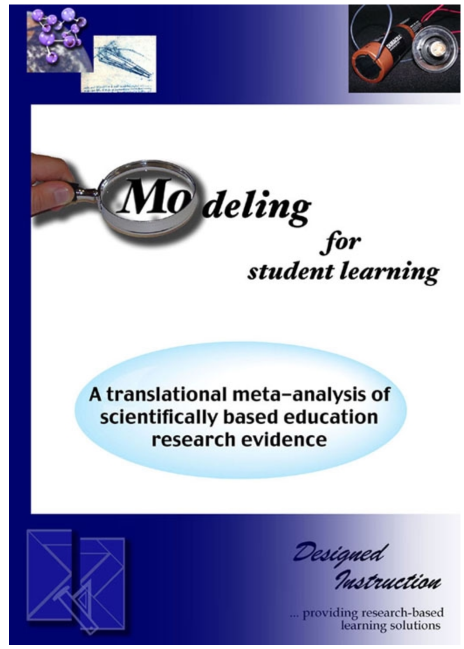
Modeling for Learning: Addressing Student Misconceptions

Students arrive in every new class—indeed, every new lesson—with their own notions of "how things work." Theorists and researchers refer to these notions by many terms—alternative frameworks, naive conceptions, alternative conceptions. We will call them misconceptions, and of all the things we can never be sure of in today's classroom, we can rely on the presence of student misconceptions in abundance.

Sometimes misconceptions are formed from a student's past experiences, sometimes from incorrect past teaching; often the cause can't be identified. Theory tells us—and it is borne out in the evidence from the studies we've analyzed—that in the absence of complete and accurate schema, students will inductively assemble the various pieces they have in whatever whole conception seems to fit all of the data at hand.

Regardless of the cause, there are strategies we can use to address and correct these misconceptions. The following tips constitute only a few of the effective uses of models in instruction—those related to misconceptions. They were drawn from our recent translational analysis Modeling for Student Learning.



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Four tips for using modeling for learning to address student misconceptions:

Pose questions. In order to address students' misconceptions, we have to know what those misconceptions are. One of the most effective means of determining what misconceptions students hold is to pose questions. Research evidence points to the

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use of *causal* questions—in large class settings, small groups, and individually—as one of the most effective means for encouraging students to allow their misconceptions to emerge. Causal questions get at students' perceptions of why we see what we see in a modeling exercise. Though they often know the facts, students' understandings of causes are typically incomplete at best. Upon questioning, watch for the puzzled response. Upon misalignment of their views with new learning, students will begin to amend their conceptions. For the most part it will also be, at least initially, a private affair.

Maintain a safe environment for reflection and discourse. Conceptual change theory tells us that to modify conceptions we should continually provide ways for students to become dissatisfied with their own ideas. Research in modeling for learning indicates that once students begin to amend their prior conceptions, the process becomes continuous throughout the modeling exercise, and even throughout the unit and onward. For every new action, activity, and discussion, new and modified conceptions form—typically still incorrect to different degrees, and typically representative of a cross between the original (or prior) misconception and the new learning that has occurred.

Many past theories suggest that teachers simply confront these misconceptions. However, modeling provides a better way. Activities that respect students' views and ideas, and support analysis of models and safe discussion of observations and model data, are effective at uncovering misconceptions and in promoting continual positive conceptual change. Allow the discourse—don't push students into tolerating your conception (the adult conception) for the duration of instruction.

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Compare and distinguish between models and reality. Research evidence emphasizes the need to address the differences between models and reality. In fact, not doing so could represent a stumbling block to providing proper direction to student conceptual change. As misconceptions often develop during investigations—constantly changing as lessons unfold—the types of experimentation and models being used are of paramount importance.

Research evidence indicates that the most common misconception regarding models is one of mistaken identity. Students at all ages tend to equate model representations with reality. They inadvertently transfer aspects of the representation (e.g., effects such as light reflection, physical properties such as color or texture, etc.)—to their perception of reality. It is not a problem with modeling—the problem with transferal of learning from the school environment to reality is ubiquitous. Rather, models provide a context for addressing the problem. Explain to students that they are only working with a model representation, not reality. Help them to understand that the purpose for

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simplification of models is to help us to conduct multiple types of tests, and obtain observations from a variety of perspectives. Emphasize that along with some valid features, models also have many invalid features that depend on the original intent of the model, and that this is okay. In short, help them to keep in mind W. Deming's statement: "All models are wrong, some models are useful." These unshared attributes cannot be left to students to discover—rather, teachers should help students identify them at the outset of instruction and often throughout lessons. This is especially the case when dealing with non-observable or abstract phenomena. Though it is teacher-intensive, direct teacher involvement clearly emerges as one of the most substantive criteria for student success in understanding the real nature of models. All studies analyzed either directly or indirectly indicated that student understandings were enhanced when teachers made sure they understood the strengths and limitations of models.

Use multiple models to address specialized vocabulary and spatial misconceptions. Students regularly have difficulty with both spatial aspects and domain-specific terms related to models. Interestingly, these problems are *more* common when working with models that are familiar to students because of past classwork and/or experience. Many of these misconceptions arise when working with models whose purpose entails studying changes at the particulate or unobservable level. Use multiple model representations in these instances, and ensure that vocabulary terms—especially those familiar to students in other contexts (e.g., electron *shell* or *cloud*, or cell *wall*, etc.)—are accompanied by descriptions of the specific meaning of those terms, and contrasted with other easily confused meanings. Likewise, emphasize alternate model views if possible to combat spatial misconceptions such as equating distance (e.g., between subatomic particles, between the earth and the moon, etc.) with the length of the stick in ball-and-stick models.