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Scientific Modeling Practice
Brief

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VANDERBILT SCHOOL OF ENGINEERING

UNIVERSITY of VIRGINIA | SCHOOL of EDUCATION and HUMAN DEVELOPMENT

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What is Scientific Modeling?

Scientific modeling is a practice used by scientists and engineers for a variety of purposes. From the *Framework (2012):* "Science often involves the construction and use of a wide variety of models and simulations to help develop explanations about natural phenomena. Models make it possible to go beyond observables and imagine a world not yet seen. Models enable predictions of the form 'if… then… therefore' to be made in order to test hypothetical explanations."
"Engineering makes use of models and simulations to analyze existing systems so as to see where flaws might occur or to test possible solutions to a new problem. Engineers also call on models of various sorts to test proposed systems and to recognize the strengths and limitations of their designs." In both science and engineering, modeling involves using a simplified version of a system in order to test, predict, or explain how an aspect of the system work. Models are used for a variety of purposes, and can take many forms.

Teaching About the Practice of Modeling

It is important to support students to understand both *that* they are developing and using models and *why* they are using modeling. Supporting students to understand the purpose of their practice helps them to engage in the practice. Knowing who your audience is (e.g. classmates who want to know how you think about this) helps students understand the level of detail needed to communicate their thinking.

Modeling is part of the practice of representing and testing one's thinking. When we develop models we need to make choices about what is important to represent, and what is not necessary in order to understand the phenomenon or design the solution. Knowing who your audience is and what you are trying to represent helps when making decisions about how to model something.

What isn't Scientific Modeling?

Scientific modeling is not just showing how a system looks visually. A picture or visual representation of a system does not help to explain or predict how the system works unless there is some representation of a process or relationship represented within the model. Therefore, dioramas, paintings, and other static images of a system or phenomenon that do not show relationships between the elements are not models.

How is Scientific Modeling Used in the Curriculum?

Engaging with different types of scientific models:

Conceptual Modeling: Conceptual modeling is the practice of representing your current understanding of the science system, process, or phenomenon. Conceptual models can be shared publicly in order to help others understand your thinking, and revised to show changes in thinking over time.

Computational Modeling: Computational models involve using mathematical equations to make predictions about how an aspect of a system will behave. Computational models can be developed by individuals to represent the system under study, or modified and used by others to reflect differences in the systems.

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Using a Model to Test: One of the benefits of experimenting with models, whether physical or computational, is that it is easier to keep aspects of the system constant and observe the effects of changes on other parts of the system. Models can be manipulated in much the same way as an experiment, with the results recorded, and predictions made about how the real world would respond to similar circumstances. This also goes for testing design solutions, the models allow us to compare the effectiveness of different solutions.

Supporting students to connect across representations

Modeling is a practice that can be used to support individuals to be aware of their own understandings. When creating models of systems, paying attention to what the inputs, outputs, boundaries, and interactions in the system are might reveal gaps in what is understood. All of the rainfall (inputs) has to go somewhere, so reducing runoff (output) means increasing absorption (what remains in the system). This is a consistent relationship across the unit. The conceptual model that students are developing here showing the scientific process can help students keep track of the components that need to be included in a computational model.

How are we supporting students' modeling?

The backgrounds provided to students with the conceptual models are intended to provide students with a starting point for representing their ideas. Within the practice of modeling, there is a trade-off between allowing students the freedom to represent the concept in a way that makes sense to them using their own conventions and supporting students to represent their ideas in a way that another classmate will understand. In this unit students are allowed to choose how they want to represent the water (lesson 4), but are also given some suggestions for standards for how to show different ideas. Models created to be able to communicate thinking to others need to involve common ways of showing similar ideas for interpretability or include information to help interpret the model. The unit supports these trade-offs by encouraging class discussions among students about how to represent their thinking so others will understand and models as a tool to communicate thinking. Students will be given an opportunity to revise their conceptual models over time, and will be prompted to attend to how their new understandings are being represented in their models. Prompts across model types will help students remember what parts should be represented.