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Developing Interactive Simulation in Physical Science for Eliminating Students' Misunderstanding of Heat Transfer: A DSLM Approach

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Abstract: Currently, interactive science simulation has been recognized as pedagogical tool in science education in several countries, and the strategic use of science simulation has changed the way of active learning in science. Researchers and educators have reported benefits of science simulation in promoting motivation to learn science and enhancing scientific conceptions for students, especially in compulsory education. This paper illustrates a development of interactive computer-simulated laboratory lessons in physical science for middle school students. For this development, the researchers utilize Dual-Situated Learning Model (DSLM) for producing the interactive science simulation and a series of dual-situated learning activity about heat transfer in physical science subject. In this preliminary study, a total of 129 middle school students in seventh grade in a public secondary school located northeastern region of Thailand participated in the development. All of them were administered a series of two-tier question items in order to discover their misunderstanding of heat transfer concepts. The exploratory result shows that the middle school students hold many types of misconceptions and incomplete conceptions in the physical science concepts related to heat transfer. Moreover, some of them had no conceptions about heat transfer even they have learned the concepts already. As such, the researchers illustrate a conceptual idea of designing an interactive science simulation addressing the physical science concepts of heat transfer for improving the students' conceptual learning performance, and it might enhance the change of student's misconceptions and their mental model development in science.

Keywords: Computer simulation, inquiry-based learning, DSLM, science concept, heat transfer

1. Introduction

Over the past decades, digital technologies have become commonplace in education reform because of their potential of bringing about change in ways of teaching and learning (Srisawasdi, 2012; 2016). Many researchers, educators, and developers have reported a problematic issue that students at all level came to science class with common misunderstanding in science concepts and students' misconceptions are highly resistant to change through un-design or traditional teaching in science (She, 2004). To solve these problems, the researchers reported the successful on the use of dual-situated learning model (DSLM) for enhancing students' conceptual understanding in science (e.g. Lee and She 2010; Liao and She 2009; She and Liao 2010; Srisawasdi and Kroothkeaw, 2014; Srisawasdi and Sornkhatha, 2014). Currently, with the support of technological features, interactive computer-simulated learning materials for science teaching and learning provide opportunities to better facilitate students' understanding of science concepts by visualizing the abstraction of science concepts into more concrete experience. Moreover, the interactive simulation could bring to change students' alternative conceptions into scientific conceptual understanding and advanced mental model of scientific phenomena (Srisawasdi, Kerdcharoen, and Suits, 2008; Suits and Srisawasdi, 2013). According to the abovementioned reasons, this study aims to specifically develop an interactive science simulation in physical science concepts of heat transfer for incorporating into simulation-based inquiry learning through DSLM approach. This interactive simulation will be used to facilitate middle school students' learning in school science for enhancing their scientific conceptual understanding and promoting science motivation in future study.

2. Literature Review

2.1. Dual-situated Learning Model (DSLM)

Dual-Situated Learning Model (DSLM) is one of the teaching and learning models which promotes students' conceptual development when alternative conceptions exist (She, 2003, 2004). The DSLM has been used in facilitating physical science learning in compulsory education, and the results showed that many misconceptions held by students were eliminated and reduced using DSLM with proper teaching methods and students had meaningful learning in science concept through the process of conceptual change (e.g. Srisawasdi and Kroothkeaw, 2014; Srisawasdi and Sornkhata, 2014).

The DSLM includes six stages of instructional procedure: (1) examining the attributes of the scientific concept; (2) probing students' alternative conceptions; (3) analyzing which mental sets the students lack; (4) designing dual-situated learning events; (5) instructing with dual-situated learning events; and (6) instructing with challenging-situated learning events (She, 2004).

2.2. Science Teaching with Interactive Computer Simulation

Concurrent with the rapid growth of computers and technologies in the practice of science education, technology-based approaches to science learning offer computer simulations with ample opportunities for inquiry-based learning environments in science (Rutten et al. 2012; Srisawasdi and Kroothkeaw 2014; Vreman-de Olde et al. 2013). Interactive science simulation is a computer-based visualization technology which can imitate dynamic systems of objects in a natural world supporting to the quality of the visual aids. In addition, it has been used extensively as a visual representation tool to advocate presenting dynamic theoretical or simplified models of real-world scientific phenomena or processes for students (Srisawasdi and Panjaburee, 2015). There are several educational values that computer simulation adds into science learning activities (Hennessy, Deaney, and Ruthven, 2006), especially in activity type of inquiry-based science. To address the learning difficulty in science, interactive simulation has been used with inquiry-based learning process and this pedagogy has increasingly become a statigic approach for enhancing students' conceptual learning and development in school science.

3. Methods

3.1. Study Participants

The participants for this study included 129 of seventh-grade students in a local public school located northeast region of Thailand. They age between 13 to 14 years old. The students never learn formally physical science concepts of heat transfer before, and all of them also never have formal learning experience with interactive computer simulation before.

3.2. Research Instrument

To investigate middle school science students' existing conceptions in physical science concepts of heat transfer, eight open-ended conceptual question items covering heat conduction (2 items), heat convection (2 items), heat radiation (2 items), and heat transferring (2 items) have been developed by the researchers regarding the dual-situated learning events about heat transfer proposed by She (2004).

3.3. Data Collection and Analysis

All students took the open-ended conceptual question items to complete it in 50 minutes. The data analysis was the primary method for analysis of students' written responses to the open-ended question items, represented their conceptual understanding about physical science of heat transfer. The researchers began with repeatedly read the students' written responses and then development of a general conceptual understanding category, analyzed, interpreted, and classified their responses into four categories i.e. scientific conception (SC), which refers to the responses that provides correct answer and appropriate reasoning in science; incomplete conception (IC), which refers to the responses that provides either correct answer or appropriate reasoning in science, without anything wrong; misconception (MC), which refers to the responses that provides incorrect answer and inappropriate reasoning in science; and no conception (NC), which refers to no response or the responses that provides not clear conception in science. The researchers have designed a series of dual-situated learning events for facilitating mechanism of change and revise of their alternative conceptions of heat transfer into scientific conception. The dual-situated learning events were emphasizing into the design of a computer simulation of heat transfer.

4. Results

The results show that there are many types of students' existing conceptions related to heart transfer concepts, as illustrates in Figure 1-4.

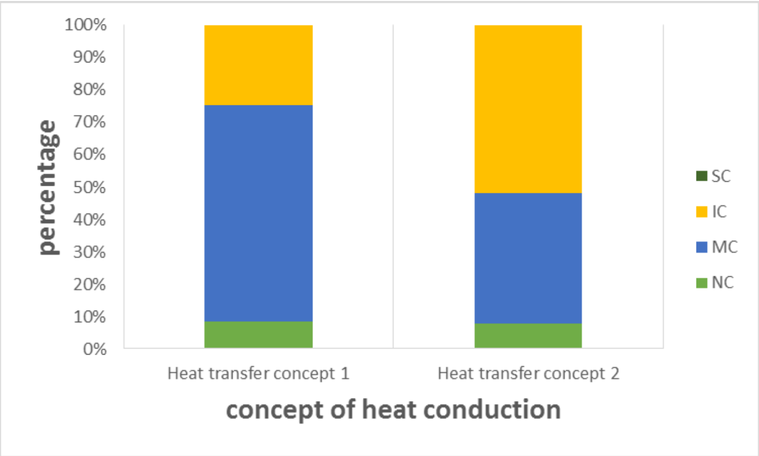

Figure 1. Distribution of students' misconceptions on heat conduction concept

According to Figure 1, the percentages for combination of mis- and no conceptions for heat transfer concept 1 of heat conduction and heat transfer concept 2 of heat conduction were 53.49% and 8.14%, respectively. The percentages of no conceptions of heat transfer concept 1 and heat transfer concept 2 were 8.53% and 7.75%, respectively. The result of students' mis- and no conceptions on heat convection was illustrated in Figure 2.

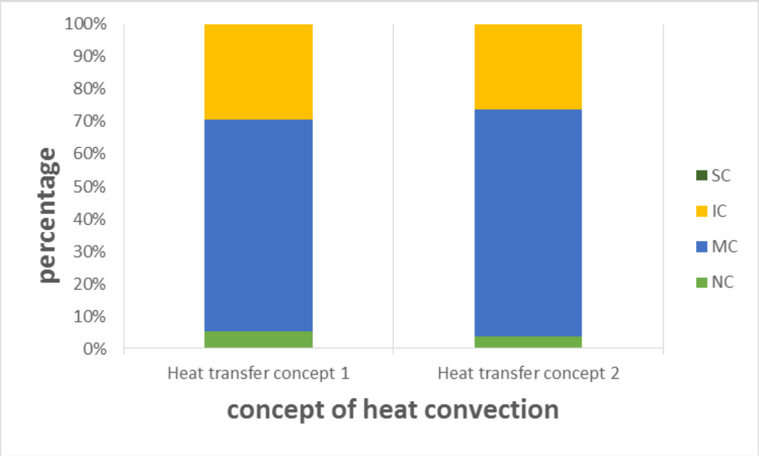

Figure 2. Distribution of students' misconceptions on heat convection concept

As seen in Figure 2, there was a small number of the students who hold no conception on heat convection (4.66%). However, more than a half of them showed misconceptions on the concept (67.45%). This means there need help for facilitating construction of conceptual understanding regarding the concept of heat convection. In the next, Figure 5, the result of students' mis- and no conceptions on radiation were presented.

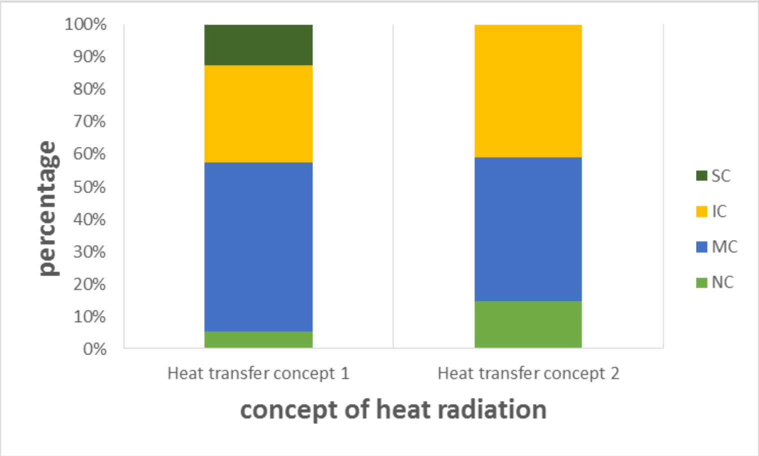

Figure 3. Distribution of students' misconceptions on heat radiation concept

Figure 3, the percentages for combination of mis- and no conceptions for heat transfer concept 1 of heat radiation and heat transfer concept 2 of heat radiation were 48.07% and 10.08%, respectively. The percentages of no conceptions of heat transfer concept 1 and heat transfer concept 2 were 5.43% and 14.73%, respectively. The result of students' mis-, no conceptions on challenge learning event concept was depicted in Figure 4.

As shows in Figure 4, the percentages for combination of mis- and no conceptions on heat transfer challenge learning event concept were 41.48% and 7.75%, respectively. The percentages of no conceptions of heat transfer concept 1 and heat transfer concept 2 were 3.10% and 12.45%, respectively.

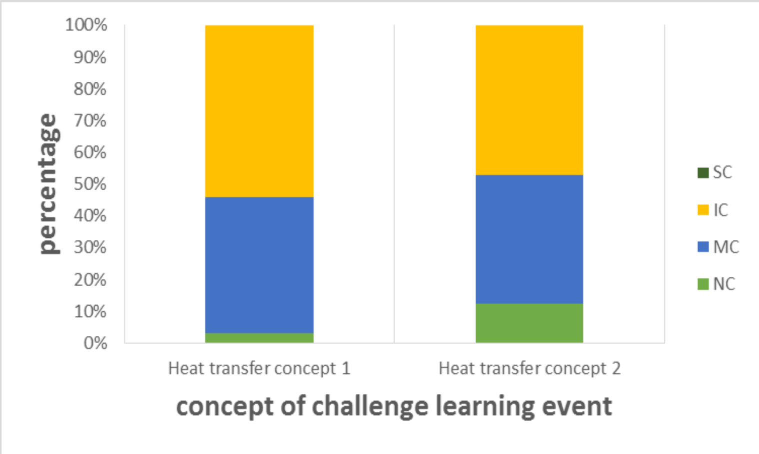

Figure 4. Distribution of students' misconceptions on heat transfer challenge learning event concept

5. The Proposed Design of Interactive Science Simulation on Heat Transfer

To facilitate the students' learning of heat transfer concepts through the designed learning events mentioned previously. Simulation was used as a conceptual tool to facilitate student's inquiry learning on heat transfer phenomena. The preliminary results indicated middle school students' common misconceptions of heat transfer, heat conduction, heat convection, and heat radiation. Moreover, the results revealed the learning difficulty of heat transfer and related concepts and the source of misunderstanding due to the invisibility of scientific phenomena and complexity of scientific concepts.

To eliminate the problem, it is important to make the physical science concepts of heat transfer to be more visible and touchable, especially in molecular or microscale level of scientific phenomena. Therefore, the heat transfer simulation has been designed to address the common misconceptions found in the preliminary study. The interactive simulation would be used pedagogically with specific dual-situated learning events for eliminating their misconceptions of heat transfer and enhancing their scientific conceptions. Figure 5 illustrates conceptual idea of the development of interactive simulation focused on heat transfer concepts.

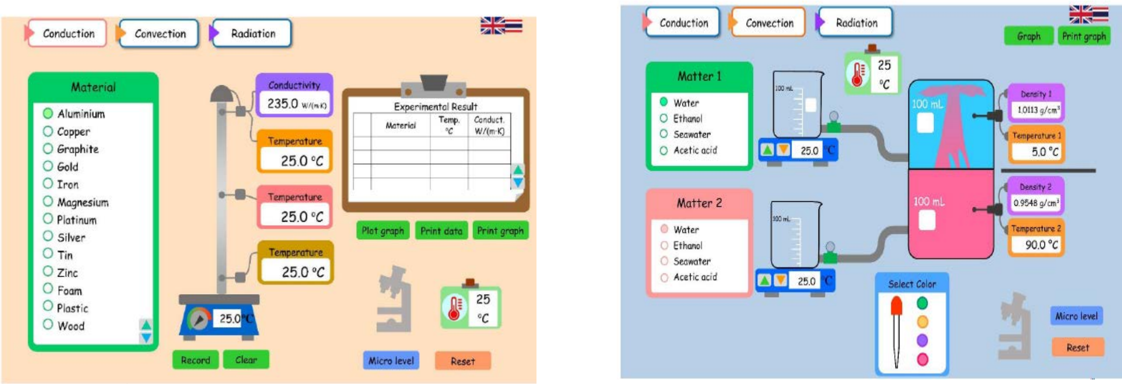

Figure 5. An illustrative example of the heat conduction (left) and heat convection (right) simulation

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