Chen, W. et al. (Eds.) (2016). Workshop Proceedings of the 24th International Conference on Computers in Education. India: Asia-Pacific Society for Computers in Education

How do They Perceive Model-based Inquiry with Computer-simulated Science Experimentation?: A Case of Thai Middle School Students

Puttawannee JUNNAMOM[a] & Niwat SRISAWASDI [b,c*]
[a]*Science Education Program, Faculty of Education, Khon Kaen University, Thailand*
[b]*Division of Science, Mathematics, and Technology Education, Faculty of Education, Khon Kaen University, Thailand*
[c]*Institute of Learning and Teaching Innovation, Khon Kaen University, Thailand*
*niwsri@kku.ac.th

Abstract: Computer-simulated experimentation, which is a visualization technology in science education, can imitate dynamic systems of authentic objects for making scientific sense to teachers and learners. To enhance science learning, the computer-simulated experimentation has been recognized as an important digital tool in the instruction. In this study, 20 middle school students in Northeast region of Thailand were recruited to interact with a physical science lesson through model-based inquiry learning with computer-simulated experimentation of light refraction. After experiencing with the model-based inquiry with the computer-simulated experimentation, they were administered a 21 items of 5-points rating scale questionnaire to examine their perceptions toward such experimentation. The results showed that the highest percentage of their perception was perceive of satisfaction, enjoyment, perceive learning, perceive ease of use, perceive of usefulness, and flow, respectively. Moreover, ten students volunteered to interview with a series of perceptual open-ended question and the results indicated their positive perceptions on the model-based inquiry learning experience with the computer-simulated experimentation of light refraction. This implied that the use of the computer-simulated experimentation for the model-based inquiry learning could be considered as a value learning experience for promoting minds-on science learning of middle school students.

Keywords: Simulation, inquiry, modeling, physical science, experiment

1. Introduction

Physics is a branch of science that is difficult to understand. Due to the learning difficulty of physics concepts, the way in which a physics course is taught, and physics problems which are sometimes very vague students (Redish, 1994). Computer simulation, which is a visualization-based technology, can imitate dynamic systems of objects in a real supporting to the quality of making sense by vision. It has been used extensively as a visual representation tool to simplify dynamic theoretical models of real world phenomena or processes (Suits and Srisawasdi, 2013). When the computer simulation coupled with reform-based teaching practices, it has been an effective way to support student learning of science. The quality of the technology itself, as well as how it is used, impacts how much students learn. Interactive simulations are dynamic virtual environments that are used to provide implicit scaffolding and targeted feedback (Hensberry, Moore and Perkins, 2015). In recent years, research has been revealed that the computer simulation could be used for supporting science learning. However, many researchers suggested that the computer simulation is important pedagogical tool for motivating students and making relevant science leaning (Suits and Srisawasdi, 2013).

Moreover, the modeling that aims to make the practice accessible and meaningful for learners is specified as scientific modeling as including the elements of the practice. It has been developed increasingly in sophisticated views of the explanatory nature of models by shifting from correct or incorrect models to encompassing explanations for multiple aspects of a target phenomenon (Schwarz et al., 2009). However, this view is challenged by recent data showing that the computer simulation with model-based inquiry has not been studied yet. The question remains computer simulation with model-based inquiry promotes science learning.

Consequently, this study has been proposed a computer simulation with model-based inquiry approach implemented on the refraction light topic. Such that, in this study, we have attempted to provide a novel approach to promote science learning by using the computer simulation with model-based inquiry to help students increase science learning performance. Before having that implementation, this paper as the first-phase study aims to investigate students' perceptions toward the proposed computer simulation with model-based inquiry.

2. Literature Review

2.1 Computer Simulation

Computer simulation is new technologies have made rich and dynamic visual representations possible on common personal computers. Previously, the power of typical computers is available in schools severely limited by the range of computer-based educational experiences of students. Educational simulations of this prior era were often based on simple line drawings, and the degree of interactivity was usually limited to setting one or two parameters and then watching a resulting animation. Modern computational power allows much complex models, higher visual representations, and gives users of educational simulations with control and flexibility to make changes and see the effects in real time. With these advances, simulations can provide students with opportunities to rich and dynamic educational experiences as well as instantaneous feedback on the results of a virtual experiment. In particular, the activities engaging students with modern computer simulations differ from those in traditional educational environments. The computer simulation provides students by accessing to questions and methods of inquiry, which are well aligned with the ways scientists use experiments for exploration and discovery. Prior work has been shown that children could be engaged in productive inquiry and exploration along these lines with computer simulations (Podolefsky, Perkins and Adams, 2010). Computer simulation has been widely used to enhance teaching and learning for last decades and researchers mentioned that the use of computer simulation experimentation could actively engage and enhance student's meaningful learning in subject contents. Concurrent with the progressive development in science education community, contemporary technology-based approaches to science learning offers computer simulations with ample opportunities for students' inquiry-related learning environments in science (Srisawasdi and Panjaburee, 2015). Researchers indicated that the computer simulation could facilitate students by reducing alternative conceptions, and improving conceptual understanding of science concepts (Suits and Srisawasdi, 2013).

2.2 Model-based Inquiry Learning with Simulation

Modeling is a core practice in science and a central part of scientific literacy. Researchers presented theoretical and empirical motivation to a learning progression of scientific modeling that aims to make the practice accessible and meaningful for learners. The sciatic modeling was included the elements of the practice, such as constructing, using, evaluating, and revising sciatic models and the meta-knowledge that guides and motivates the practice, such as understanding the nature and purpose of models. The learning progression of scientific modeling included two dimensions that combine meta-knowledge and elements of practice scientific models as tools for predicting and explaining, and models change as understanding improves (Schwarz et al., 2009). Modeling Designs for Learning Science has been developing a learning progression to represent successively in sophisticated levels of engagement and knowledge of scientific modeling practices. It is to make the core scientific practice accessible and meaningful for learners in the upper elementary and middle grades. A scientific model is an abstract, simplified, representation of phenomena that makes central features explicit and visible. It can be used to generate explanations and predictions (Harrison and Treagust, 2000). Model-based inquiry is a core component of science and a central part of scientific literacy. It is critical to reform-based science education efforts that emphasize students' participation in scientific practices. The model-based inquiry is an instructional approach in which learners are engaged in scientific inquiry and are sked to focus on the creation, evaluation, and revision of scientific models that can be applied to explain and predict the natural world (Duschl, Schwingruber and Shouse, 2007).

Moreover, simulation-based learning environments are considered as appropriate learning tools for manifesting conditions of conceptual change in science learning (Chen et al. 2013). Inquiry-based learning with simulations is a promising area for science-based instruction to foster learners' mental interaction with the physical and social world in order to develop scientific understanding, explanation, and communication among science ideas. Researchers have found that simulation-based inquiry learning works as a remedial process by producing change in the alternative conceptions held by learners (Srisawasdi and Panjaburee, 2015).

3. Method

3.1 Participants

The 20 eighth-grade students in a local public school at the northeastern region of Thailand were recruited to participate in this study. They came from the same class and ages between 13-14 years old. They have informal experience with the use of computer simulation with model-based inquiry in classroom

3.2 Learning Material and Activity

The computer simulation was designed on refraction of light, named Bending Light, obtained from Physics Education Technology (PhET). Many physical situations of light wave refraction are unusually observed, and it makes discrepant events bothering human common senses. Therefore, the design of conceptual learning events on light refraction with computer simulation supports students with visualizations of the refraction of light phenomenon and helps them build more scientific views of light refraction concepts. It was implicated to content of lights properties. The simulation defines situation to student for the exploratory phase. The student was asked to interact with computer simulation. Figure 1 shows examples of computer simulation and Figure 2 presents overall learning activities through the computer simulation with model-based inquiry. Moreover, Figure 3 shows middle school students' mental model showing how the About the phenomenon of refraction of light.

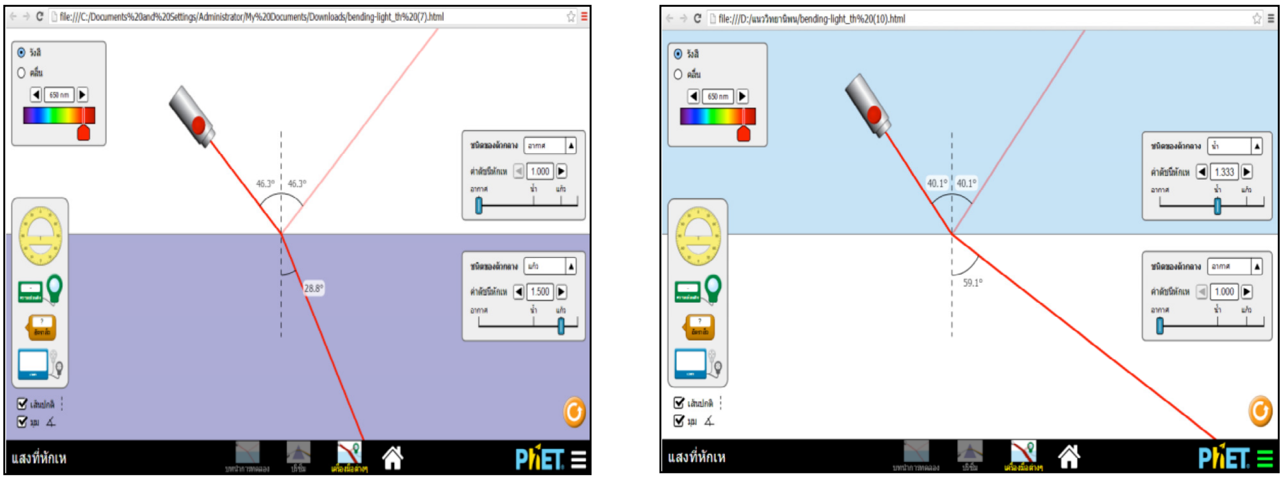


Figure1. Examples of computer simulation from Physics Education Technology (PhET) named Bending Light representing: boundary behavior of light refraction (left) and angle of refraction (right)

To enhance students' understanding of science concepts on refraction light, computer simulation obtained from PhET was utilized as visual aid of unobservable phenomena in the class. In an addition, the model based-inquiry strategy was used as an intervention for students' learning activities across light refraction concepts.

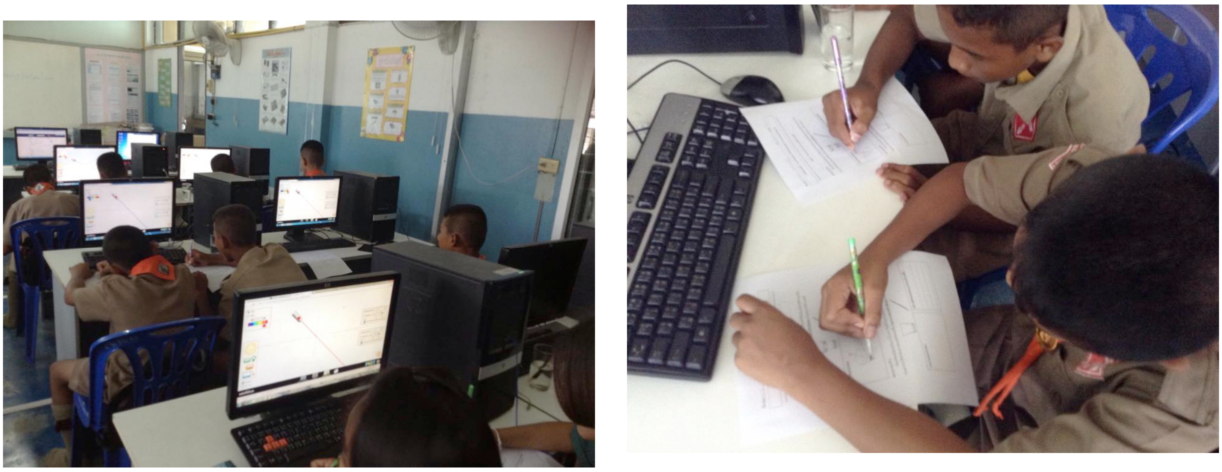
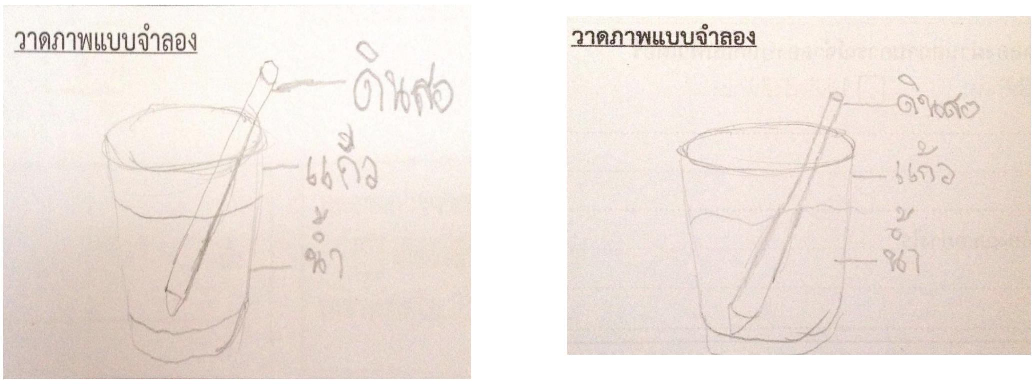


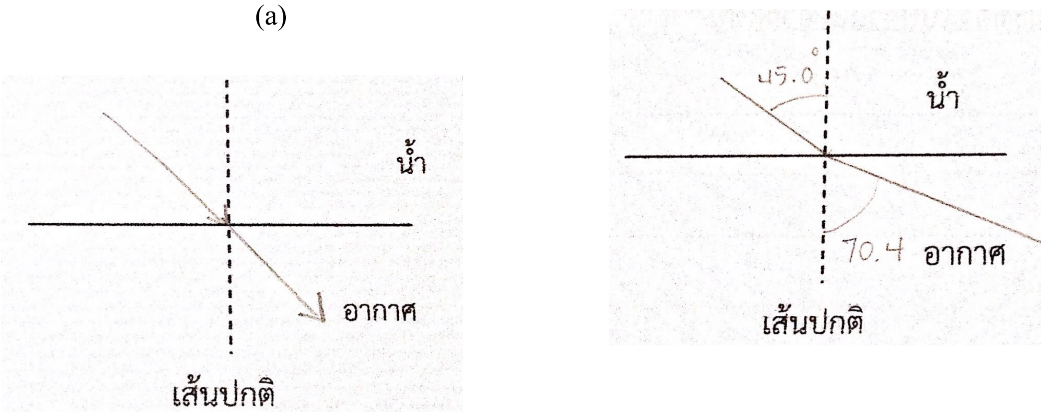
Figure2. Students' interaction with computer simulation (left) and their mental modelling within the model-based inquiry learning activity (right)

3.3 Research Instrument

This study employed a questionnaire for exploring students' perceptions toward computer simulation with model-based inquiry about topic refraction. A 21-item perception questionnaire was used to collect data in this study. There are six components, such as perceive learning (PL) consisting of four items, flow of learning (FL) consisting of five items, enjoyment (E) consisting of three items, perceive ease of use (PEU) consisting of three items, perceive of usefulness (PU) consisting of three items, and perceive of satisfaction (PS) consisting of three items.



(a)



(c) (d)

Figure 3. Students' construction of mental model before (a and c) and after (b and d) interacting with simulation

3.4 Data Collection and Analysis

The participants consist of 20 8th grade students. The students interacted with computer simulation regarding model-based inquiry learning activity in 50 minutes. After finishing the learning activity, each student was asked to complete the perception questionnaire. The data was analyzed by mean, standard deviation, and percentage of students' perception scores.

4. Results and Discussion

To investigate the students' perceptions toward model-based inquiry with computer simulation, Figure 4 reports the percentage of their perception scores. The statistical analyses of the data suggest that there were some differences between the perception scores for each perceptual constructs.

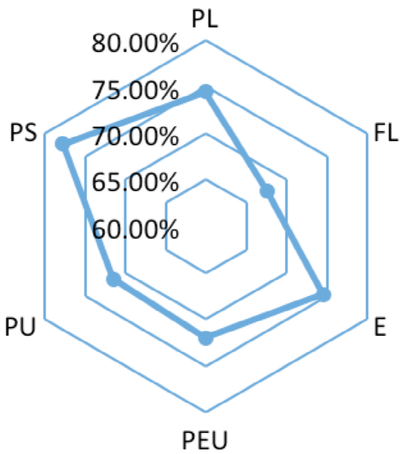


Figure 4. Mean difference in perceptual characteristics scores by attitude level

In a summative evaluation, the highest percent of PS is 77.67%, E is 74.67%, PL is 74.50%, PEU is 72.00%, PU is 71.33%, and FL is 67.60%, respectively. These pilot study reports students' perception scores toward the computer simulation with model-based inquiry. These results consistent with findings that the computer simulation could be used to promote students' physics learning experience in which the perception of student was increased. The computer simulation was digital technology to promote perceptions of students (Udomrat and Srisawasdi, 2015). That simulation could enhance students' perceptions. Moreover, it confirms with previous studies of Buyai and Srisawasdi (2014). The findings from previous studies never revealed the perceptions toward the computer simulation with model-based inquiry. However, researchers revealed the effect perceptions with technology (Dorji et.al, 2015). That is the finding from this study could confirm that the students' perceptions through learning material could improve their perceptions toward computer simulation with model-based inquiry.

5. The Design of Computer Simulation with Model-based Inquiry for Light Refraction

The computer simulation is able to promote learning science and is important pedagogical tool for motivating students in phenomena having dynamic visual and abstract as the refraction light. Students cannot see that the way of light is refracted and difficult to understand. The computer simulation could be used to solve this issue. Moreover, the model-based inquiry could be served as teaching method. That is teacher provides students strategy to make science accessible by empirical evidence that is observable phenomena and lead them to distinguish macroscopic explanation. The students are asked to further conducting an investigation of unobservable phenomena. When they gain knowledge by related concepts, they are asked to link three explanations together and result in knowledge integration for becoming the conceptual understanding, as shown in Figure 5

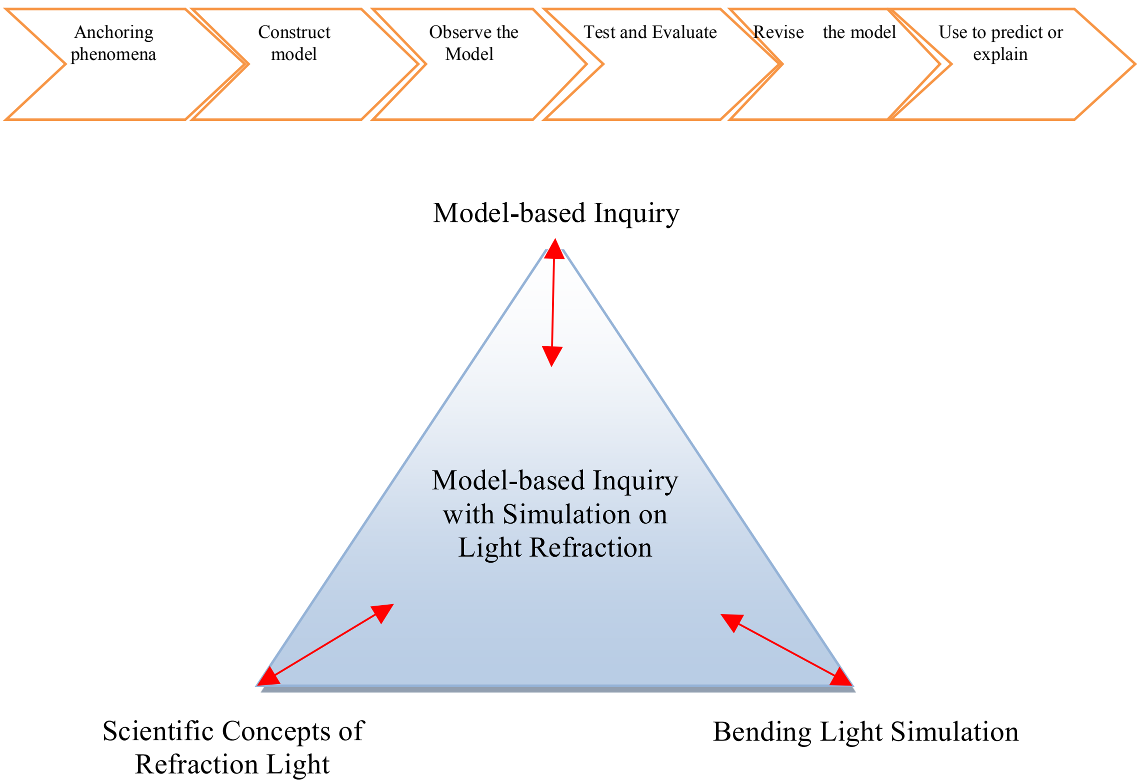
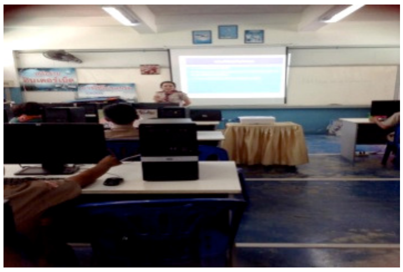


Figure 5. A conceptual model of model-based inquiry with simulation facilitated students' conceptual development in science

5.1 An Example of Model-based Inquiry with Simulation on Refraction of Light

In this part, the researchers use computer simulation with model-based inquiry to provide instruction. It could help students to visualize the material. After investing the phenomena, they are asked to discuss in class that is an important component of their understanding of the subject. In this method, the students are asked to predict the outcome of phenomena and drawing models of their prediction and use models, evaluate models, revise models to increase their explanatory and predictive power by taking into account additional evidence or aspects of a phenomenon from observing the situation with computer simulation as shown in Table 1.

Table 1: An example of learning process in computer simulation with model based inquiry

Components	*Description of learning process*	*Examples of learning activity*
1. Anchoring phenomena	Introduce driving questions and phenomena for a particular concept. Use a phenomenon that may necessitate using a model to figure it out.	
2. Construct model	Create an initial model expressing an idea or hypothesis. Discuss purpose and nature of models.	
3. Observe the model	Investigate the phenomena predicted and explained by the model	
4. Test and Evaluate	Return to the model and compare with empirical findings. Discuss qualities for evaluation and revision. Test the model against other theories, laws.	
5. Revise the model	Change the model to fit new evidence. Compare competing models, and construct a consensus model.	

Components	Description of learning process	Examples of learning activity
6. Use to predict or explain	Apply model to predict and explain other phenomena.	

6. Conclusion and Further Work

This study reported impacts of computer simulation on students' perceptions. The findings of students' perceptions towards learning of science with computer simulation clearly revealed increasing perceived learning, perceived ease of use, perceived usefulness, enjoyment, perceived satisfaction, and flow after interacting with the proposed learning environment in physics course. The results from this study could lead us to conclude that the learning environment combining with the educational computer simulation with model-based inquiry could be an alternative way for promoting science learning and students' perceptions in school science. In further study, the computer simulation with model-based inquiry will be used to enhance eleventh-grade students' conceptual understanding about properties of light including the reflection of light refraction of light and to promote students' scientific motivation. The participants will be students in the middle school level. The instruction will be designed based on knowledge integration framework by taking the questions before and after using computer simulation with model-based inquiry within class period. The pre-test, post-test and embedded questions will be analyzed and interpreted to answer whether computer simulation with model-based inquiry learning effect eight-grade students on conceptual understanding and knowledge integration of properties of light and on scientific motivation.

Acknowledgement

The distribution of this study was financial supported by Graduate School, Khon Kaen University, Thailand. The authors would like to express sincere thanks to Physics Education Technology (PhET) research group at University of Colorado Boulder for creating a very useful interactive computer simulation in science education.

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