Teacher Tune-up

Quick Content Refresher for Busy Professionals

What is a model?

When we think of models, we may picture small, physical replicas of objects, like a scale model of The Alamo or a Boeing 747. In science, we use the word "model" as a catch-all for any description or representation of a complex object, system, process, or entity. More simply, a model is something that helps explain how something is or how it works. Consider these very different representations, all models.

- A physical form made out of LEGOs, clay, balsa wood, or plastic filament on a 3D printer
- A mechanical object that demonstrates something more complex (like an astrolobe modeling the solar system)
- A mental concept or analogy ("The Big Bang")
- An equation (F = ma)
- A mathematical expression, such as, if b = slices of bread; p = mL peanut butter; and j = mL jelly... my PB&J sandwich could be modeled as 2b + 30p + 15j
- Computer simulations that can predict things like weather or financial market behavior
- Animals (mice, monkeys, C. elegans, etc., all serve as models for humans)
- Maps
- Diagrams and drawings

We use models to test a hunch or a hypothesis, or to better understand or communicate about phenomena. At the middle school level, encourage your students to move beyond simply making miniature-sculpture–type models (something they may have done extensively in elementary school), towards using models as a way to test and make predictions of more abstract phenomena. In high school, students will focus on evaluating the usefulness of different models.

Some scientists have been advocating for the use of the word "model" to replace the term "theory," because the term theory connotes more uncertainty or controversy in colloquial usage than it does in scientific parlance. For instance, "the *theory* of evolution" sounds tentative so some, though it is widely accepted among scientists.

A model organizes data or observations so that they generate predictions or hypotheses. If you have a theory about how pollution spreads through wetlands for example, one way to test predictions from that theory is to build a computer model of the domain so that you can test the hypotheses without, for example, polluting watersheds and river valleys.

The Limitations of Models

Consider a simple model: a crumpled paper to represent a watershed.

Why the crumpled paper watershed model works	Its limitations
• Water flows downhill. • The shape of the land determines water flow. • Ridges usually divide watersheds. • Water pools in low-lying areas. • Activity upstream affects water quality.	• Water behaves differently at such different scales. • Water behaves differently with different materials.

The Advantages of Models

Models help us make inferences, and often inferences go into our model-making. Models make an insight useable so we can make predictions. If the model is not helpful in predicting (or mimicking) something in the natural world, it's not much good.

Models broaden our thinking. They may represent things that we can't usually experience in real life. Could you study ocean currents by getting on a boat and observing the ocean? Not easily. But you can collect data (make observations) while on that boat to draw inferences that will help you build a model.

A model externalizes our thinking and makes it into an object that can be discussed with others and used to understand an idea or visualize a concept. A model, whether expressed in digital bits or physical atoms, words or numbers, becomes a thing to think with: a tool to demonstrate your thinking to others and to examine your own thinking.

The Size of Models

Often, students will think models are a smaller version of the thing we're studying.

Not necessarily! Think of cells, molecules, atoms—our models for those are a lot larger than the things we're studying.

Look Out! Student Misconceptions

Misconceptions spring up when the model and the real thing get mixed up. Use these four questions to help you use your models wisely in the classroom and to avoid breeding misconceptions.

- How does this model work in ways similar to what it represents?
- How does this model work differently from what it represents?
- What are the strengths of this model? The weaknesses?
- How does this model compare and contrast with what it represents?*

*(*Four questions from Understanding Models in the Earth and Space Science – Steven W. Gilbert and Shirley Watt Ireton - 2003 NSTA Press)*

Two important final notes:

- A lot of what teachers call experiments are really models (frequently demonstrating a concept). For example, if dye is dropped into a pan with a heat source at only one end, we see convection because the dye will move in a specific way. The phenomenon is a real instance of convection, but it's also a model of larger bodies of water. What it is *not* is an experiment. (You could develop this activity into an experiment if you were to compare the movement of the dye under several conditions.)
- Telling kids that "anything can be model" doesn't really teach them much, even though it may be true. A model is something that helps explain how something else is or how it works. Perhaps anything can be a model—but only if you are thoughtful and deliberate about how it does and does not represent the thing being modeled.