics motivation, and perceptions toward simulation-based learning in physics of electricity. The participants were 32 sophomore students in Department of Physics, Faculty of Education, Savannakhet University, Lao PDR. In phase I, they were investigated preconception of electricity concepts and their physics motivation using 12 two-tier multiple- choice items and 25 items of 5-point rating scale, respectively, and it was observed that the preservice physics teachers held many misunderstanding about electricity and they had low level of physics motivation. In phase II, they were, then, examined their perceptions toward the use of computer simulation for physics learning after interacting in a simulation-based inquiry learning activity, and it was examined that they expressed positive perception on the learning, where the highest perception scores was on enjoyment (E), perceive of usefulness (PU), perceive of satisfaction (PS), perceive learning (PL), Flow (FL), and perceive ease of use (PEU), respectively. Moreover, the qualitative results showed that they can interact with computer simulation and learn physics concepts of electricity from the activity. The main implications of this study is the rethinking of pedagogy used for teaching physics of electricity in order to improving the preservice physics teachers' conceptual understanding, fostering their physics motivation, and enhancing pedagogical ideas and performance on how to teach physics with computer simulation.

Keywords: Teacher education, preservice, physics education, perception, understanding, motivation

1. Introduction

In present day, technology has profound and lasting impacts in school classrooms as being a powerful instructional tool (Srisawasdi, 2015). Researcher, educators, and developers believed that several technologies including probeware, computer simulations, software applications, programmable instruments, mobile devices, and laptop/notebook computers could be used effectively to impact student learning in science subject. As such, digital technologies became effective tools to support teaching and learning in today classroom (Vreman-de Olde, 2013; Srisawasdi & Sornkhatha, 2014). Recently, computer simulations, which contain visualization and features for representing an authentic system or phenomena, have a number of instructional features that has been recognized as a pedagogical tool for teaching and learning in science (Blake & Scanlon 2007; Wellington 2004). In addition, computer simulations are influential tools which can make unobservable phenomena being visual representation and also could support students' conceptual learning in science. Researchers reported that the pedagogical use of computer simulation can help student reducing and eliminating alternative- or misconceptions in science, and review and also can improve scientific conceptual understanding and advanced mental model of scientific phenomena (Srisawasdi & Kroothkeaw, 2014; Suits & Srisawasdi, 2013).

In context of Lao PDR country, there is very important for science teaching and learning to use innovative learning technology, such as computer simulation, as a potential tool for students learning in science. However, science teachers in Lao PDR rarely used computer simulation in their class ranking from elementary school to college or university, even it adds several educational values to science learning activities. In fact, science teaching in Lao PDR seemed to focus on content represented on textbooks and by teachers rather than student-centered learning approach and learning science as way of knowing. In term of physics teaching, most of physics teachers in Lao PDR taught physics subject in class by emphasizing mathematical equations for explaining physical phenomena and lecturing theoretical physics without situational and authentic contexts. In context of teacher education program at University of Savannakhet in Lao PDR, preservice physics teachers have not a positive perception to study physics because physics is difficult and hard to understand, due to its abstraction and complexity by nature. As such, there is a need and call for development of preservice physics teachers' teaching performance for supporting and enhancing physics learning with the use of technology-enhanced learning tool such as computer simulation. In this research, the researchers conducted a two-phase study for investigating sophomore preservice physics teachers' conceptual understanding of electricity and their physics motivation, and also examined their perception toward simulation-based learning on electricity at Department of Physics, Faculty of education, Savannakhet University, Lao PDR.

2. Literature Review

In several decades, computer technology can play important roles in the science classroom and laboratory, and one type of computer application in science education is computer simulation or simulation. To enhance the learning of scientific phenomena, computer-based modelling tool, such as computer simulations, have been used extensively as a visual representation tool to advocate presenting dynamic theoretical or simplified models of real world components, phenomena, or processes (Srisawasdi et al., 2016). Many instructional qualities of computer simulation are potentially useful for promoting conceptual development in science and inducing cognitive dissonance of conceptual change (Srisawasdi & Kroothkeaw, 2014; Srisawasdi & Panjaburee, 2015). In science education community, computer simulations are promising area for enhancing the development of conceptual comprehension and inducing the change of misconceptions in science (Bell, 2012). Recent research indicated that computer simulation can effectively support teachers' efforts to integrate inquiry instruction in their science classrooms (Higgins & Spitulnik, 2008; Varma et al., 2008). Smetana and Bell (2012) pointed out that computer simulation can be effective instructional practices in promoting science content knowledge and developing process skills. However, to be most effective, computer simulation should be situated in a substantial and flexible framework of knowledge of content, pedagogy, and technology.

In order for teachers to develop professional teaching performance for successful integration of computer simulation, it is important for them to understand what such instructional practices involve and consider how they may be of value to teaching and learning. Moreover, positive perceptions toward simulation-based learning in science were a necessary for professional development of preservice and in-service science teachers. Therefore, the effective use of computer simulations requires teachers' positive perceptions as well as how to specifically use to the curriculum, students, and classroom setting.

3. Methods

3.1 Participants

The participants in this study were 32 sophomores preservice physics teachers at Department of Physics, Faculty of Education, Savannakhet University, Lao PDR. In phase I, they were recruited to explore physics conceptual understanding of electricity and their motivation to learn physics in the first semester of academic year 2015. After, they were, in phase II, recruited to interact with a physics lesson of simulation-based learning of electricity, and examined their perceptions toward the simulation-based learning experience in another semester later.

3.2 Research Instruments

In phase I, the researchers aimed to explore current status of sophomore preservice physics teachers' conceptual understanding of electricity and their physics motivation. As such, the researchers used 12 of two-tier multiple-choice items measured physics conceptual understanding of electricity, including (i) electric circuit, (ii) current law in series circuit (iii) current law in parallel circuit, (iv) voltage law in series circuit, (v) voltage law in parallel circuit, and (vi) Ohm's law. In order to investigate their physics motivation, 25 items of 5-point rating scale questionnaire measured intrinsic motivation (IM), career motivation (CM), self-efficacy (SEC), self-determination (SDT), and grade motivation (GM). In phase II, 21 items of 5-point rating scale questionnaire measured perceived learning (PL), flow (FL), enjoyment (E), perceived ease of use (PEU), perceive of usefulness (PU), and perceive of satisfaction (PS).

3.3 Data Collection and Analysis

In order to explore the preservice physics teachers' conceptual understanding of electricity and their physics motivation in the phase I, they were administered the 12 two-tier multiple-choice conceptual understanding test and the 25 items of physics motivation questionnaire for 60 and 15 minutes, respectively. For the multiple-choice test, each two-tier item was scored by 1 point and total score was 12 points. The students' responses were calculated by frequency and percentage of the complete score. For exploring their physics motivation, the questionnaire classified into five motivational constructs and total score for all motivational constructs was 125 points, 25 points each construct. Their responses to the questionnaire were calculated into mean and standard deviation. In phase II, the preservice teachers were administered the 21 items of perception questionnaire for 15 minutes after their interaction with a lesson of simulation-based physics learning of electricity in 60 minutes. The perception questionnaire classified into six perceptual constructs, and total score for all perceptual constructs was 105 points. To analyze their perception scores, percentage was used to indicate their perceptual status after interacting with the simulation-based physics learning. Figure 1 shows a pilot implementation of simulation-based physics learning of electricity. Moreover, the preservice physics teacher was assigned to interact with simulation in dyads and each dyad was assigned to interact and collect data into an experimental work sheet.

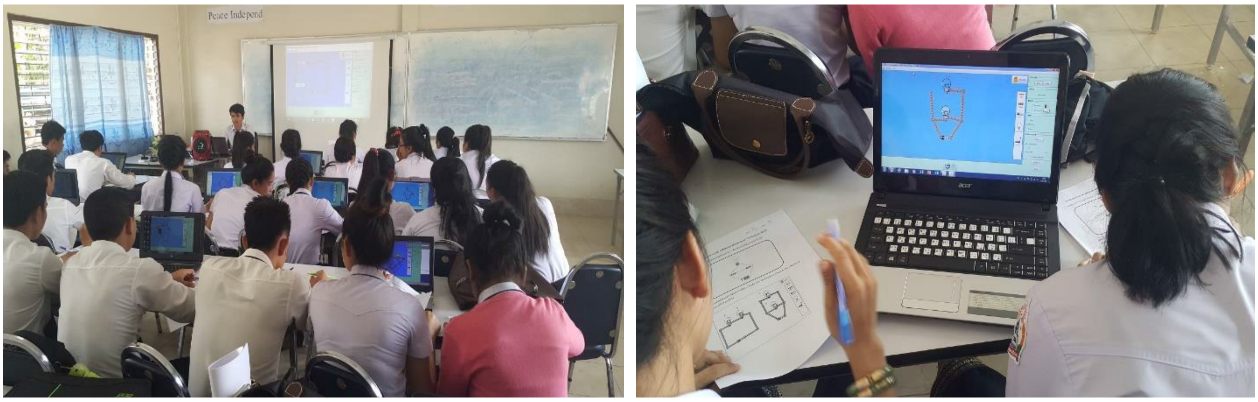


Figure 1. Illustrations of simulation-based learning activity: teacher introduced how to learn physics of electricity with simulation (Left) and preservice physics teachers interacted to collect experimental data with the simulation (Right)

4. Results

In this section, the researchers present the results into two phases. The results of phase I study indicated current status of the preservice physics teachers' conceptual understanding of electricity and their physics motivation. Another, the evaluation of the preservice physics teachers' perceptions toward simulation-based physics learning of electricity in phase II was reported in this section.

4.1 Phase I: Conceptual Understanding of Electricity and Physics Motivation

4.1.1 Conceptual Understanding of Electric Current

Figure 2 reports the percentage of the preservice physics teachers' conceptual understanding scores classified into misunderstanding and scientific understanding on six concepts, i.e. C1-electric circuit, C2-current law in series circuit, C3-current law in parallel circuit, C4-voltage law in series circuit, C5-voltage law in parallel circuit, and C6-Ohm's law.

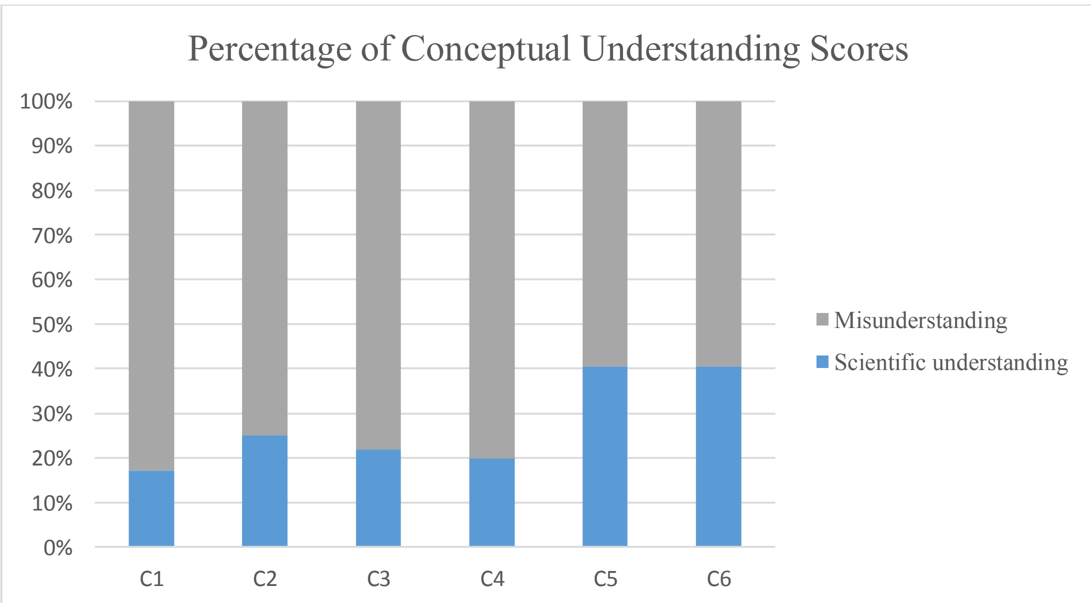


Figure 2. Percentages of mean score of conceptual understanding

In Figure 2, the highest percentage of misunderstanding was relied on C1(82.81%), C4(80.21%), C3(78.13%), C2(75.00%), C5 and C6 (59.38% both), respectively. In addition, the percentage of misunderstanding on all concepts indicated that the preservice physics teachers hold unscientific conceptions or understanding on physics of electricity in school science level.

4.1.2 Physics Motivation

Figure 3 displays the percentage of the preservice physics teachers' physics motivation scores classified into five motivational constructs, i.e. intrinsic motivation (IM), career motivation (CM), self-efficacy (SEC), self-determination (SDT), and grade motivation (GM).

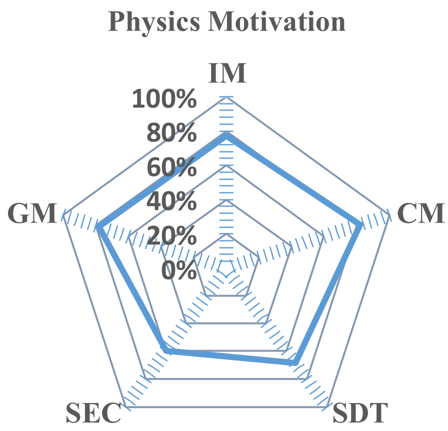


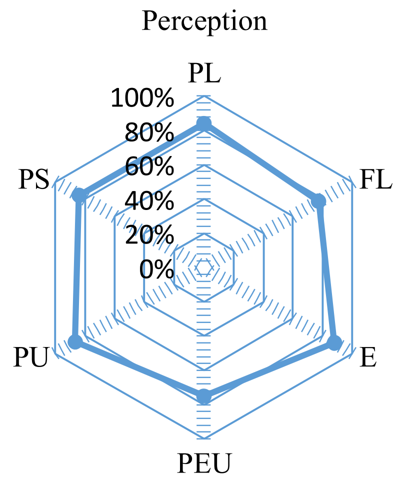
Figure 3. Mean score of 5-point rating scale physics motivation

For the results of physics motivation displayed in Figure 3, the highest score was relied on CM (82.13%), GM (78.00%), IM (77.13%), SDT (68.50%), and SEC (59.75%), respectively. The Figure 3 reveals a different level of motivation on each motivational constructs. This indicated that the preservice physics teachers had a high level of extrinsic motivation, i.e. CM and GM, and a middle level of intrinsic motivation, i.e. IM, SDT, and SEC, to learn physics.

4.2 Phase II: Perceptions toward the Learning Experience of Simulation-based Learning in Physics and Performance to Learn with Simulation

4.2.1 Perceptions toward Simulation-based Learning

To evaluate the preservice physics teachers' perceptions toward simulation-based physics learning of electricity, six perceptual constructs have been used to frame their perceptions. Figure 4 shows the 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).



In Figure 4, the highest percentage score of their perceptions were relied on E (87.92%), PU (86.67%), PS (84.17%), PL (84.06%), FL (77.25%), and PEU (75.00%), respectively. The Figure 4 allows to see a positive trend of their perceptions on each perceptual constructs. This indicated that the preservice physics teachers had a high level of perceptions towards simulation-based learning in physics of electricity.

4.2.2 Performance to Learn with Simulation

During they interacted with simulation, each dyad received an experimental work sheet and was assigned to complete the work sheet within 60 minutes. To explore their learning performance with simulation, the researchers analyzed and interpreted their worksheet and found that most of them are able to interact and then extracted scientific understanding of electricity from the simulation. However, a few of them still encountered with difficulty to learn with the simulation. Figure 5 illustrates examples of the preservice physics teachers' experimental data sheet obtained from the interaction with simulation.

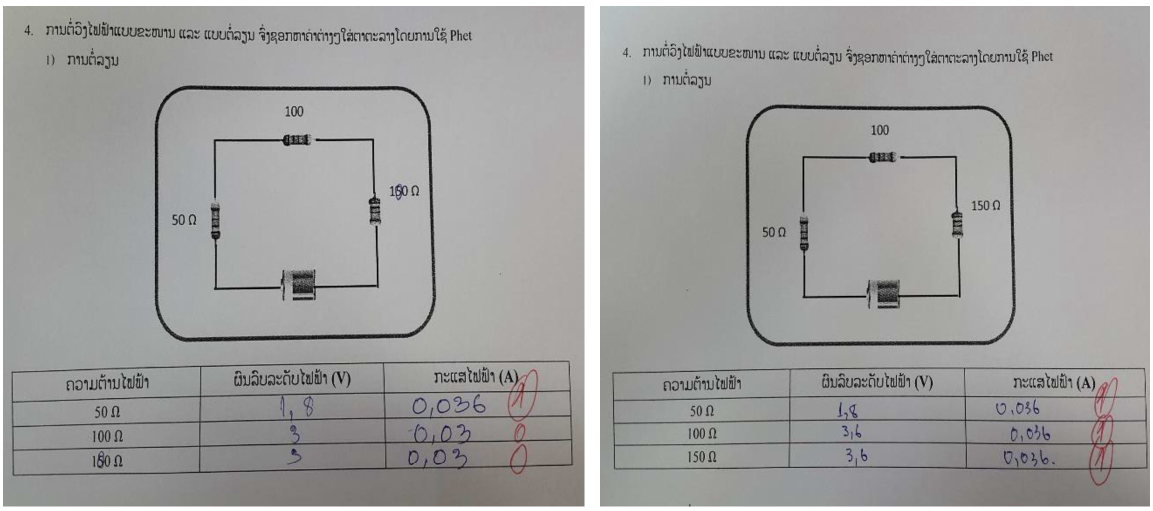


Figure 5. An illustration of preservice physics teachers' experimental data sheet: an example of a wrong answer (Left) and a correct answer (Right) obtained from the simulation-based learning

5. The Design of Simulation-based Guided Inquiry Learning for Physics of Electricity

In order to enhance the preservice physics teachers' conceptual understanding of electricity and promote their motivation towards physics, the researchers propose a learning design of simulation-based guided inquiry on physics of electricity. Figure 6 illustrates a representative diagram of the learning design regarding a harmonization of conceptual physics of electricity, computer-simulated experimentation or simulation, and a pedagogic approach of guided inquiry.

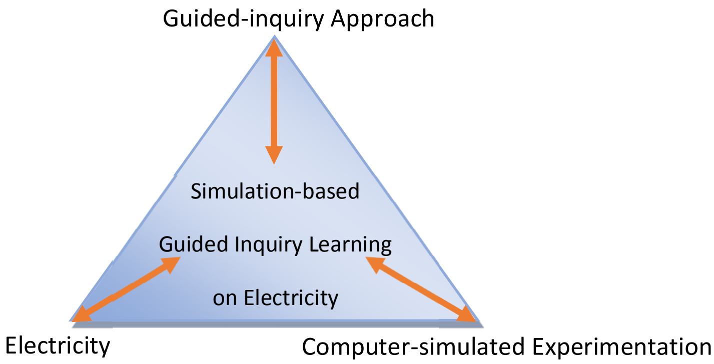


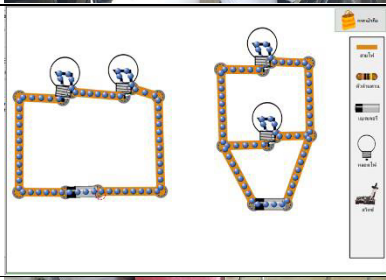
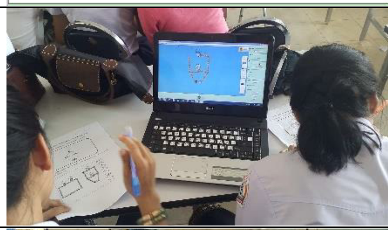
Figure 6. A learning model of simulation-based guided inquiry on electricity

In this proposed learning design, the researchers aim to promote preservice physics teachers' active conceptual learning in the concepts of electricity by visualizing the abstract and complicated physics phenomena, and also encourage them to participate with simulation through way of inquiry learning for improving their physics motivation. This learning design 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 are provided to learners. Then, a series of testable hypotheses are 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 are required to perform designing of an investigative experiment with simulation, analyzing the data, communicating results of experiment, and drawing a conclusion based on evidence for testing of their own selected hypotheses (see Table 1.)

6. Conclusion and Future Work

This two-phase study demonstrates current status of Lao PDR preservice physics teachers' conceptual understanding of electricity, physics motivation, and perceptions toward simulation-based learning with simulation. The results suggested that the preservice physics teachers held many misunderstanding or unscientific conceptions on electric circuit, current law in series and parallel circuit, voltage law in series and parallel circuit, and Ohm's law. The results, also, suggested that they had low level of intrinsic motivation, career motivation, self-efficacy, self-determination, and grade motivation. Due to interacting with new experience of simulation-based learning, they expressed positive perception on the perceptual constructs of perceived learning, flow of experience, enjoyment, perceived ease of use, perceived usefulness, and perceived satisfaction. According to the results, the main implications of this study is the rethinking of pedagogy used for teaching physics of electricity in order to improving the preservice physics teachers' conceptual understanding and fostering their physics motivation. As such, a learning design of simulation-based guided inquiry approach would be implement in a physics coursework for Lao PDR preservice physics teachers. The future work is to develop a module of the approach and then implement into a real context of coursework in Lao PDR.

Table 1. Components of simulation-based guided inquiry learning on electricity

Components of simulation-based guided inquiry learning		Examples of learning process	Examples of learning activity
Pre-lab	Open-ended inquiry question	Teacher provides an open-ended inquiry question: If we have two lamps (A and B) on a parallel circuit, and the lamp A is lost, what would happen to another lamp? Explain.	
	Scientific background/ information	Teacher induces collaborative discussion toward the definitions and pictorial diagram of electricity.	
Lab practice	Procedure/design	Teacher presents a series of hypotheses, the simulation, and then introduce the experimental procedure to students. Moreover, teacher also explains what kinds of the experimental data that the students should collect from the simulation.	
	Data and result 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	Result communication	Students have to select the way to present, communicate, and discuss the meaning of data and experimental results to others	
	Conclusion	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	

Acknowledgements

This study was financially supported by Thailand International Cooperation Agency (TICA), and Graduate School and Faculty of Education, Khon Kaen University, Thailand.

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