By Molly Weinburgh and Cecilia Silva

Math, Science, and Models

Fourth-grade students express erosion understanding in an interdisciplinary way.

Young children are surrounded by models every day and accept them without much thought of how accurate or inaccurate they may be. They play with small objects—such as cars, people, animals, and airplanes—which represent larger objects, and with large objects—ants and spiders—that represent smaller objects. As they engage in play, they do not think about models as being an important part of science. They may not realize that scientists rely heavily on models to depict phenomena in the natural world, communicate ideas of what may be, and test ideas of what could be. Introducing children to the wonderful world of scientific models is rewarding for the student.

For the past five summers, we have taught summer school to recent immigrants and refugees. Our experiences with these fourth-grade English language learners (ELL) have taught us the value of using models to build scientific and mathematical concepts. In this article, we describe the use of different forms of 2- and 3-D models to show students how, when, and why scientists and mathematicians use models. In addition, we capitalize on how models can enhance the use of discipline-specific language. The language of science goes beyond natural language (oral and written). To make meaning in science, we also make use of "mathematical relationships, visual representations, and manual-technical operations" (Lemke 2004, p. 38). Although teachers may use models as tools for learning, they may not as often see their use as tools for expressing understanding. The use of models for expressing meaning is particularly helpful when working with ELL students.

Build on Prior Experience

To build on prior experiences with models, we began our unit on erosion by asking the students to talk about the models they encountered on a daily basis. Although the students had been in the United States for fewer than

two years, they could easily draw from a variety of experiences with models. The students first associated the word *model* with fashion models. This discussion provided the opportunity to think about the differences in the everyday and academic meaning of the word *model*. We moved from its everyday understanding to its scientific meaning by taking advantage of the classroom environment and having students observe other types of models in the room (e.g., maps, globes, skeletons). Based on these initial observations, the student developed a working definition of a *model* as a representation of something real, similar to but not exactly like the actual thing (AAAS 2001).

Figure 1.

A 2-D representation of an erosion site in a student's journal.

Making Models

As we introduced the ELL students to the unit on erosion, we walked to sites on the school campus where evidence of erosion was obvious. Students saw the places where soil had washed away leaving cuts in the Earth and areas where sediment had deposited as piles of soil. Knowing we would be taking the children outside, we checked the area around the school yard for possible hazards and established that there were none.

CAUTION

After observing several sites, we asked students to select one and draw it in their journals as a 2-D representation (Figure 1). Knowing that we would use these drawings later to make a connection to other types of models, we highlighted the importance of journals as a place to capture data that could be used at a later time.

Working in small groups, the students revisited their journals and discussed the various erosion sites they had observed on the school walk. Within these groups, the students selected a site they wished to represent, and used their 2-D drawing to construct a 3-D model using Crayola Air-Dry Clay (a substance which hardens after a few hours). We selected clay but any material may be used—for example, paper-mâché or Lego bricks. Some children may be allergic to modeling clay. Be sure to have gloves for students needing them. As the

CAUTION

Figure 2.

Sample student model of an erosion example on school grounds.

Figure 3.

Materials used for the erosion unit.

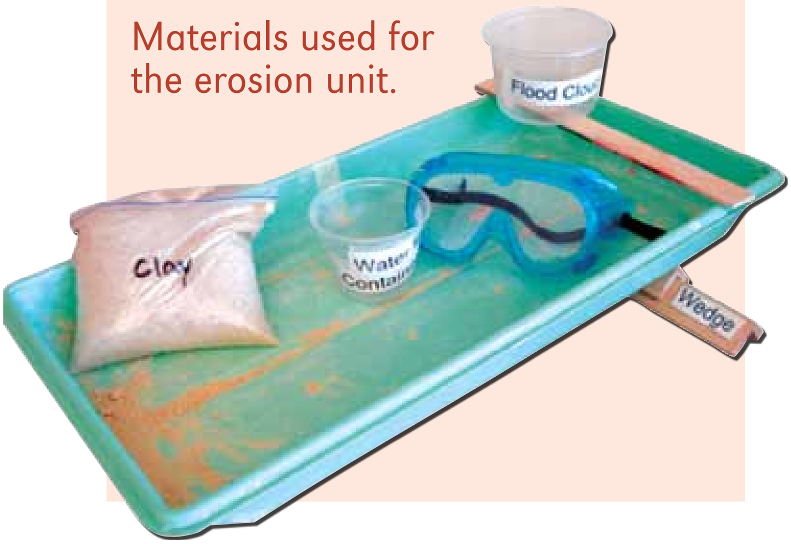


Figure 4.

Students work with a stream table.

PHOTOGRAPHS COURTESY OF THE AUTHORS

models hardened and became fixed, the students were asked to look at another group's model and determine which site the model represented. The students soon discovered that, although some of their models (Figure 2, p. 59) depicted many features of their chosen site, they were not always accurate enough for others to identify their location. This activity allowed the students to discuss elements of their models: Models were smaller than the actual erosion site, made of clay not soil, were the wrong color, lacked distinguishing details, and were not in correct proportion. This activity also helped the students to compare the 2-D drawing and 3-D models to each other and the real thing.

Introducing Landforms

On the third day, we revisited the notion of models as students were introduced to an inquiry lesson. We used the stream table, wedge, standard and flood plastic cups, sand, and ruler from the Full Options Science System (FOSS) fifth- and sixth-grade Landform kit (see Internet Resources). Students were given an authentic problem related to erosion. We explained to the students that our sloped yard was in the process of being landscaped. For a week, the sandy soil would be exposed. The weather forecast called for rain over the next few days and then for dry, windy days. Students were asked to think about the potential problems that could arise with a sandy, sloped yard if exposed to rain or wind. They brainstormed and generated a list of ideas of what could happen to the yard. We then asked the students how we would find out whether their ideas were feasible knowing that we could not test their ideas on the real yard site. This helped move the discussion to models and how scientists use models for testing ideas. At this point in the unit we could then logically introduce the stream table as a model that could be manipulated to test ideas. The stream table (Figure 3) is a plastic rectangular tray used in many science classrooms as a way to recreate land formations using sand or soil (Figure 4).

Testing Variables

The students used the stream tables as models to explore the ideas they had previously generated and test different variables and their relationship to erosion. For all activities involving sand or water, be sure to use newsprint under the stream tables to help with spills and cleanup. Be-

cause sand can leave the floor slippery, work with the students and janitorial staff to be sure the floors are properly cleaned. Students wore safety goggles to keep sand out of their eyes, and we made sure they washed their hands after the activity.

Questions to be tested included: What would happen to the soil in the yard if we had a gentle rain? How would this be different if we had a hard rain? To test their ideas about the effects of rain, students used plastic cups with different-size holes to represent clouds of varying rain intensity. Small holes represented gentle rain, whereas large holes represented hard rains. To have a fair test, students used equal amounts of water with different-size holes and observed what happened to the land formation. Teachers can formatively assess students by looking at their setups.

Testing to Find an Answer

When students asked what would happen if there were a gentle or hard wind, they tested the affect of wind using straws. For gentle wind, they positioned themselves farther away from the stream table and lightly blew through the straw. For hard winds, they positioned themselves closer to the sand and blew with greater force. By observing the stream table before, during, and after their tests using water or wind, the students could see the sand moving and could see evidence of displaced sand.

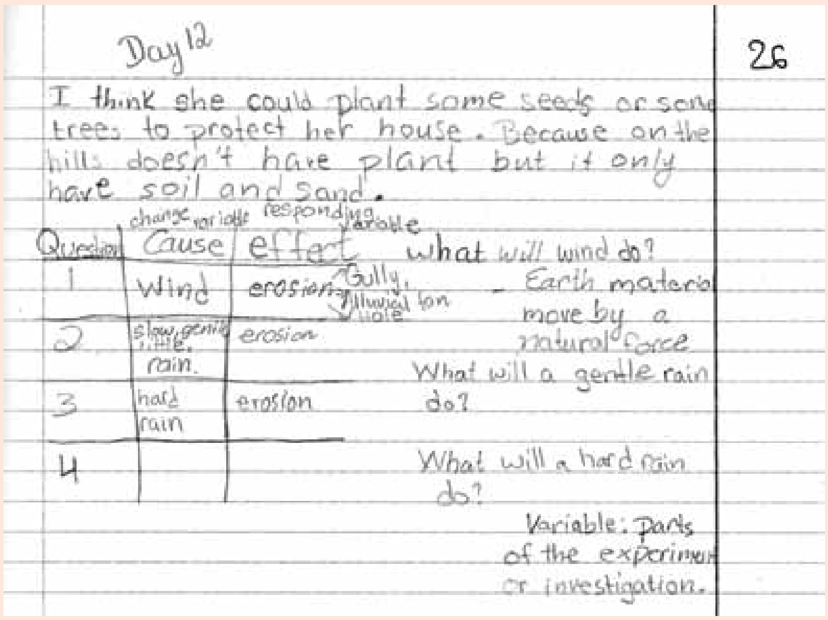
After using the stream table to test students' ideas about different variables, we were able to compare the functions of static models with experimental models. *Static* models, such as the ones they had constructed earlier to depict their erosion sites, provide a snapshot of physical characteristics at some point in time. In contrast, *experimental* models depict a process as it happens. Working with an experimental model also gave us the opportunity to discuss experimental design and which variable we are testing (e.g., which variable can be changed or manipulated and which variables must remain the same). The language that emerged from the initial investigation included *fair test, manipulated variable* (cause), and *responding variable* (effect) (Figure 5). Over several days, the students investigated what happens when different amounts of "wind" or "rain" were applied to the same site. Figure 5 shows one student's journal entry recapping three of the four trials that were used to help address the research questions on wind and water. Teachers can use pages from students' journals, such as Figure 5, to assess learning. The students talked about the model's accuracy and its use in understanding a process that would have been difficult to witness in real time. They also learned content about erosion, land formations (gully, alluvial fan), and earth processes (movement of earth materials, deposition). The students ended their investigation of erosion by developing their own question. They asked questions such as "What effect will a plastic ground cover have on the lawn if there is a hard rain?" "What will happen if rocks are placed in the yard and there is a hard rain?" "What will happen if the gentle rain is spread over a greater area?" Students also tested their hypotheses using the stream table.

Integrating Science and Math

The use of models provided us with an excellent opportunity to further integrate science and mathematics

Figure 5.

Recapping three of the four trials that were used to help address the research questions on wind and water.


Day 12

26

I think she could plant some seeds or some trees to protect her house. Because on the hills doesn't have plant but it only have soil and sand.

Question	Cause (change variable)	effect (responding variable)
1	Wind	erosion Gully, Alluvial fan, hole
2	slow, gentle, little, rain.	erosion
3	hard rain	erosion
4		

what will wind do? – Earth materials move by a natural force

What will a gentle rain do?

What will a hard rain do?

Variable: parts of the experiment or investigation.

Figure 6.

Students replicate the stream tables in their notebooks.

Connecting to the Standards

This article relates to the following *National Science Education Standards* (NRC 1996):

Content Standards

Grade K–12

Unifying Concepts and Processes
- Evidence, models, and explanation

Grades K–4

Standard A: Science as Inquiry
- Abilities necessary to do inquiry
- Understanding about inquiry

Standard D: Earth and Space Science
- Changes in Earth and sky

National Research Council (NRC). 1996. *National science education standards.* Washington, DC: National Academies Press.

through the study of scale. Although teaching about scale and actually engaging children in scaling activities can be challenging, we made use of children's literature to scaffold the idea and process of scaling. *Cut Down to Size at High Noon* (Sundby 2000), a mathematical concept book, served as an invaluable resource for children to explore the use of scaling. In the book, the main character, a barber named Louie Cutorze, "measured a life-size thing, then used the measurement to create an exact drawing of it, only smaller" (p. 6). Later in the book, the idea of using the same process to scale up from a small object to a large object is introduced. The students took pleasure from reading about fictional characters who used scaling to solve problems in their daily work and then using the same skills in solving their erosion problem.

Students were asked how much of the yard was still available for planting after the "rain" had eroded some soil. This question required the students to apply mathematics concepts to further understand the scientific model of an eroding yard. Because the students did not have graph paper the size of the stream table, they were forced to use a smaller scale to solve the problem. Students replicated their stream table model on 21.6 × 27.9 cm graph paper (Figure 6). By counting the total number of squares that represented the "yard" part of the model on the graph paper, students had a total surface area. They then measured the pattern of erosion in their model and subtracted from the total. This allowed them to figure the fractional part of the yard's surface that had eroded due to the "rain."

Building Awareness

Students enjoyed constructing the clay model of the erosion site, using the stream table to answer class questions about cause and effect, and later developing their own questions that could be answered using the stream table. We have found that we can teach *about* models as we teach *with* models. As the students moved back and forth between the different representations of erosion, they discussed the merits and shortcomings of each. In the process, they became more aware of the role that models play in scientific and mathematical communities. ■

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Sundby, S. 2000. *Cut down to size at high noon: A math adventure*. Watertown, MA: Charlesbridge.

Internet Resource

FOSS Landforms Module

www.lhsfoss.org/scope/folio/html/Landforms/1.html