Turning Beliefs Into Practices: Pre-Service Teachers' Epistemologies of Models and Their Model Formation

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Abstract
The purposes of this study were to evaluate pre-service teachers' epistemologies of scientific models and their model formation in a model-based inquiry environment and to look for a relationship between their epistemologies and model formation. Theoretical underpinnings of this paper were the following: Pre-service teachers' epistemologies of models are structured as their beliefs, can be reshaped by instructional experiences, and may have relationship with their model construction. Case study design using quantitative and qualitative research methods was carried out for this study. Participants were senior pre-service physics teachers. The participants were requested to generate initial models, develop inquiry questions, propose hypotheses, do investigations and conduct experiments to test their models in model-based inquiry. The results showed that the participants' epistemologies of nature and function of models were between transitional and sophisticated levels. That is, they tended to think that models were representations and tentative. The pre-service physics teachers also gradually constructed more quality models while experiencing model-based inquiry. Their models started to represent scientific ideas and include logical limits, directed them to inquiry, and changed based on the empirical results during the study. Results of Spearman's rank correlation coefficient test revealed significant positive high relationship between the participants' models they constructed and their epistemologies of models. In other words, the preservice physics teachers reflected their epistemologies to their models. Model-based inquiry might facilitate this relationship. The conclusion drawn from the results is that pre-service physics teachers can put their beliefs into their practices in model-based inquiry environment.

Keywords: Model-based inquiry, model epistemology, model formation, pre-service teachers

Introduction

Gobert and Buckley (2000) defines model formation as the construction of a model of some phenomenon by integrating pieces of information about the structure, function/behavior, and causal mechanism of the phenomenon, mapping from analogous systems or through induction. Involving learners in modeling practices can help them build subject matter expertise, epistemological understanding, and expertise in the practices of building and evaluating scientific knowledge (Ogan-Bekiroglu, 2007; Schwarz et al., 2009). To introduce modelling successfully in science teaching requires that teachers have an appropriate understanding of nature and function of models and their role in the accreditation and dissemination of scientific knowledge. Hence, the purposes of this study were to evaluate pre-service teachers' epistemologies of scientific models and their model formation in a model-based inquiry environment and to look for a relationship between their epistemologies and model formation.

Theoretical Framework

Theoretical underpinnings of this paper are the following: Pre-service teachers' epistemologies of models are structured as their beliefs, can be reshaped by instructional experiences, and may have relationship with their model construction (Hofer, 2000; Nespor, 1987; Richardson, 1996).

Methodology

Case study design (Stake, 1995) using quantitative and qualitative research methods was carried out for this study to compare participants' epistemologies of nature and function of models and their model formation. Participants were 11 senior pre-service physics teachers in the physics teacher education program at a state university, six of whom were females. The instruction in the course was based on model-based inquiry (MBI). Model-based inquiry is an instructional strategy whereby learners are engaged in inquiry in an effort to explore phenomena and construct and reconstruct models in light of the results of scientific investigations (Campbell, Oh & Neilson, 2012). The pre-service physics teachers were requested to generate initial models, develop inquiry questions, propose hypotheses, do investigations and conduct experiments to test their models. They constructed three dimensional models, revised their models and compared their final models with scientific models.

The pre-service epistemologies of nature and function of models were assessed with the help of the epistemology questionnaire used by Gobert and Discenna (1997). The questionnaire has nine open-ended questions. Their responses were evaluated as "sophisticated", "transitional", and "naïve" after the codes were derived from their answers. The participants' final models were evaluated by observing and asking questions to them. Their models were examined from three perspectives: the nature of models, the function of models, and the role of models in inquiry based on the rubric developed by Windschitl, Thompson and Braaten (2008). Their models were categorized as "congruent with experts' models", "intermediate models", and "congruent with novices' models".

In order to do non-parametric statistical analyses, scores 1, 2, and 3 were given to the participants' epistemologies and their models according to different levels mentioned above. Spearman's rank correlation coefficient test was performed to look for a relationship between participants' epistemologies of nature and function of models and their constructed models.

Results and Discussion

Majority of the participants (81.8%) thought that models were for perspicuity. More than half of the students (63.6%) wrote that a model comprised aspects of a subject. In addition, 54.5% of the students explored that a model could contain theory, hypothesis and formulas. Less than half of the participants (36.4%) could realize that models could change because of tentativeness of science and 54.5% of them understood that models could change because of scientific research and technology. The whole participants' overall mean value was 2.34 showing that 45.5% of the participants had transitional epistemologies while 45.5% of them had sophisticated epistemologies. That is, they tended to think that models were representations and tentative. This result is not consistent with the results that emerged from the research by Crawford and Cullin (2004) because none of their participants were in the highest level.

The participants created two models in two activities through the model-based inquiry instruction. Their final models for the second activity (overall mean is 2.13) were more close to experts' models than their final models for the first activity (overall mean is 1.86). They gradually constructed more quality models while experiencing model-based inquiry. Their models started to represent scientific ideas and include logical limits, directed them to inquiry, and changed based on the empirical results during the study. These findings are not much in line with the results of Windschitl and Thompson (2006) because most of the pre-service teachers in this study used models to ground their own empirical investigations. Additionally, unlike the participants of Schwarz and Gwekwerere (2007)'s study, great majority of the participants of this research recognized the role of models in inquiry.

Results of Spearman's rank correlation coefficient test revealed significant positive high relationship between the students' models they constructed and their epistemologies of models ($r = .75$, $p < 0.05$). That is to say, the preservice physics reflected their epistemologies to their models. Model-based inquiry might facilitate this relationship because learners are engaged in inquiry in an effort to explore phenomena and construct and reconstruct models in light of the results of scientific investigations during MBI (Campbell, Oh & Neilson, 2012).

Conclusion and Suggestion

Preservice physics teachers can put their beliefs into their practices in MBI environment. Therefore, teacher education courses would enable pre-service teachers to experience learning and teaching science by using MBI.

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