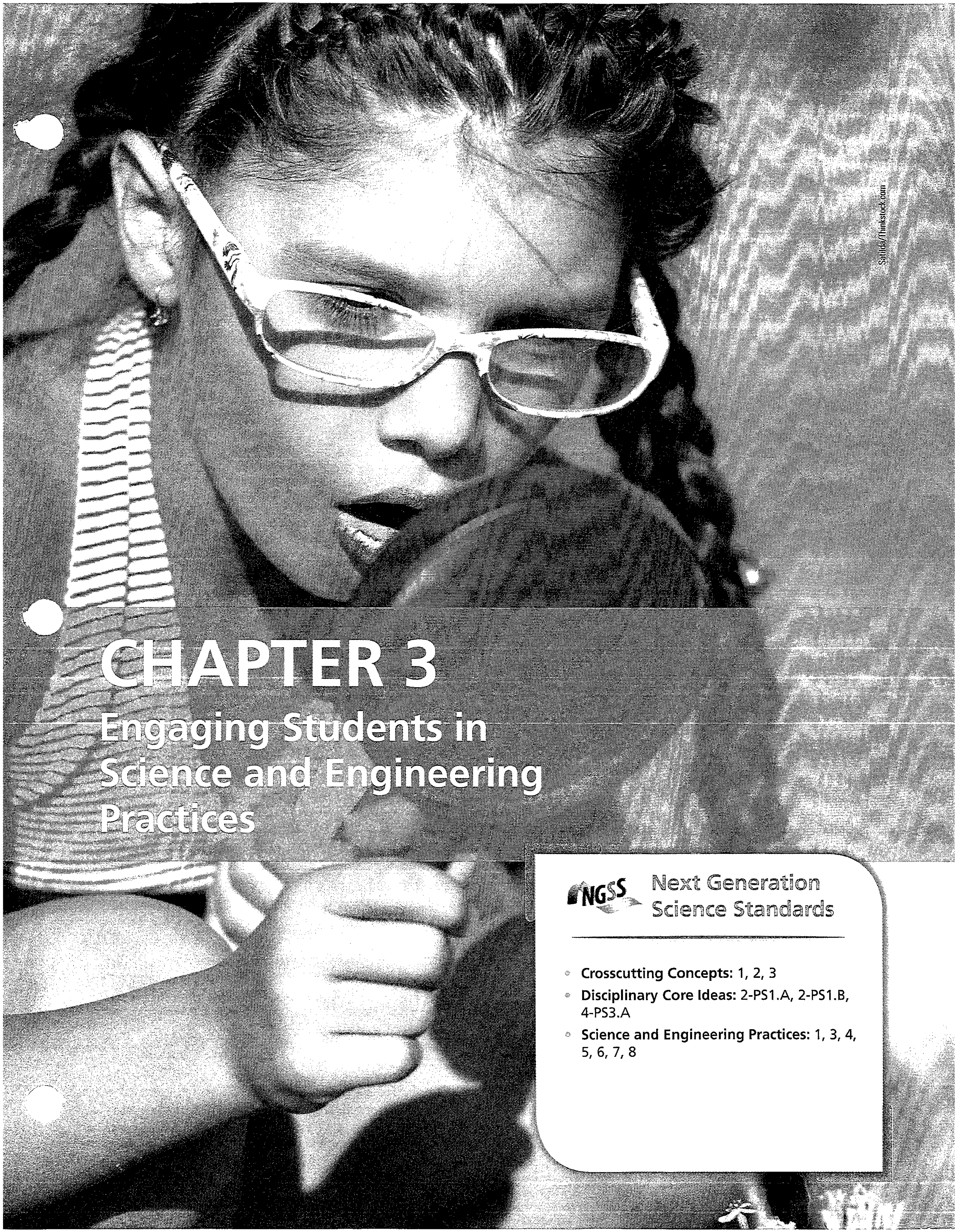


Satilda/Thinkstock.com

CHAPTER 3
Engaging Students in Science and Engineering Practices

NGSS Next Generation Science Standards

- **Crosscutting Concepts:** 1, 2, 3
- **Disciplinary Core Ideas:** 2-PS1.A, 2-PS1.B, 4-PS3.A
- **Science and Engineering Practices:** 1, 3, 4, 5, 6, 7, 8

LEARNING OBJECTIVES

After reading this chapter, you should be able to:

- 3-1 Discuss the connections between multistation activities and the NGSS SEPs.
- 3-2 Examine the use of science notebooks in school science.
- 3-3 Design a five-station science "circus."
- 3-4 Connect technology to science as practice.
- 3-5 Relate school science to family science.

Reflection

To Think About:

- Do you ever predict the day's weather from your early-morning observations?
- Can you remember diagnosing a sick pet, a child, or a sibling on the basis of the symptoms you noticed?
- Did you ever vary just one ingredient in a recipe and come up with a new dish?
- Do you ever shop at the supermarket by arranging your grocery list according to the aisles in the store?
- Do you keep records of your expenditures and then sort them according to categories? Do you have a separate notebook for these entries?

3-1 Science and Engineering Practices: Using Multistation Activities

People who regularly engage in scientific activity or engineering design employ practices that help them gain information about the natural world. As we noted in Chapter 1, these scientific and engineering practices are often used in our daily lives, though we do not "code" them as scientific. Employing them on a planned and regular basis is what makes scientific activity different from ordinary activity. This is the essence of what we mean by "science as practice." It is important to remember that scientific thinking is "a complex intertwining of knowledge of the natural world, general reasoning processes, and an understanding of how scientific knowledge is generated and evaluated" (Duschl et al., 2007, p. 152). The science and engineering practices require several skills that are sometimes called "process skills or science skills." If the purpose of the activity is to answer a question, the students are doing science; if the purpose is to define a problem, students are doing engineering. While helping students gain experience with scientific and engineering practices, keep in mind that they bring their prior knowledge and their daily life experience to the tasks.

In this chapter, we explore a multistation classroom environment that provides students and teachers with science and design activities in which they must use certain skills to resolve a question or solve a problem. By a "station" I mean simply a desk, a table, or any other special area in which an investigation is described and materials are provided. By examining this environment and thinking about how it works, you can become more familiar with the ways in which students develop the skills of scientific study and use them to solve problems.

Multistation science activities are often developed around a content area theme, such as "states of matter" or "living things." In this chapter, however, we will look at an example in which the content areas of the stations are unrelated to one another. In other words, the context for each problem-solving activity is provided by the scenario created at that particular station. The organizing principle, in this case, is "using the skills of science to solve problems." Because, in addition to obtaining and evaluating information, *communicating* information is a significant scientific practice, we need to consider how students engaged in such activities can record their findings. Writing and drawing are important aspects of making observations and collecting data.

3-2 Science Notebooks

How and where do students record their science findings, draw their pictures, and explain their reasoning? Notebooks are an excellent choice. Scientists have always used notebooks to document their work, and they are also effective tools for students.

In Chapter 1 we discussed the use of science journals as a vehicle for exploring nature and recording observations, ideas, and questions, and I urged you to begin a science journal of your own—a personal journal focused on nature and the natural events you encounter in your daily experiences.

science notebook
A notebook in which students record their observations, reflections, questions, predictions, and conclusions during a science investigation.

Like a journal, a **science notebook** integrates writing and science, but it is more carefully structured as a thinking tool for students. In a systematic way, teachers can use students' science notebooks as part of the classroom science instruction. By helping students to structure their contributions to the notebook—for instance, by using prompts and sentence starters—the teacher scaffolds the students' learning.

A student science notebook is more than a collection of data or facts. It is a record of the student's reflections, questions, predictions, and conclusions. Writing is one way that students express the science ideas they are learning in their own words. This facilitates sense making and what we referred to in Chapter 1 as metacognition: being able to reflect upon what you know. Overall, as students use their science notebooks, they are enhancing their scientific reasoning skills and making meaning of the experiment, activity, or observation in which they are engaged (Klentschy, 2008).

There are many structures that teachers use for student entries in notebooks. There are also many types of notebooks. Often elementary and middle school science teachers use standard composition notebooks (those black-and-white marbleized notebooks). For the fourth-grade class described in the next section, the students were asked to set up a page in their science notebooks for each activity, following the organization shown in Figure 3.1. In Chapter 13 we will examine how science notebooks may be used to assess student learning.

Recall the scientific and engineering practices that represent an important dimension of the Next Generation Science Standards (NGSS Lead States, 2013). As seen in Figure 1.1, these range from asking questions to using mathematics and computational thinking to planning investigations and developing models. As you read the descriptions of each station in the science circus activity of the

FIGURE 3.1 A suggested structure for students' science notebooks for the multistation "science circus" activity

Date: ________

Station Number: ____________

This station is asking me to ________________________________

What do I think? ________________________________

Drawing and Observations:

Some Conclusions: ________________________________

This activity reminds me of ________________________________

Professional Resource Download

fourth-grade class at Mount Holly Elementary School, reflect on which of these practices are required to satisfy the challenges posed at each station. The scientific and engineering practices capture the essence of how the scientific community works to generate knowledge (Duncan & Cavera, 2015). Notice that there are several practices—plural—because there is no single method in science. Rather, there are many methods that converge to answer our questions about the natural world.

3-3 A Science Activity "Circus"

If you have ever been to a circus, you have noticed how many different things are going on at the same time. In three-ring circuses, a variety of entertainment acts occupy the rings in the center, while jugglers, clowns, and people on stilts walk around the periphery. It is quite a busy place. One hardly knows what to look at first. For students, these events create a world of excitement that they want to explore.

A friend of mine introduced me to a multistation classroom activity that she labeled a "science circus" because many activities were occurring simultaneously. I said, "When I think of a circus, I think of disorder." "On the contrary," my friend remarked. "It takes a great deal of organization to plan an activity where students are all at different places at the same time" (Abder, 1990).

science circus
A science activity that consists of several stations at which the visitors are asked to perform certain tasks and record their results or reactions.

A **science circus** is not quite as complicated as a real circus. Contained within a single room, the science circus consists of several stations at which the visitors are asked to perform certain tasks and record their results or reactions. It is circus-like because many different activities are going on simultaneously, but it is far from chaotic.

Each time I set up a science activity circus, it looks different. I try to use materials common in daily life and to create a scenario that invites students to explore them and come up with their own ideas. Often, too, I situate the activities in a personal context that is related to my own experience—a context I hope the students will recognize and share. It is always important to provide a rich context for the science stations so you are not pacing the students through science activities just for their own sake. The experiences must be constructed in a way that makes a connection to a larger idea or a personal story.

In the following story, I describe one typical science activity circus that I helped create, but keep in mind that the potential for different activities is practically infinite. Notice also that the stations try to arouse in the students a *need to know*, giving them a strong reason to use their science skills. As you explore these stations, you may be reminded of instances in which you have satisfied your own need to know by using the skills of science.

After seeing how the science activity circus works, we will explore the particular scientific and engineering practices connected to each station. As you read, think about how *you* would describe the skills that the students are developing.

SCIENCE STORY

The Science Activity Circus Comes to Mount Holly

I am visiting Ms. Markon, a new teacher at Mount Holly Elementary School. I have been her teaching supervisor, and today we are setting up a science circus in her fourth-grade class. We have used the students' lunch break to prepare the tables in the room. The students are aware that they will be returning from lunch to find that their room has been transformed.

When the students come in, they discover several tables, each with a different object or collection of objects and an index card, also called a *task card*, with instructions and questions on it. They are delighted with the transformed classroom and eager to begin. Because it is important for students to share ideas with each other, Ms. Markon asks each to work with a buddy as they explore the stations in the science circus. Each pair of students is assigned to a different station to start. They are instructed to visit each of the stations, spending between five and ten minutes at each stop. As the students explore the stations, I have the opportunity to interact with them.

An Old Log

At one station, the table holds an old log from my backyard. It comes from a birch tree that was felled in a storm several years ago. The log is very dry, but its thin, whitish bark is still intact. It is about 2 feet (60 cm) long and has a diameter of about 5 inches (12.5 cm). One end of the log is rough where it broke off from the rest of the trunk. The other end is smooth because the log was sawed for firewood. In the middle of one side of the log is a large, oval opening, probably made by the gradual pecking of a large-beaked bird.

Ms. Markon and I do not tell the students everything we know or surmise about the log. Instead, we refer the students to the index card on the table next to the log. It reads as follows:

> This is a piece of a tree trunk that I found in my backyard. Can you explore this piece of trunk and try to figure out what happened to it?
>
> What are all the things you observe about this tree trunk? What are some of your ideas about how it got to look this way?

The children handle the small log and record their ideas. Working in pairs, they talk about the log and how they think it got to be here in our science circus. One girl takes a marble from a neighboring shelf and drops it into the hole in the log. When I notice her doing that, I walk over to watch more closely.

"Oh!" she exclaims. "I'm sorry I took the marble!"

Surprised that she believes she has broken some rule, I reassure her that I think she has a great idea and that I'm just curious about what she wants to find out.

"I was just trying to see if the hole in the log went all the way through," she says. "It doesn't."

My thinking: *The girl's reaction dramatically illustrated how rule-bound students become after only a few years in school. I reminded myself to rejoice in those moments when students use their creativity to explore.*

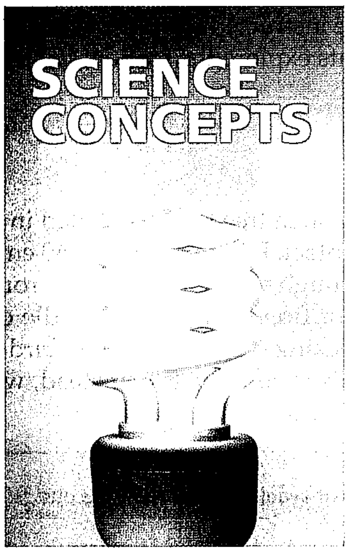
The students readily notice the differences between the two ends of the log. "Somebody sawed this," says one. "This looks like it broke off," another student suggests, looking at the other end of the log. "I bet a woodpecker did this," still another student offers, looking at the large hole inside which the marble has been rolling around. They draw pictures of the log in their science notebooks. They also record the title of the station and their observations and ideas about the log.

The Soda Can

On another table we have placed a soda can that was left in a car on a very hot summer day. The heated gas bubbles in the soda exploded the lid of the can at its seams and puffed out the bottom. The can is empty now, but it looks quite unusual. The lid is still attached at one point along the edge. The index card at that table reads:

> On a very hot summer day, I left my unopened soda can in the back of my car. Several hours later, when I returned to my car, the soda was all over the car seat and this is what the can looked like. What do you think happened?

Effect of Temperature on Liquids



At the soda-can station, students have the opportunity to learn what happens when we heat or freeze a liquid. When a carbonated liquid is kept in a very hot place, the carbon dioxide gas dissolved in the soda water becomes less soluble as the temperature increases. Heat energy increases the speed at which the liquid and gas particles move. The faster the gas particles move, the more frequently they hit the sides of the container and the greater the pressure. This pressure can eventually burst the seams of the can.

As one of the students in the story realized, the same kind of thing can happen when a soda can is frozen. Even though most liquids contract when they are cooled, water-based liquids like soda water start forming crystals when they begin to freeze, and these ice crystals occupy more volume than the original water. As the carbonated liquid occupies more space, it can burst through the seams of the can. This usually does not occur when soda cans are left in the freezer or out in the icy cold weather because a little space is typically left in the can that the freezing soda expands into. But many containers of water-based liquid that are filled to the top and sealed do burst when frozen. Hence, if the students inferred that the can was left either in a freezer or in a very hot place, they were correct.

Listening to students brainstorm about this can is very interesting. "Once," says one child, "my mom left a soda can in the freezer by mistake, and this is what it looked like." Another child remarks, "It looks like it exploded." The students record their various ideas in their science notebooks.

My thinking: I am interested to learn whether the students make a connection between temperature and the behavior of liquids in a can. I'm using a real story from my experience, one that I hope they can relate to. Asking new questions about daily-life experiences is my way of engaging them in the task of problem solving.

Crazy Rocks

In a large plastic bowl on one table, Ms. Markon has arranged her rock collection, which consists of several kinds of rocks. She has collected these rocks from many different places, and they are of various colors, textures, sizes, and shapes. The index card on the table reads:

> When astronauts brought rocks back from the moon, the first thing the scientists did was to group them according to similar characteristics. This is MY rock collection. You may have a rock collection too. I started collecting rocks when I was a small child. When you explore these rocks, what do you notice? In what ways are they the same? In what ways are they different? How many categories could you place the rocks into? Where do you think I found these rocks?

The students love rummaging through these rocks. It is a fairly large collection, and they come up with categories like "bumpy," "smooth," "light colored," "dark colored," "shiny crystals," "no crystals," "stripes," and "no stripes." Some of these rocks may be ones the students have never seen before.

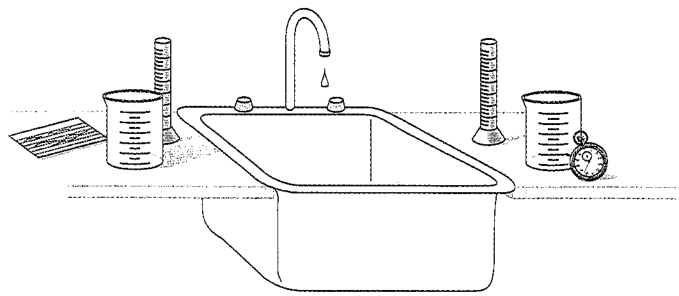


FIGURE 3.2 A dripping sink or water jug makes a simple but effective station in a science circus, stimulating students to observe, measure, and calculate

> *My thinking: Although many students could not relate to some of the rocks in the collection, most could relate to the idea of having a collection—at least an informal group of rocks that they had picked up here and there because they liked them.*

The Leaky Faucet

This station is at the classroom's sink, where water is dripping slowly from the faucet. (If your room has no sink, you can use a large jug of bottled water with its own spigot and a basin to collect the dripping water.) Nearby are a stopwatch, beakers, and graduated cylinders (Figure 3.2). The card reads as follows:

> You may have seen a leaky faucet in your own home. Measure and write down the amount of water that drips from the tap in one minute. Work out how much water will drip in one hour. How would you find out how much water will drip in one whole day?

As I watch the pairs of students, I remind them to write their plan in their science notebooks before carrying it out. Then I continue to watch and listen as they solve the problem.

> *My thinking: I am interested in understanding how the students will figure this out. What will they do? What units will they use? What will their decisions tell me about their prior experience and the ways they think?*

Many of the students are surprised to learn that as many as 7,200 milliliters of water can drip from a leaky faucet in one day if only 5 milliliters drip out in one minute. The next day, Ms. Markon brings in empty liter bottles, and the students help her stack seven of them up to see what 7,000 milliliters looks like. Several of them suddenly realize why their parents nag them to turn the water off. Several remember hearing that in some parts of the world fresh water is a scarce natural resource.

The Penny in the Pie Pan

At this station there are some pencils and a few pennies on the table, plus an aluminum foil pie tin that is half filled with water. The students read the following:

> Many of us like to swim. Have you ever noticed that your hands and feet look different when they are under water? Today we are going to submerge a penny in the pie tin of water. Before doing that, take your pencil and trace the penny in your science notebook. Now draw what you think the penny will look like when you put it in the water. Now place the penny in the water. What do you notice?

The students trace their pennies with their pencils and sketch their predictions. When they see the pennies in the water, they are often surprised. "I didn't know it would look so big," one boy exclaims. They record their observations in their science notebooks.

My thinking: *At this station, Ms. Markon and I want to engage the children in an activity that invites them to look at ordinary materials in a different way. Pennies, water, and pie pans are commonplace items. Making the connection to swimming is another way to provide a personal context for the activity.*

Three Types of Soil

At this station there are no materials at all. This is a "thought experiment." The card reads as follows:

> Imagine you have three different types of soil. How would you determine which soil holds the most water? What will you keep the same? What will you change?

The students spend a long time at this station. They brainstorm a way (or several ways, sometimes) to figure out the problem. When they decide on a way to solve the problem, they write it in their science notebooks. Here is an example from two of the fourth graders:

> Use three cups. Put three holes on the bottom of each cup and stand each cup in a pan—like a pie pan from the last station. Add each soil to a cup [one type of soil per cup] and then put the same amount of water in each cup. Wait one hour. Measure the water that drips out the bottom. The cup that doesn't drip out too much water has the best soil.

I ask this pair of students, "How big is each cup?" I want them to understand that we need to keep the size of the cups the same. Then I ask, "How much soil do you put in each cup?" I want them to see that they should use exactly the same amount of each soil. They decide to use half a cup of each soil. Next I ask them, "How will you measure the water that drips out?" The two students explain that they will pour it from the pie pan into a measuring cup.

On my next visit, I bring in three types of soil, paper cups, and measuring cups, and these two students try their experiment. It works! We examine the soils for size of particles and color. We determine how the soils are the same and different.

Another pair comes up with a different solution. They will also use paper cups, they decide, but they won't punch holes in the bottom. Instead, they will add the same amount of water to each type of soil and wait fifteen minutes. Then they will take three sheets of paper toweling, and on each sheet they will empty one of their cups, dumping out both the soil and the water. They have reasoned that whichever paper towel is the wettest will contain the soil that can hold the least amount of water.

"How much water will you add to each cup?" I ask.

They haven't thought about that—just that each cup would get the same amount of water. They think a little more about their plans. On my next visit, they carry out their experiment. They have decided to add one-half cup of water. But they find that their cups are too small for that amount, so they need to add less. They try again.

My thinking: *I particularly like thought experiments, especially ones that involve experimenting with materials that the students can readily imagine. In this case I used soils because most children have had plenty of experience with dirt! Also, of course, it was easy for me to bring samples of three types of soil to the classroom on my next trip. It is important for students to learn that design, and specifically designing an experiment, is an* ***iterative process****. You try it out, see what happens, alter your plans for the next attempt and do it again! Designing experiments is an integral part of doing science with students.*

The Weather Station

This station has a wireless laptop set up to access an Internet weather site. This and other weather sites provide statistics, photos, and explanations of unusual weather events. At this station the card reads:

> Compare the air temperature and weather conditions for San Francisco, California; Chicago, Illinois; and New York City. In what ways are they the same? In what ways are they different? How do they compare to Mount Holly? Set up a chart in your science notebook that organizes these data.
>
> Which of these cities would you prefer to be in today? Explain your reasons.

The students use the Internet site to gather data that they then record in their science notebooks. They need to manipulate the computer to obtain the information they are seeking.

My thinking: The relatively simple task of recording data from a website is one way the students can become familiar with using computers as a tool for scientific study. This same activity engages the children in map reading, which gives them experience with another significant tool. I like to personalize the activity by asking the students to choose the city that has their favorite weather.

The Teaching Ideas behind This Story

- The science activity circus stations provide opportunities for students to practice using scientific skills. While doing this, they also gain practice with investigations that generate some original thinking.
- Notice how curious the girl was at the station with the small log. When she acted on her curiosity by placing a marble in the hollow, she was momentarily unsure if she had done the "right thing." Often youngsters are timid about trying out their ideas, fearing they will be "wrong." Teaching science invites students to overcome that fear.
- At the station with the thought experiment about three types of soil, there were at least several possible "right" answers. Challenging students to solve a "How would you find out?" problem invites multiple responses as students personalize the problem and design solutions. Notice how, through my questions, I prodded them into setting up a fair test by pointing out how important it is to keep the experimental conditions the same. Notice, too, that at a later time I brought different soils to class. Thought experiments can be frustrating to students if the experiments cannot actually be tried.

The Science Ideas behind This Story

- The activities of the science activity circus are designed to give students practice with several skills. Most of the stations involve more than one scientific or engineering practice and more than one set of skills.
- At the station with the log and at the soda-can station we are asking the students to *construct explanations* using the skills of observation and inference. An **observation** is all of the information we can gain about an object or an event by using our senses. An **inference** is a reasonable statement about an object or an event that is based on an observation. We make observations with our senses and use our minds to make inferences—to really think about something. For instance, what happened to this tree trunk? Why does it look this way?
- An inference may or may not be provable. In science, if an inference or a guess is stated in a way that allows it to be tested, it is called a **hypothesis**.
- When the students explored the rock collection, we were asking them to observe in a particular way. This skill is **classifying**—sorting objects or ideas into groups according to similar properties. Classifying is a basic skill that human beings use to try to make meaning of the natural world and all its diversity. We use classifications in all of our thinking. Classifying the rocks into different groups required that students *argue from evidence* to justify their groups.

- The leaky faucet station involved **using** *mathematics and computational thinking*. Here, the students had the opportunity to work with tools that helped extend their abilities to observe. At this station, they used a stopwatch, graduated cylinders, and beakers, which are helpful for **measuring** time and volume. Other useful measuring instruments are balance scales, spring scales, thermometers, and meter sticks. Your students may also have the chance to use probe devices connected to a computer.
- When they recorded their measurements, the students were *obtaining information*. In school science, data include many different types of information, and students can record them by using words, numbers, graphs, drawings, or a computer program.
- At the penny and pie-pan station, the students were asked to **predict** what they thought the penny would look like under water. Then, after they dropped it in the pie pan, they *analyzed* their observations and compared them with their predictions.
- At the station without materials, which we called a thought experiment, the students were asked to **plan an investigation**. To do this, they had to recognize that testing ideas involves *controlling variables*. That is, they had to ask themselves, "What do I keep the same, and what do I change?" When we do science, we have to plan investigations where all variables but one are controlled. So if we want to find out which soil holds the most water, we need to keep the volume of the water, the amounts of the soil, and all other experimental conditions the same, changing only the type of soil. These are the attributes of a fair test.
- At the weather station, students were again obtaining and evaluating information and **recording data** that they had gathered.

Exploring Further

Think about a science circus station that you would like to create—perhaps one very different from the stations described in this chapter. If possible, plan it for a particular class with which you have had some experience. Then ask yourself the following questions about your plans:

- What scientific and engineering practices will students use to complete the task?
- How engaged will the students be in their own thinking? Will your station provide opportunities for them to ask their own questions? How can you promote their thinking?
- How can the station be relevant to your students' lives?
- What sorts of things do you expect to learn about the students from their questions, and how will this knowledge help you plan other science activities for them?
- How will you structure the entries in their science notebooks?
- How does this activity circus correlate with the new generation of science and engineering standards?

3-4 Technology Extends Our Senses

The practices of scientific exploration rely on our senses as well as on our prior knowledge and experience. Computer technology greatly enhances our capacity for making and saving observations and recording data, hence extending our senses. You saw a hint of this capacity in the weather-station activity, in which students used an Internet site to explore weather in three other cities as well as their own. They could also use a wireless handheld device like an iPad or an iPhone. There are many software programs that help students extend their senses as they engage in science as practice.

iterative process
The act of repeating a process of design where the final result of one process or *iteration* is the starting point for the next iteration until an optimized solution or target goal is reached.

observation
Perception of an object or an event, using as many senses as possible.

inference
Reasonable explanation that we construct on the basis of our observations. Inferences sometimes lead us to set up further investigations.

hypothesis
An inference or a guess that is tested through a planned investigation or experiment.

classifying
Sorting objects or ideas into groups on the basis of similar properties.

measuring
Determining distance, volume, mass, or time by using instruments that indicate these properties (such as centimeter sticks, graduated cylinders, scales, or stopwatches).

predicting
Estimating the outcome of an event on the basis of observations and, usually, prior knowledge of similar events.

planning an investigation
Determining a reasonable procedure that could be followed to test an idea. This includes listing the materials needed, writing out the procedure to be followed, and identifying which variables will be kept the same and which will be changed.

recording data
Writing down (in words, pictures, graphs, or numbers) the results of observations of an object or an event.

probe
An electronic sensor, connected to a computer or other wireless handheld device, that allows the user to record real-time data about the environment.

3-4a Real-Time Data Collection Software

An important support for science learning is the use of measuring instruments with computer interfaces. Electronic sensors, usually called **probes**, connect to a computer or wireless handheld device, including iPods, iPads, or a smartphone with the appropriate software. These probes allow students to record real-time data about their environment. These probes come with instructions for downloading the software from the Internet. The probe itself can usually be connected through the USB port on your computer or handheld device.

Common probes include temperature, voltage, and motion sensors. The use of probes in an inquiry environment assists students in understanding important scientific concepts, such as heat and temperature. Data from a probe can also automatically generate a graph. Further, mobile applications for smartphones and tablets can automate data collection and capture images, sounds, and text. In Chapter 4, we will examine how urban sixth graders use a mobile app to identify local street trees.

In one third-grade classroom, the students were exploring whether heat is produced during seed germination. They were germinating seeds in plastic bags with wet paper towels and had inserted a temperature probe into one of the bags. This probe took the temperature of the air inside the bag every two hours over the course of five days. Collecting the data every two hours in a conventional way would have been impossible, as no one was around at night. The probe stored the readings on the computer, making the data easily accessible. Using this equipment, the students were able to collect data that showed that, as their seeds germinated, the temperature rose.

3-4b Using Video to Extend Observations

Because digital video is now commonplace, science teachers have discovered that video is an exciting technology for improving and extending the process of observation. Students can make their own videos of science experiments. Further, videos can record what happens when you are sleeping. Nighttime camera videos have helped students to learn what animals live around their school environment or how their classroom hamster delivered her babies. When a science teacher used digital video to record the popping of a water balloon, the students watched it in slow motion and saw things they could not have seen with the unaided eye. Their video helped them answer the question, "What really happens when a balloon bursts?" (With a water balloon, from which the water is expelled as the balloon pops, the bursting process is slow enough for the details to be revealed in a digital video.)

The *video microscope*, which uses digital technology to magnify images of objects, revealing a microscopic world on a computer screen, is a readily available tool that allows a class to examine microscopic organisms in real time on a computer screen or any other monitor. Some video microscopes have detachable digital cameras; others have all-in-one systems. There are many choices. Using this technology, one sixth-grade class observed the single-celled organisms in a small sample of water from a nearby pond. The water was set up on a slide of a video microscope that displayed its images on a computer screen. Because the technology allowed all the students to view the slide at the same time, the teacher was able to facilitate a conversation about the microorganisms with the entire class. Today, many YouTube videos are available for you to share with students. You can use digital video devices to record the students' investigations and upload them to the science videos currently on YouTube!

3-5 Science in the Classroom and with the Family

If you answered "yes" to any of the "To Think About" questions at the beginning of this chapter, then you have been using scientific and engineering practices in your daily life. Making decisions about products, the weather, our health, and the state of our nutrition requires careful attention to what counts as evidence; how explanations are constructed; and how information was obtained, evaluated, and communicated, which helps us to be more aware citizens.

Asking questions and testing ideas in a planned and consistent manner is the foundation of scientific practices.

Through activities like the ones in the science activity circus, young children begin to build confidence in their abilities to understand the natural world. They learn to observe closely, sort things into categories, and ask how things are the same and how they are different. Even very young children can make predictions—"What will happen if . . .?" They come up with tentative explanations for their observations, and these inferences change as they get older. Children begin measuring by using string, centimeter sticks, and balance scales. They weigh objects using uniform masses like the teddy-bear counters in the icicles story from Chapter 2. As they mature, they begin to use standard units of measurement for distance, mass, and volume. By third grade, many students can design investigations, recognize variables, and control the experimental conditions. By middle school, students can plan and carry out a greater variety of investigations, including experiments that involve more than two variables and require them to record detailed data. At all levels, students are recording data in some fashion in their science notebooks, first through drawings and later through words, graphs, and numbers.

Remember that activities like those at the science circus stations succeed only if they generate students' questions and promote further thinking. The students' minds as well as their hands have to be applied. They will not learn to employ scientific practices merely by manipulating objects. The enduring learning occurs as a result of their brainstorming, discussion, reflection, and communicating of what they have learned.

3-5a Family Science Night

The concept of a science circus—several stations offering a wide variety of activities—can form the basis for an event that involves students' family members. Engaging adults in science experiences together with students is a way to not only bring families together but also to encourage a deeper interest in science and science-related activities. Moreover, research tells us that parents' attitudes affect their children's attitudes, and some adults' fears of science may have a negative impact on their children (Kober, 1993). By emphasizing the relevance of scientific activities *outside* school—in our students' everyday lives—we can help change those negative images of science.

family science night
A community-involvement activity in which students bring a significant adult or adults to the school to participate in inquiry-based science activities typically set up at stations in a large classroom or in the school cafeteria.

A **family science night** can take many forms (Photo 3.1). At one school I observed, the event was spread over two nights so as many families as possible would have the opportunity to participate. As parents and students filed into the school cafeteria, they picked up red booklets titled "My Family Science Notebook." The teachers had designed seven stations that invited participants to manipulate materials and use trial-and-error problem solving. The activities were carefully planned to stress process skills like the ones described in this chapter.

Each of the stations offered complete directions, materials, and questions to encourage higher-order thinking and discussion. Each activity corresponded to a page in the notebook on which the families could record or sketch what they were doing. The students were encouraged to act as the note takers for the family. The notebook also included questions to guide the students and follow-up activities to perform at home.


Paul Conklin/PhotoEdit

PHOTO 3.1 Students share their understanding with their class and visiting parents.

At one station, families investigated how many drops of water could fit on the head of a penny and how a water droplet can become a magnifier. At another station, students listened to their heartbeats with a stethoscope, counting the number of beats in a fixed period of time, before and after exercise. At a third station, families explored the movements of garden land snails. Four other stations touched on other aspects of life science, physical science, and earth science.

All of the families' observations and inferences were recorded in their science notebooks, which contributed a great deal to the success of the evening. Families used their notebooks as a way to keep track of what they did and what they learned. Further, the notebook became a symbol both of science and of the family science night. At home, families could use their science notebooks to duplicate the science night activities.

Sometimes family science nights became an annual tradition. The teachers change the design of the science stations each year. Letters sent home with the students ask community members what they would like to see at the next family science event, which establishes an ongoing science link with the students' homes.

This story illustrates just one successful format for a community science night. You can design your own format and your own stations. The key is to engage students and their families in a genuine process of inquiry that relates to their own lives and challenges them to construct their own ideas.