

Chapter 6

Reification of Five Types of Modeling Pedagogies with Model-Based Inquiry (MBI) Modules for High School Science Classrooms

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ABSTRACT

It has been declared that practicing science is aptly described as making, using, testing, and revising models. Modeling has also emerged as an explicit practice in science education reform efforts. This is evidenced as modeling is highlighted as an instructional target in the recently released Conceptual Framework for the New K-12 Science Education Standards: it reads that students should develop more sophisticated models founded on prior knowledge and skills and refined as understanding develops. Reflecting the purpose of engaging students in modeling in science classrooms, Oh and Oh (2011) have suggested five modeling activities, the first three of which were based van Joolingen's (2004) earlier proposal: 1) exploratory modeling, 2) expressive modeling, 3) experimental modeling, 4) evaluative modeling, and 5) cyclic modeling. This chapter explores how these modeling activities are embedded in high school physics classrooms and how each is juxtaposed as concurrent instructional objectives and scaffolds a progressive learning sequence. Through the close examination of modeling in situ within the science classrooms, the authors expect to better explicate and illuminate the practices outlined and support reform in science education.

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INTRODUCTION

It has been well documented that doing science is aptly described as making, using, testing, and revising models (Clement, 2008; Giere, Bickle, & Mauldin, 2006; Halloun, 2004; Nersessian, 2008). Nersessian (2008), for example, stated that “model construction, manipulation, evaluation, and adaptation are a primary means through which scientists create new conceptual representations” (p. 10) and indicated models as the basic units for scientists to work with theories. Modeling has also emerged as an explicit pedagogical practice in science education reform efforts. This is evidenced as modeling is highlighted as an instructional anchor in the recently released *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (National Research Council, 2011), whereby students are envisioned developing more sophisticated models founded on prior knowledge and skills and refined as understanding develops. Modeling is conceived as a central practice for science learning that can 1) allow “students to be themselves within a culture of scientific inquiry” (Johnston, 2008, p. 12), 2) support the development of explanations extracted from evidence (Khan, 2007; Windschitl, Thompson, & Braaten, 2008a, 2008b), and 3) engage students in scientific argumentation through sharing, comparing, and deciding between competing models (Böttcher & Meisert, 2011; Passmore & Svoboda, 2012). While these are but a few of the possible important benefits of modeling, these and other benefits are dependent on the intentional educational applications of scientific modeling practices, some of which are described next.

Reflecting the purpose of engaging students in modeling practices in science classrooms, Oh and Oh (2011) have suggested five pedagogical conceptualizations for modeling, the first three of which were based on van Joolingen’s (2004) earlier proposal: 1) *exploratory modeling*, 2) *expressive modeling*, 3) *experimental modeling*, 4) *evaluative modeling*, and 5) *cyclic modeling*.

These five ways of modeling are referred to as modeling pedagogies to highlight how they can assist in framing pedagogical transformations of scientific practices that teachers perceive as helpful in meeting desired student learning outcomes (e.g., scientific discourse, scientific understanding). To get a sense of how modeling is currently being leveraged in science classrooms, this chapter explores how these modeling pedagogies are embedded in high school physics classrooms. Through the close examination of the modeling pedagogies in situ within a high school physics course, we expect to better illuminate classroom inquiry outlined and supportive of reform in science education, which can in turn reveal possible ways of enacting model-based science instruction.

MODELING AS SCIENCE AND SCIENCE LEARNING

Situating modeling in science education begins to make sense by considering the roles modeling plays in the work of scientists and in the context of specific scientific fields (e.g., astronomy, chemistry, evolutionary biology, geology). Although there is no single definition of a model, models are broadly recognized as representations or systems of objects, events, processes, and ideas (Gilbert & Boulter, 2000). In modeling, extra-linguistic entities like pictures and diagrams assume fundamental roles in the functions of models when they serve to describe, explain, and predict natural phenomena and communicate scientific ideas with others (Buckley & Boulter, 2000; Oh & Oh, 2011; Shen & Confrey, 2007).

Passmore and Stewart (2002) articulated modeling as a central cognitive goal of evolutionary biology, as one example, as they explained how this field works to understand how life on Earth has changed and to develop models that can provide explanatory power in this pursuit. Therefore, the cognitive tasks evolutionary biologists are concerned with are developing chronologies of

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