DYNAMIC ASSESSMENTS OF PRESERVICE TEACHERS' KNOWLEDGE OF MODELS AND MODELLING

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ABSTRACT

The authors are concerned with identifying and developing preservice teachers' understandings and use of scientific models related to the nature of science and scientific inquiry. Empirical research suggests that teachers possess uninformed and/or alternative views of aspects of scientific work, in particular of the role of models and modelling in science. In this study we focus on a particular kind of scientific model: models based on mathematical equations and depicting multiple processes. Participants included graduate students and advanced undergraduates in a teacher preparation program for biology, earth and space science, physics, and chemistry in a large university in the U.S.A. The purpose of this paper is to present several assessments used to track our preservice teachers' understandings, as they engaged in building computer models of pond ecosystems. These assessments, developed for research purposes, include 1) an open-ended questionnaire; 2) a semi-structured interview protocol used in combination with the computer models constructed by preservice teachers, and 3) a process map to track pair conversations and activities. We consider these as dynamic assessments, designed for use with the non-static work of teachers learning to build and test computer models of natural phenomena. Strengths and limitations of these assessments are discussed.

1. INTRODUCTION AND PROBLEM STATEMENT

How does one enhance and assess teachers' understandings of the nature and use of scientific modelling? The authors have grappled with this problem during the last several years (Crawford & Cullin, 2002; Cullin & Crawford, 2003). To enhance our preservice teachers' understandings, we first created a context for situating our preservice teachers squarely in the act of model building. Second, we utilized various ways to uncover and track their understandings of the nature of scientific models and modelling in science. We addressed the question, how can we assess preservice teachers' knowledge of modelling in science in order to monitor changes? The assessments described in this paper were developed to ascertain progress made by our preservice teachers, as they endeavored to understand the complexity of models. We used several kinds of assessments to provide a rich view of their modelling understandings: 1) an open-ended Questionnaire to determine quickly the initial and later understandings of models; 2) a semi-structured Interview to probe the depth of their understandings; and 3) a Process Map analysis of the process-videotape to depict how the participants built their models. For the purposes of this paper, we describe these assessments and discuss the strengths and limitations, in

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light of previous research on views of modelling. We also highlight our design of the interactive learning environment, which enabled our preservice teachers to actively engage in modelling tasks.

The vision of science education reform in many countries and the U.S.A. (American Association for the Advancement of Science [AAAS], 1989 & 1993; National Research Council [NRC], 1996) requires students to be knowledgeable in varied aspects of scientific inquiry and the nature of science, including the role of models and modelling. Models guide scientists in building explanations, interpretations, understanding, and discovery, and they enable scientists to generate predictions (Jungck & Calley, 1985). It seems intuitive that teachers themselves need a robust understanding of how models are built and used by scientists in order to support their students in developing knowledge. It is evident from empirical studies that prospective and practicing science teachers possess uninformed and/or alternative views of models and modelling. Teachers may recognize the usefulness of models as pedagogical tools, but they fail to recognize the true power of scientific models – the function of idea testing (De Jong & van Driel, 2001; Harrison, 2001a & 2001b; Justi & Gilbert, 2002; Smit & Finegold, 1995; and van Driel & Verloop, 1999). Therefore, there is a clear need to develop teachers' knowledge of key aspects of models and modelling.

School students can utilize simulation models to help develop understandings of important science concepts, such as diurnal cycling and predator-prey relationships. Simulation models can also provide an opportunity to learn how scientists use model-based reasoning and computational technologies in order to investigate complex phenomena. Finally, school students can learn how to use such technologies to make sense of the natural world. Modelling provides opportunities for students to demonstrate important thinking strategies (Stratford, 1996), learn science subject matter (Harrison & Treagust, 1996), and learn about science inquiry (Schwarz & White, 1998; Wisnudel-Spitulnik, Krajcik & Soloway, 1999).

A major assumption of our work is that teachers need an adequate grasp of subject matter and the purpose and nature of scientific models in order to teach their own students (Justi & Gilbert, 2001). It is important for teachers to know how to *do* modelling and know *about* modelling (Hodson, 1993). There are only a few studies focused on preservice teachers' understandings of models and views of using scientific models in classrooms (e.g. van Driel & Verloop, 1999). To address this problem, we created a context for situating preservice teachers as model builders.

In our previous work we determined that our secondary science preservice teachers had fragmented knowledge of the purpose and nature of scientific models (Crawford & Cullin, 2002; Cullin & Crawford, 2003). During the last several years we have designed several variations of instructional modules to address this problem. Each of the modules used the modelling software, Model-It, and an authentic investigation. These earlier authentic projects included designing TerraAqua Columns and investigating the water quality of a nearby stream (Cullin & Crawford, 2003).

The current research focused on a revision of an instructional module, in this case, one that was designed to explore the ecosystems of two nearby ponds. This study is a formative evaluation of the quality (in terms of validity, practicality,