What Are Models?

Science educators are probably quite familiar with models, and so are K–12 students and their families. People often use models in their everyday lives. Maps are models of roads and locations. A globe is a model of Earth. Model cars, airplanes, and trains are tiny replicas of vehicles. All models are representations of something else—an idea, an object, an event, a process, a system—and act as substitutes for the real things.

Why Use Models?

Models are central to the process of understanding, doing, and communicating about science. Scientists use models to make predictions and construct explanations for how and why natural phenomena (i.e., observable facts and events) happen. For example, weather maps are

Practicing scientists draw on models already developed by others in the field, but much of the power of models comes from developing them. Developing models helps scientists visualize complex concepts, understand problems, and communicate new ideas. They evaluate and refine models through an iterative cycle of comparing their predictions with what they discover. When new evidence is uncovered that a model can't explain, scientists modify the model.

The work of student scientists mimics that of real scientists and engineers. Goals of science education envisioned by the writers of

Beyond using the models created by others, the practice of modeling is an important science skill for students to learn and practice. The process of constructing models aids students in making sense of the science behind a phenomenon. When students practice developing, testing, and revising their own scientific models, they are prompted to articulate and communicate their own thoughts and ideas about how things work. This contrasts with striving to understand the thought process of another person when working with an already established model. It is through the experience of modeling that students learn to think like scientists and arrive at a deeper understanding of scientific concepts.

Developing and using models (Practice #2) can help teachers use and connect other NGSS practices into a dynamic, interactive set. For example, students' observations and questions (Practice #1) are mediated by models. Models assist them in designing their own investigations to answer questions (Practice #3). Models are filters students use to interpret data (Practice #4) as they look for patterns or use math formulas to think about the effects of changing variables (Practice #5). Models help students make sense of and construct explanations for phenomena (Practice #6). Students use argumentation (Practice #7) to communicate information about models and evaluate them (Practice #8).

Science teachers work to advance their students' mental or internal models and assist them in expressing their ideas. All students have ideas. Through modeling, they can further establish, extend, and refine incomplete or incorrect ideas. Modeling also helps students understand the nature of science and allows them to improve skills such as systems thinking and evaluating ideas.

Christina Schwartz and C (h apd)-7 (t)-24tn1.6 3576 357.panan fu

7. Students use their findings (evidence) to elaborate on the ideas represented in their modified models. They make additional revisions.
8. Students share their models with one another and develop a class (consensus) model.
9. Students apply what they have learned to a novel, but related phenomenon or problem to show their understanding.

The NGSS outline a coherent progression of developing and using models in grades K–12. In grades K–2, modeling incorporates students' prior experiences and progresses to include using and developing models. These models include diagrams, drawings, physical replicas, dioramas, dramatizations, and storyboards that represent concrete events or design solutions. In grades 3–5, modeling advances to building and revising simple models. Models are used to represent events and design solutions. In grades 6–8, modeling builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. In grades 9–12, modeling adds to the K–8 experiences and moves students forward to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

The participants learned that models enable us to explore things that we don't have access to and allow us to manipulate factors we otherwise could not. Perhaps more importantly, they learned that models help us make our thinking visible to others, which supports the collaborative sense-making, model evaluation, and model refinement that is characteristic of science and engineering. Although we were together for only a few hours, we all had a deeper understanding of developing and using models by the end of the workshop.

Using Modeling in Your Classroom

Think about how the sequence of model-based learning you read about earlier and the NGSS grade-level expectations for modeling would work in your classroom. Would it be similar to what you already do, or would it require a big shift for you and your students?

You will probably face some challenges as you shift to using model-based inquiry, and you may want to think about how to overcome them. Maybe time is an issue. For example, you may need more time for your own learning to better understand the modeling practice before you try to implement it in your classroom with your students. It's okay to take that time. You can tap into many online and print resources. However, keep in mind that you don't need to be an expert to start with something small. The systems model workshop I facilitated didn't take much time to plan or implement.

You may think that you don't have enough time for your students to practice modeling because there is pressure to cover a large amount of material. Consider foceaddl438.975 Tm[plan o)8 (r implement

Remember, you don't need to do everything yourself. Parents and other caregivers play a critical role in encouraging and supporting their children's science learning at home, in school, and throughout their communities. Parents are valuable partners in cultivating science learning confidence and skills. Because models are commonly experienced by everyone in their lives, parents can foster the use of models outside of school through authentic tasks like cooking, planning a trip, and other everyday activities. You must work with them to make connections.

If you do incorporate models in your instruction, it is likely your students will think more critically