SCIENCE IN AFTERSCHOOL


# An Instructor's Guide to the AFTERSCHOOL TRAINING TOOLKIT

A Supplement to the
Online Afterschool
Training Toolkit
for 21st Century
Community Learning Centers
www.sedl.org/afterschool

Produced for the U.S. Department of Education by the National Partnership for Quality Afterschool Learning.

## Contributors

Errin McComb

Tina Johnson

## Design and Production

**Production**
Laura Shankland
Deborah Donnelly
Catherine Jordan

**Editorial**
Leslie Blair
Debbie Ritenour
Joni Wackwitz

**Designers**
Shaila Abdullah
Lisa Dirks
Jane Thurmond



SEDL
4700 Mueller Blvd.
Austin, TX 78723
Voice: 512-476-6861
Fax: 512-476-2286
www.sedl.org

SERVE Center at the University of North Carolina at Greensboro
P.O. Box 5406
Greensboro, NC 27435
Voice: 800-755-3277
www.serve.org

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# An Instructor's Guide to the AFTERSCHOOL TRAINING TOOLKIT

# Lesson Overview



* Most sessions will last 45–60 minutes.



# Introduction

## The Afterschool Training Toolkit

If you work in afterschool, you most likely know the challenge of offering afterschool academic enrichment that will boost student performance during the regular school day while making sure activities are engaging enough to keep students coming back. Through a contract with the U.S. Department of Education, the National Partnership for Quality Afterschool Learning has developed tools to help you meet this challenge. National Partnership staff visited 53 afterschool programs, nationwide, that had evidence suggesting they had a positive effect on student achievement.

Based on this research, the National Partnership developed the Afterschool Training Toolkit (www.sedl.org/afterschool/toolkits), an online resource that is available to afterschool professionals to help them learn how to offer engaging educational activities that promote student learning. The toolkit is divided into sections that address six content areas: literacy, math, the arts, homework help, technology, and the content area for this guide, science. Like the other content areas in the toolkit, science is taught through promising practices, or teaching techniques with evidence suggesting they help students learn important academic content.

The five promising practices in afterschool for science identified in the Afterschool Training Toolkit are as follows:

- *Investigating Science Through Inquiry*
- *Exploring Science Through Projects and Problems*
- *Integrating Science Across the Curriculum*
- *Engaging Families and Communities in Science*
- *Tutoring to Enhance Science Skills*

When used with the Afterschool Training Toolkit, the lessons in this instructor's guide will help you master these promising practices. Once you become proficient at these practices, you should be able to use them to develop other science lessons.

This instructor's guide will help you

- understand how to use the science section of the Afterschool Training Toolkit;
- use science to offer fun lessons that help students learn in afterschool;
- motivate students to participate in afterschool; and
- use the lessons to become a more effective afterschool instructor.

## The Role of Science

Before you begin, you should know that this instructor's guide is *not* a manual for starting an afterschool science program. You do not need to be a science expert or science teacher to use this guide. In addition to the lessons on promising practices, we have a number of helpful resources at the end of this guide. See "Principles of Quality Afterschool Science Programs" and "The 5Es" at the end of this guide for more information on afterschool science enrichment.

## How to Use This Instructor's Guide

This guide will help you master promising practices in science for afterschool through the following steps:

- Watch video clips to see real afterschool programs using the promising practices from the National Partnership's online Afterschool Training Toolkit.
- Teach the sample lessons included in this instructor's guide to your students.
- Reflect on the student lesson.

### Video Clips

The Afterschool Training Toolkit (www.sedl.org/afterschool/toolkits/) includes video segments taken from outstanding afterschool programs across the United States. Watching these video segments allows you to observe afterschool instructors in action as they use promising practices in science. Take notes on what you see and think about ways that you can use these practices in your afterschool program.

### Lessons

To support each video that illustrates a promising practice in science, this instructor's guide provides sample lessons using the same practice. Each lesson includes step-by-step instructions and a list of supplies you will need to help you prepare for and teach the lesson. You can teach as many of these lessons as you think are appropriate to your students, depending on their grade levels and skills and the time available in your afterschool schedule.

### Reflection

After each lesson you will find a series of questions addressing the preparation, academic enrichment, classroom management, and expansion of that lesson. The purpose of the reflection is to allow you to be intentional in your instruction—to think about what aspects of a lesson worked well and what changes you might want to make for future lessons. Reflection is an important part of becoming a successful instructor and will help you apply what you learned from one lesson to another.[1]

The following is an example of how a teacher might answer the reflection questions after leading a lesson on sinking and floating.

## Reflection [Sample]

### Preparation

- How well did the lesson planning help you prepare for this activity?
- What can you do to feel more prepared?

*Teaching science activities requires different preparation than the other subject areas I have taught. It wasn't necessarily more difficult, but it seemed like there were more logistics involved. I had to gather a number of materials and do a fair bit of advance preparation. The lesson planning helped guide me a great deal.*

*To feel more prepared next time, I will do a dry run of the activity, which I did not do this time. I needed to have more towels on hand to mop up spills, and I should have brought some plastic bags to cover the table. A dry run would have enabled me to see these issues before I was doing the activity in front of the students.*

### Academic Enrichment

- How did this lesson support other academic content areas like math or literacy?
- What changes could you make to strengthen academic enrichment while still keeping the activity fun?

*This lesson supported language arts and literacy (with the read aloud and the graphic organizer). To strengthen academic enrichment, I could have kept a vocabulary list on the chalkboard so that students could remember some of the terms we used and incorporate them into their vocabulary.*

[1] McEwan, E. K. (2002). *Ten traits of highly effective teachers.* Thousand Oaks, CA: Corwin Press, Inc.

### Classroom Management

- What strategies did you use to make the lesson go smoothly?
- What changes would you make if you taught the lesson again?

*Most of the time students were focused on the activity, which they found to be a lot of fun. Crowding around the testing tank was a problem, though; and some students had trouble seeing. If I do this activity again, I might set up more than one tank of water for testing and then divide students into teams. That would enable students to be more involved in the activity and to see better. I might also need to get an older student to volunteer to help monitor the other tank.*

### Expansion

- How can this activity be improved to include concepts from other content areas?
- What resources or connections can be made to the larger community to provide support for this activity?

*To connect the activity to other content areas I could plan to have students write a short story or poem that includes what they learned about sinking and floating, which is one of the suggested extensions for the lesson. To connect to the larger community, I could include this activity as part of a Family Science Night at the school. Students would really enjoy doing this activity with their parents, I think.*

## Practice 1

# Investigating Science Through Inquiry

### What Is It?

Inquiry is both an approach to teaching and a way of learning. It involves a process of exploring through asking questions and looking for answers. It includes making observations; planning and conducting investigations; using tools to gather, analyze, and interpret data; and learning more about the world by proposing explanations that lead to new understandings.

### What Is the Content Goal?

The key goal of *Investigating Science Through Inquiry* is to help students learn science by doing science. Inquiry combines the process of discovery with scientific knowledge. Students use what they know to design and conduct investigations to understand science better.

### What Do I Do?

Begin by connecting with the day-school science teacher to find out what science concepts, skills, activities, and grade-level standards students are working on and what kinds of activities lend themselves to investigating science through inquiry in afterschool. You will want to start with a question (e.g., what factors affect plant growth? What makes a good bubble blower? Why are the trees on the playground dying? Do energy-saving light bulbs really last longer?). Then consider an experiment that will let students discover the answer by investigating, observing, collecting and analyzing data, and communicating the results. Inquiry is grounded in asking questions, making predictions, and testing those predictions. Many initial investigations will be more instructor-directed (guided inquiry). As students learn the process, they can be more self-directed.

## Tech Tips for *Investigating Science Through Inquiry*

A digital microscope, a relatively inexpensive (less than $100) technology tool, enables students to go beyond understanding scientific processes such as photosynthesis and respiration to actually seeing such processes in action. With some additional attachments, you can also display a digital microscope's output on a projector or computer screen so that students can share, record, and save their investigations.

For educators working with preK through fifth grade students, the George Lucas Educational Foundation offers an online learning module, "Exploratory Learning with a Digital Microscope." It includes an introduction to the digital microscope as well as activities for classroom use. Visit www.edutopia.org/teachingmodules/EL/index.php.

Molecular Expressions offers an interactive Java tutorial on digital microscopes as part of "Science, Optics & You," an interdisciplinary optics, light, and microscopy curriculum for elementary grade students. Visit http://micro.magnet.fsu.edu/optics/tutorials/index.html.

## Why Does It Work?

*Investigating Science Through Inquiry* works because students are directly involved in their own learning—questioning, observing, recording and analyzing data, reflecting on their findings, and sharing those findings with others. Students develop cognitive abilities—critical thinking and reasoning skills—as well as science understanding.

## Getting Started


The video "Exploring Trebuchets" in the science section of the Afterschool Training Toolkit illustrates the practice of *Investigating Science Through Inquiry*. In the video, first through sixth graders at the Brighton-Allston Afterschool Enrichment Program (BASE) in Boston, Massachusetts, use inquiry skills to construct trebuchets, medieval catapults used to hurl stones.

Go to the *Investigating Science Through Inquiry* practice found in the science section of the Afterschool Training Toolkit (www.sedl.org/afterschool/toolkits/science/pr_investigating.html). Then click on the "Exploring Trebuchets" video.

**BEFORE YOU WATCH THE VIDEO,** write down what you think the teacher will do to help students learn what trebuchets are, the science behind how they work, and how to build one.

**DURING THE VIDEO,** consider the following:

How does the instructor engage students in the activity and lay the groundwork for what they are going to learn? How does the instructor promote the process of inquiry during the activity and keep the students on track and engaged?

How does the instructor integrate other content areas such as literacy into the activity? What other content areas does the activity reinforce? Be sure to give specific examples.

**AFTER YOU WATCH THE VIDEO,** write what modifications you might need to make to teach this lesson in your class.

# Lesson 1

## Sink or Float

This sample lesson is one example of how you can implement the practice of *Investigating Science Through Inquiry*. In this activity, students use everyday objects to make and test predictions about what sinks and what floats. Students then chart their results in a graphic organizer.

**Grade Level(s):**

K–2

**Duration:**

One session of 45–60 minutes

**Student Goals:**

- Practice scientific inquiry through questioning, predicting, observing, recording and interpreting data, and communicating results
- Keep records of scientific investigations by using graphic organizers
- Develop group-work skills such as working together and listening to others

## Imagine This!

The slightly damp students form two loose-knit groups around a tank of water. They have already tested several everyday items to see whether they sink or float and are now engaged in a lively debate over an apple. "It's way too heavy to float," declares one student, as several others nod in agreement. "But haven't you ever bobbed for apples?" another student asks. "I'm sure the apples were floating in the water." A number of students voice their support. The discussion ends as the instructor holds up a hand, and an eager student drops the apple into the water. Kerplunk. Suddenly, a cheer goes up among one group. "It's floating, it's floating, we were right!" The instructor writes the word *floats* under the picture of an apple and explains why apples do not sink. The debate then begins anew with the next item to be tested.

## What You Need

- ❒ A copy of either *Sink or Float?* by Lisa Trumbauer (New York: Newbridge Communications, Inc., 1997) or *Who Sank the Boat?* by Pamela Allen (New York: Putnam, 1985)
- ❒ KWL chart
- ❒ Large, see-through aquarium or plastic container
- ❒ Various objects that either float or sink, such as a rubber band, an orange, an apple, a carrot, a leaf, a twig, a pencil, empty plastic bottles, floating toys (boats, rubber duck), empty and full soda cans (sugar-free and regular), a bar of soap, a sponge, a tennis ball, a ping pong ball, a pumice stone, a crayon, a marble, a nail, a paperclip, a rock, a fishing sinker, a penny, and an ice cube

### Teaching Tip

**KWL Charts**

KWL stands for *know*, *want to know*, and *learned*. This type of chart consists of three columns labeled "K: What We Know or Think We Know," "W: What We Want to Know," and "L: What We Learned." Before students begin the activity, have them complete the first two columns of the chart by brainstorming what they know and want to know about why some objects float in water and others sink. Prompt students with questions to help them brainstorm. Then, during and after the activity have students fill in the "learned" column of the chart as appropriate.

| KWL Chart | | |
|---|---|---|
| **K**<br>What We **K**now<br>or Think We Know | **W**<br>What We **W**ant to Know | **L**<br>What We **L**earned |
| | | |

## Getting Ready

- Read one of the books listed and consider how you will engage students in your read aloud.
- Create a KWL chart for students to complete as a class (see Teaching Tip on p. 9).
- Gather or ask students to bring in a variety of objects to test.
- Make drawings or cut out illustrations to represent the items to be tested.
- Collect pictures of additional things that float or sink, such as large boats, animals and people in water, and sunken treasure.
- Prepare a space to test the items and partially fill the aquarium or plastic container with water.

### Teaching Tip

**Leading Read Alouds**

See the *Read Aloud* practice in the literacy section of the Afterschool Training Toolkit online to get reading ideas, especially for younger students (www.sedl.org/afterschool/toolkits/literacy/pr_read_aloud.html).

## Safety Considerations

If you use a glass aquarium, ensure that it does not have any cracks or leaks.

## What to Do

- **Engage** students by introducing the study of sinking and floating.
  - Ask students what they already know about why some things sink and others float in water. Record students' statements in the "know" column of the KWL chart. Then help students complete the "want to know" column of the chart.
  - Read aloud either *Sink or Float?* by Lisa Trumbauer or *Who Sank the Boat?* by Pamela Allen. Ask questions about the book's illustrations and main ideas to keep students engaged and to determine what they know about why things sink or float.
- **Explore** which objects sink and which ones float. Form students into a large group around the tank of water. Hold up an item so that all the students can see it. Then, pass the item around for students to feel and ask them to predict if the item will sink or float. Ask older students to write down their prediction under the name or a picture of the item. Have one student tester (rotate this role) place the object into the tank of water to test its ability to float.
- **Explain** the results. As each item is tested, add the information to the "learned" column of the KWL chart. Older students might fill in their own charts. After several items have been tested, ask students to think about why some things sink and others float.
- **Extend** learning if time allows.
  - Use a plastic children's pool to test larger objects.
  - Have older students construct boats out of clay or aluminum foil and test how much the boats will hold before they sink.
  - Incorporate literature, art, and writing by having students write a short story or create a drawing about sinking and floating. You may also consider extending the lesson for students ages 9 to 11 by including the topics of buoyancy and density.
- **Evaluate**. Look for the following outcomes:
  - Student participation and engagement
  - Student ability to make and test predictions
  - Student understanding of why some objects float and some sink
  - Student ability to record scientific findings in a KWL chart

# Reflection

## Preparation

- How well did the lesson planning help you prepare for this activity?
- What can you do to feel more prepared?

## Academic Enrichment

- How did this lesson support other academic content areas like math or literacy?
- What changes could you make to strengthen academic enrichment while still keeping the activity fun?

## Classroom Management

- What strategies did you use to make the lesson go smoothly?
- What changes would you make if you taught the lesson again?

## Expansion

- How can this activity be improved to include concepts from other content areas?
- What resources or connections can be made to the larger community to provide support for this activity?

# Lesson 2

## Festival of Bubbles

This sample lesson[2] is one example of how you can implement the practice of *Investigating Science Through Inquiry*. In this activity, students investigate soap bubbles and the properties of bubble-making substances. Student groups pose questions and conduct experiments to test three different bubble solutions and determine which one produces the largest bubbles. This lesson also incorporates mathematics.

**Grade Level(s):**

3–5

**Duration:**

Two sessions of 45–60 minutes each

**Student Goals:**

- Practice scientific inquiry through questioning, predicting, observing, recording and interpreting data, and communicating results
- Use science and math tools—rulers, tape measures, graduated cylinders—to measure and collect data
- Develop group-work skills such as working together and listening to others

[2] This lesson is adapted from the *Bubble Festival Teacher's Guide* by J. Barber and C. Willard (Berkeley, CA: University of California, Berkeley, 1992) and the *Bubble-ology Teacher's Guide* by J. Barber (Berkeley, CA: University of California, Berkeley, 2001), part of the Lawrence Hall of Science's Great Explorations in Science and Mathematics (GEMS) curriculum series.

## Imagine This!

The classroom is filled with bubbles. One student dips a straw into a soap solution in a shallow tray, takes a deep breath, and slowly blows into the straw to create a large bubble just above the tray. The group giggles as the bubble pops. Then another member of the group quickly measures the length of the footprint the bubble has left in the tray. "It's 5.7 centimeters," he says. A third student records the measurement in a data sheet. The group blows two more bubbles with the solution and then moves on to repeat the procedure with two other types of solution. When all the groups have finished blowing bubbles, the instructor helps the students determine the average bubble size for each solution. The students murmur as they examine a bar graph of the results. It is clear which solution produces the biggest bubbles.

## What You Need

*For the soap solution:*

- ❒ Three brands of different-colored liquid dish soap
- ❒ Glycerin with eye dropper (available at most pharmacies)
- ❒ Three 1-gallon plastic bottles with lids for mixing soap solution
- ❒ Plastic pint containers with lids (one to two per station)

*For the activity:*

- ❒ Black plastic bags or plastic tablecloths to cover the tables
- ❒ Straws (at least three per person)
- ❒ Clear rulers or plastic tape measures (with centimeters)
- ❒ Plastic tubs, trays, or baskets to hold materials (one per group)
- ❒ Handout 1: Learning Log (one per student)
- ❒ Handout 2: Data Sheet (one per group)
- ❒ KWL chart (see p. 10)

*For cleanup:*

- ❒ Vinegar
- ❒ Sponges (one per group)
- ❒ Squeegees (one per group)
- ❒ Bucket with water

## Getting Ready

*One or more days before the investigation:*

- Prepare soap solutions. Fill each 1-gallon plastic bottle with water and then remove 1 cup of water from each bottle. Add 1 cup of liquid dish soap and 60 drops of glycerin to each bottle and shake gently. Label each solution. Note that this recipe makes enough soap solution for weeks of activities; about 1 cup for each group is used in this lesson.
- Cut large pieces of plastic to cover the tables.
- Review the lesson, assemble all materials, and print and make one copy per student of the learning log handout and one copy per group of the data sheet handout.
- Prepare a class KWL chart (see Teaching Tip on p. 9).

*Day of the investigation:*

- Pour soap solutions into labeled pint containers (one to three containers per brand of detergent).
- Prepare three stations, one for each brand of soap solution. Cover each table with black plastic bags or plastic tablecloths. At each station provide straws (one per person) and one to three labeled pint containers of soap solution.
- Organize materials in plastic tubs, trays, or baskets (one per group). Each tub, tray, or basket should include a plastic cover, pencils or pens, a ruler, a tape measure, and a sponge.
- Have vinegar, squeegees, and buckets on hand for cleanup. When cleaning up, first squeegee the area to remove as much soap solution as possible, and then sprinkle vinegar over the area and squeegee again or wipe with a sponge.

## Safety Considerations

- Students should wear safety goggles to protect their eyes.
- Students should wear smocks, oversized T-shirts, or aprons to protect their clothing.
- If solution gets in a student's eyes, instructors should wash the student's eyes with clear water.
- Instructors should have materials handy to clean up any spills on the floor.
- After the investigations, students should wash their hands to remove any soap solution.

## Session 1: Blowing Bubbles and Recording Data

### *What You Need*

- ❒ Soap solutions in labeled pint containers (see directions under "Getting Ready")
- ❒ Straws (three per person)
- ❒ Plastic bags or tablecloths to cover tables
- ❒ Plastic tubs, trays, or baskets containing the necessary supplies: a plastic cover, pencils or pens, a ruler, a tape measure, and a sponge
- ❒ Handout 1: Learning Log (one per student)
- ❒ Handout 2: Data Sheet (one per group)
- ❒ KWL chart (see p. 10)
- ❒ Cleanup materials: vinegar, sponges, squeegees, and buckets

### *What to Do*

- **Engage** students by introducing the study of bubbles.
  - Ask students where they have seen or blown bubbles before and if they have ever used anything unusual to create a bubble. Record students' answers on the KWL chart.
  - Divide students into small groups of four and distribute the learning logs, data sheets, and group supplies.
  - Ask one student in each group to gather and return materials, one student to direct the investigation, one student to record the data onto the group's data sheet, and one student to make sure students are wearing goggles and keeping the area clear.
- **Explore** the science of bubbles with small groups.
  - Assign each group to a station. Instruct students to spread a thin layer of bubble solution about the size of a large pizza over a flat surface. Next, one group member should blow a bubble by wetting a straw and gently blowing just above the surface of the wet area. After the bubble pops, another group member should use a clear ruler or a tape measure to measure the diameter of the bubble's footprint to the nearest 0.1 cm. Students should then record the data in their learning logs and on the group's data sheet.
  - After all group members have had an opportunity to blow three bubbles each with one solution, the group should clean up its area and rotate to another station with a different solution. Groups will need about 15 minutes per solution.

## Session 2: Analyzing the Data

### *What You Need*

❒ Student learning logs from previous session

❒ Group data sheets from previous session

### *What to Do*

- **Explain** the results. Instruct students to complete their data sheets and find their group's average bubble size for each solution. Ask each group to report its results. Record each group's results in a table or electronic spreadsheet and then create a bar graph of the average class data. Have students compare their data, their group's data, and the class data as they complete their learning logs. Discuss the results and have students write a conclusion. Which liquid detergent produces the largest bubble?
- **Extend** learning if time allows.
  - Find a poem on bubbles at your local library or using an Internet search engine. Consider "Blowing Soap Bubbles" by Gerard Manley Hopkins or "Bubbles" by Carl Sandburg. Discuss the poem with students. Read the poem aloud to students. Then ask them to write and illustrate their own bubble poems.
  - You may want to research and study how liquid detergent is made, test several more liquid detergents, or vary the amount of glycerin used in one brand of detergent to see if that variable makes a difference in bubble size.
- **Evaluate.** Look for the following outcomes:
  - Student participation and engagement
  - Student collaboration and cooperation
  - Answers that reflect an understanding of how to observe and measure bubbles and calculate averages
  - Answers that reflect an understanding of how to collect, record, and interpret data

## Handout 1: Learning Log

| Key Points, Question of Study, Hypothesis, Procedure, Observations, Data, Tables, Graphs, Graphic Organizers | What I Learned/ Questions I Have |
|---|---|
| Question: Which brand of liquid detergent makes the biggest bubble?<br><br>Hypothesis: I think that _____ will make the biggest bubble.<br><br>Procedure:<br><br>1. Gather solutions, prepare tables, get straws.<br>2. Make a pizza with soap solution.<br>3. Blow a bubble.<br>4. Measure the diameter.<br>5. Record the diameter.<br>6. Repeat 4 times.<br>7. Calculate the average bubble size for each solution.<br>8. Write observations and notes.<br>9. Share results with class.<br>10. Draw conclusions.<br><br>Data Table: | |

| Brand of Liquid Detergent | Diameter of Bubble (cm) | | | | Average Bubble Diameter (cm) |
|---|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | Trial 4 | |
| | | | | | |
| | | | | | |
| | | | | | |

Observations and Notes:

_____

_____

_____

**Handout 1: Learning Log, continued**

| Key Points, Question of Study, Hypothesis, Procedure, Observations, Data, Tables, Graphs, Graphic Organizers | What I Learned/ Questions I Have |
|---|---|
| | |

| Team Name | Average Bubble Diameter (cm) | | |
|---|---|---|---|
| | Sunlight | Palmolive | Dawn |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| Overall Average Diameter (cm) | | | |

Conclusions: (Compare your hypothesis to your data and the class data.)

_____

_____

_____

_____

_____

_____

_____

## Handout 2: Data Sheet

| Brand of Liquid Detergent | Diameter of Bubble (cm) | | | | |
|---|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | Trial 4 | Average |
| | | | | | |
| | | | | | |
| | | | | | |

# Reflection

## Preparation

- How well did the lesson planning help you prepare for this activity?
- What can you do to feel more prepared?

## Academic Enrichment

- How did this lesson support other academic content areas like math or literacy?
- What changes could you make to strengthen academic enrichment while still keeping the activity fun?

## Classroom Management

- What strategies did you use to make the lesson go smoothly?
- What changes would you make if you taught the lesson again?

## Expansion

- How can this activity be improved to include concepts from other content areas?
- What resources or connections can be made to the larger community to provide support for this activity?

# Lesson 3

## MyPyramid

This sample lesson is one example of how you can implement the practice of *Investigating Science Through Inquiry*. In this activity, students work with the U.S. Department of Agriculture (USDA) food pyramid recommendations. Students will form questions and investigate whether the food offered at their school meets the food pyramid guidelines and provides support for a healthful diet. The lesson provides experience in all aspects of the inquiry process.

**Grade Level(s):**

9–12

**Duration:**

6–8 weeks (45–60 minutes weekly)

**Student Goals:**

- Practice scientific inquiry through questioning, predicting, observing, recording and interpreting data, communicating results, and planning further investigations
- Measure using scientific tools, such as scales and various measuring devices
- Keep journals or records of scientific investigations
- Apply mathematical concepts of measurement
- Communicate results
- Compare results from multiple groups and draw conclusions

## Imagine This!

The group of students place several meals from the school's cafeteria on a table and begin analyzing their nutritional value. "You are what you eat," says one student. "Then I'm cool as a cucumber," says another, using a fork to poke at a cucumber slice in a salad. The students refer to a chart of the USDA food pyramid guidelines as they analyze the cafeteria meals and determine how healthy they are. The students then record their findings as part of their investigation of the quality of the food available at their school. Later, they will present the results of their investigation to the class.

## What You Need

- ❒ Handout 3: USDA Food Pyramid (one per student)
- ❒ Handout 4: MyPyramid Data Sheet (one per student)
- ❒ School or district breakfast and lunch menus
- ❒ Snacks from school vending machines or a local convenience store
- ❒ Data or statistics about health and weight for the local area
- ❒ Food scales
- ❒ Measuring cups
- ❒ Clear rulers or plastic tape measures (centimeter)
- ❒ Journals or learning logs

### Teaching Tip

**USDA Food Pyramid Online**

The USDA MyPyramid.Gov Web site (www.mypyramid.gov) provides a wealth of information about the food pyramid, dietary guidelines, menu planning, and exercise. The site includes a page for children that provides games, classroom materials, and information for families.

## Getting Ready

- Inform the school cafeteria staff or the school or district nutritionist of the planned activity.
- Obtain current research and news articles about nutrition, the effect of food intake on health and weight, and the foods and ingredients recommended for health (reasons provided should vary).
- Develop pointers to give to each team on how to develop research questions.
- Organize materials in team folders (one per team). Folders should include learning logs, calculators, scales, metric conversion charts, copies of Handout 3: USDA Food Pyramid and Handout 4: MyPyramid Data Sheet, and any other useful materials. Establish a location and system for storing the folders.
- Consider connections! As this topic is relevant to the larger community, consider using the activity as part of a community or family science night.

## What to Do

- **Engage** students by introducing the study of food and exercise. Have students review newspaper and magazine articles related to health, weight, and wellness. Ask students if they or their peers consider the nutritional value of what they eat or if they consider calories or ingredients when selecting foods. You may want to use a KWL chart to record what students know about the food pyramid and food-group quantities.
- **Explore** the USDA food pyramid and nutrition. Have students investigate whether the food offered at their school meets the food pyramid guidelines. Create two or more student teams. Students on each team should fill the following roles: materials gatherer, chief investigator, recorder, and reporter. You may assign roles or allow team members to choose them.
  - The materials gatherer brings materials and folders to the team and returns the materials to the designated central location at the end of each session.
  - The chief investigator directs the investigation and coordinates the development of the research questions and hypotheses. With appropriate guidance from the instructor and in concert with his or her group, this student will frame the questions and hypotheses that the team's research will explore. In addition, this student will determine the procedure and methods for contacting school or district food services and for gathering the following information:
    - The establishment and purpose of the food pyramid
    - Recommended daily allowances
    - Types of food available in school vending machines and snack bars
    - The percentage of students that participate in student lunch programs
  - The recorder filters the data the team collects each week and records the data in Handout 4: MyPyramid Data Sheet.
  - The reporter is responsible for generating an output of all findings and facilitating the group presentation of the findings.

### Teaching Tip

**Sensitivity in the Classroom**

Remind students that they should not use the information they learn during their research to judge or criticize their peers or others. Explain to students that they should examine the topic of nutrition from a scientific and not a personal perspective and should show sensitivity for others' eating habits.

- **Explain** the research findings.
  - Instruct students to complete their data sheets and to answer the research questions they identified at the start of the project. Ask each team to report its results. Consider having students use a large chart or a computer spreadsheet to record and graph the class data.
  - Help students compare the teams' data. Discuss the results and have each student write a conclusion. Ask students whether the food program for their school or district aligns with the recommendations of the USDA food pyramid.

- **Extend** learning if time allows.
  - To incorporate technology, have students conduct an Internet search to obtain, compare, and evaluate school menus from different regions of the country. Teams can work together and present their findings to the class.
  - To incorporate the arts, have students create a food pyramid graphic that represents the percentage of the school's food offerings for each pyramid food category.
  - To incorporate history, have students investigate past versions of the food pyramid dietary recommendations. Students should analyze current school food offerings against the previous recommendations and then record and report any changes. Students might consider the question, "Why has the USDA food pyramid changed over time?"
- **Evaluate.** Look for the following outcomes:
  - Student participation and engagement
  - Written work, including learning logs and data sheets, that reflects an increased understanding of the USDA food pyramid and the process of scientific inquiry
  - Students' ability to collect, measure, record, interpret, and compare data
  - Students' ability to perform assigned roles and tasks and to work collaboratively

## Handout 3: USDA Food Pyramid (Anatomy of MyPyramid)

**One size doesn't fit all.** USDA's new MyPyramid symbolizes a personalized approach to healthy eating and physical activity. The symbol has been designed to be simple. It has been developed to remind consumers to make healthy food choices and to be active every day. The different parts of the symbol are described below.

**Activity** is represented by the steps and the person climbing them, as a reminder of the importance of daily physical activity.

**Moderation** is represented by the narrowing of each food group from bottom to top. The wider base stands for foods with little or no solid fats or added sugars. These should be selected more often. The narrower top area stands for foods containing more added sugars and solid fats. The more active you are, the more of these foods can fit into your diet.

**Personalization** is shown by the person on the steps, the slogan, and the URL. Find the kinds and amounts of food to eat each day at www.MyPyramid.gov.

**Proportionality** is shown by the different widths of the food group bands. The widths suggest how much food a person should choose from each group. The widths are just a general guide, not exact proportions. Check the Web site for how much is right for you.

**Variety** is symbolized by the six color bands representing the five food groups of the pyramid and oils. This illustrates that foods from all groups are needed each day for good health.

**Gradual improvement** is encouraged by the slogan. It suggests that individuals can benefit from taking small steps to improve their diet and lifestyle each day.

**MyPyramid.gov**
Steps to a healthier you

## Handout 4: MyPyramid Data Sheet

| | School Lunch Offerings | | | | |
|---|---|---|---|---|---|
| | Monday | Tuesday | Wednesday | Thursday | Friday |
| **Grains**<br>Food Items | | | | | |
| % of meals | | | | | |
| **Vegetables**<br>Food Items | | | | | |
| % of meals | | | | | |
| **Fruits**<br>Food Items | | | | | |
| % of meals | | | | | |
| **Oils**<br>Food Items | | | | | |
| % of meals | | | | | |
| **Milk**<br>Food Items | | | | | |
| % of meals | | | | | |
| **Meat and Beans**<br>Food Items | | | | | |
| % of meals | | | | | |

# Reflection

## Preparation

- How well did the lesson planning help you prepare for this activity?
- What can you do to feel more prepared?

## Academic Enrichment

- How did this lesson support other academic content areas like math or literacy?
- What changes could you make to strengthen academic enrichment while still keeping the activity fun?

## Classroom Management

- What strategies did you use to make the lesson go smoothly?
- What changes would you make if you taught the lesson again?

## Expansion

- How can this activity be improved to include concepts from other content areas?
- What resources or connections can be made to the larger community to provide support for this activity?

## Practice 2

# Exploring Science Through Projects and Problems

### What Is It?

*Exploring Science Through Projects and Problems* involves real-world learning experiences. Ideally, the problem or project comes from a community need or a case study based on students' interests. Problems and projects that students are interested in engage students, make science relevant, and encourage them to make decisions to solve the problems.

### What Is the Content Goal?

The key goal of *Exploring Science Through Projects and Problem*s is to engage students in a given topic, develop inquiry and problem-solving skills, and increase students' understanding of how to apply science in real-world situations. The specific content goals will vary depending on the project or problem involved.

### What Do I Do?

Begin by connecting with the day-school teacher to find out what science concepts, skills, and standards students are studying and what kinds of activities might lend themselves to science projects. For example, raising fish from eggs can extend what students may be learning about habitats, species, and life cycles. Or, combine science and literacy activities by reading a book and developing an activity that builds on the story, such as building the bridge from *The Three Billy Goats Gruff.*

Work with students to select a topic or experimental question that interests them. Then discuss the project, identify what students will do, make a project plan and timeline, identify resources you will need, and conduct the project. Projects work best when students can work on them in a regular, ongoing way as some projects can take several days or weeks. You will also want to determine how you and your students will present and evaluate their projects.

## Tech Tips for *Exploring Science Through Projects and Problems*

Handheld computers with probes, also known as dataloggers, are great tools for students to collect and analyze data. In addition, the accompanying software enables students to write journal entries, create data tables and graphs, and use graphic organizers. Some battery-operated dataloggers are especially effective because they enable students to work in the field and gather data instantly or over long periods of time. Many sensors are available for student use including motion detectors, magnetic field, voltage, temperature, pH, light, sound, air pressure, relative humidity, and more. Check out the following Web sites for lesson plans and activity ideas:

- ProbeSight! Taking a Closer Look at Computer-Based Probeware in Education (http://probesight.concord.org)
- GEC Computers in the Classroom Junior Science Probes Project (www.gecdsb.on.ca/d&g/probes.htm)

## Why Does It Work?

Exploring science through project- or problem-based learning works because students are directly involved in their own learning as they develop problem-solving skills, learn new content, and apply what they learn in authentic, real-world situations.

## Getting Started


The video "Project-Based Science: Small Fry to Go" in the science section of the Afterschool Training Toolkit illustrates the practice of *Exploring Science Through Projects and Problems*. In the video, third through fifth graders at the Kingsley Elementary School in Atlanta, Georgia, connect science to the real world by raising rainbow trout and learning about their habitat.

Go to the *Exploring Science Through Projects and Problems* practice found in the science section of the Afterschool Training Toolkit (www.sedl.org/afterschool/toolkits/science/pr_exploring.html). Then click on the video titled "Project-Based Science: Small Fry to Go."

**BEFORE YOU WATCH THE VIDEO,** write down what you think the project will involve; how the instructor will find the materials, equipment, and expert guidance needed for the project; and what skills students will learn from the project.

**DURING THE VIDEO,** consider the following:

How does the instructor find people in the community to support and help with the project and to provide expert advice? How does the instructor promote the processes of inquiry and problem-solving during the project? How does the instructor keep students engaged in the project?

How does the instructor integrate real-world problems and skills into the project? What real-world skills and experiences does the project reinforce? Be sure to give specific examples.

**AFTER YOU WATCH THE VIDEO,** write what modifications you might need to make to teach this lesson in your class.

# Lesson 1

## The Three Billy Goats Gruff

This sample lesson is one example of how you can implement the practice of *Exploring Science Through Projects and Problems*. In this activity, students work in groups to solve a problem: construct a prototype of a bridge or other device that will allow the goats in the story *The Three Billy Goats Gruff* to get to the other side of the river without getting eaten by the troll. This lesson incorporates literature and mathematics.

**Grade Level(s):**

3–5

**Duration:**

Two 45-minute sessions

**Student Goals:**

- Use reading, math, and science skills to solve a real-world problem
- Design a solution and construct a model
- Keep journals or records of scientific investigations
- Learn and use appropriate science and engineering vocabulary
- Work together to solve a problem

## Imagine This!

The class is abuzz with the sounds of construction as teams of students work on building models. At one table, several students hold their breath as they test their makeshift device. They are trying to help the three Billy Goats Gruff get across the river safely without harming the evil troll who lives under the bridge. One student places a small plastic goat in a paper coat attached to a string and spools of thread. But the cup tips and the goat falls into the imaginary river. "Back to the drawing board," says one student. "Being an engineer and solving problems is hard work." Eventually, all the teams create working models and present them to the class.

## What You Need

❒ A copy of *The Three Billy Goats Gruff* by P. Galdone (New York: Claron Books, 1981)

❒ Index cards

❒ Pencils (one pair per student)

❒ Scissors (one pair per student)

❒ Handout 5: Engineering Design Project Assessment Rubric (one per team)

*Per team (prepared in baggie or small box):*

❒ Cereal box, individual portion size, empty

❒ String, any type, 45 cm long

❒ Thread spool, empty or taped to keep from unwinding

❒ Plastic spoon

❒ Clay, nonhardening, 2-inch ball

❒ 12 craft sticks

❒ Tape, transparent, small roll

❒ Three pipe cleaners

❒ Three 3-ounce paper cups (bathroom cups)

❒ Three plastic goats (optional), or additional pipe cleaners for students to make goats

## Getting Ready

- Assemble all materials for easy distribution.
- Purchase or check out from a library a copy of *The Three Billy Goats Gruff* by P. Galdone.
- Read through *The Three Billy Goats Gruff* and develop questions for discussion.
- Decide on the best grouping of students and roles to be assigned.
- Prepare the area for each team to work and a display area for the finished products.

## Safety Considerations

Allow enough space for students to work safely.

## What to Do

- **Engage** students by introducing and reading aloud the story of *The Three Billy Goats Gruff*. As you read, ask students what problems the goats have to solve, such as getting across the river safely. (See the Teaching Tip on p. 10 for more information on leading read alouds.)
- **Explore** possible solutions to the problem. Divide students into small groups and give each group one copy of the assessment rubric (Handout 5). Then present the challenge: Tell students that they are members of an engineering company hired by the goats' parents. Each team needs to come up with a solution that enables the goats to cross the river safely every morning yet does not harm the troll. Each team will then design and make a model of its solution. Students have 60 minutes to complete the project. (You may want to vary this time and extend it to the next day.)
  - Ask students to brainstorm and discuss with you four possible solutions, the pros and cons of each one, and their final choice. Allow about 15 minutes for brainstorming. Instruct students to record their ideas as they go. Remember that the goal is to have students create an invention or device (such as a bridge) to solve the problem.
  - Once each team has shared its ideas and made a decision, give the students their kit of materials so that they may begin making a model. Each team should create a name for the device, label it with an index card, and create a company portfolio for the goat parents to consider.
- **Explain** the solutions. Have the teams present their models and completed rubrics to the whole group while you and the remaining students ask probing questions about the model and how it works.
  - Each team cleans up by returning leftover materials to the bags.
  - Debrief about the brainstorming and invention process, and the difficult and fun elements of designing like an engineer.

### Teaching Tip

**Word Walls**

To help students learn and use appropriate science and engineering vocabulary related to this activity, consider using a large piece of paper or a bulletin board as a word wall. On it, write vocabulary terms such as *engineering model* and *prototype* in large type. Throughout the activity add new words to the wall as appropriate and review the existing words with students. Have students make copies of the word wall to keep in their folders.

- **Extend** learning if time allows.
  - Ask students to write a reflection of what they learned.
  - Create a display of the students' inventions in the school library or other public area.
  - Based on what did and did not work, have students plan how they might change their models.
- **Evaluate.** Look for the following outcomes:
  - Student engagement and participation
  - Students working together cooperatively
  - Ideas and answers that reflect an understanding of the problem, the use of problem-solving skills, and how to form possible solutions
  - Journal entries or records of ideas, pictures, and what did and did not work

## Handout 5: Engineering Design Project Assessment Rubric

| **Team Name:** | |
|---|---|
| **Team Members** | |
| | |
| | |
| | |
| | |
| | |

How did you do?

| Requirements | Points |
|---|---|
| Your team brainstormed at least 4 different ideas.<br>(10 points per idea, 40 points maximum) | |
| The invention helps the goats get to green grass.<br>(yes = 30 points; no = 0 points) | |
| The invention does not hurt the goats or the troll.<br>(yes = 30 points; no = 0 points) | |
| Portfolio bonus points (0 to 10, teacher award) | |
| Presentation bonus points (0 to 10, class award) | |
| **Total Points** | |

# Reflection

## Preparation

- How well did the lesson planning help you prepare for this activity?
- What can you do to feel more prepared?

## Academic Enrichment

- How did this lesson support other academic content areas like math or literacy?
- What changes could you make to strengthen academic enrichment while still keeping the activity fun?

## Classroom Management

- What strategies did you use to make the lesson go smoothly?
- What changes would you make if you taught the lesson again?

## Expansion

- How can this activity be improved to include concepts from other content areas?
- What resources or connections can be made to the larger community to provide support for this activity?

# Lesson 2

## What Happened to Mya?

This sample lesson is one example of how you can implement the practice of *Exploring Science Through Projects and Problems*. In this activity, students examine a mysterious case study involving a girl who fainted. By using both clues in the case study and additional research, students discover the problem and learn about diabetes, its symptoms, and its treatment. This lesson incorporates technology.

**Grade Level(s):**

6–8

**Duration:**

Seven sessions of 45–60 minutes each

**Student Goals:**

- Work collaboratively to solve a problem
- Practice scientific inquiry through hypothesizing, questioning, researching, recording and analyzing data, and communicating results
- Understand health issues, specifically diabetes and nutrition
- Use technology tools, especially the Internet, in a responsible and legal manner

## Imagine This!

The game's afoot as afterschool students turn detective and work to solve a real-life medical mystery. A girl named Mya has fainted several times. To find out why, students turn to the Internet to research clues. When students discover that the cause of the fainting might be related to diabetes, they collaborate with each other to learn about the disease and nutrition. Finally, their investigation reveals what happened to Mya.

## What You Need

❒ Handout 6: "What Happened to Mya?" Scenario

❒ Notebooks and pencils

❒ Computers for Internet research, word processing, and presentations

## Getting Ready

- Familiarize yourself with the case study and information about diabetes.
- Prepare enough copies of the case study for each student. Make sure you separate the handouts into two stacks, one for Day 1 and one for Day 2.
- Identify Web sites and other resources for students to use to learn about Mya's symptoms in general and diabetes in particular.
- Because you will be guiding your students' online research from your computer, decide which search engine you will use and practice searching for Mya's medical symptoms as described in the scenario for Day 1 on the handout.

### Teaching Tip

**Useful Web Sites**

The following Web sites provide useful information about diabetes among youth. If afterschool students do not have access to computers or the Internet, go to the sites and print and copy articles for students to use in their research.

- American Diabetes Association Youth Zone (www.diabetes.org/youthzone/youth-zone.jsp)
- National Diabetes Education Program: Resources on Children and Adolescents (www.ndep.nih.gov/diabetes/youth/youth.htm)
- Diabetes Youth Services (www.dys4kids.org)

## Session 1: Introducing Mya's Mystery

### *What You Need*

❒ Handout 6: "What Happened to Mya?" Scenario (one per person)

❒ Teacher computer with Internet access and projector

### *What to Do*

- **Engage** students in the story of Mya by reading aloud the scenario for Day 1 on the handout.
- **Explore** what happened to Mya. Discuss Mya's symptoms and list the data or clues provided in this first scenario. Use the questions that follow the first scenario to guide student discussion. Note any other student questions that require research to answer. Using the Internet search engine that you have pretested, show students how to use keywords and phrases to conduct research online and to find answers to their questions. Guide students in taking notes during their research. Then have students record in their notebooks the answers to the following questions, which also appear on the handout:
  - Why do people faint?
  - What is glucose, and what happens if you do not have enough?

## Sessions 2–3: Exploring Mya's Mystery

### *What You Need*

❒ Handout 6: "What Happened to Mya?" Scenario (one per person)

❒ Computers with Internet access (at least one computer for every two students)

❒ Teacher computer with Internet access and projector

### *What to Do*

- **Engage** students again in Mya's story by reading aloud the scenario for Day 2 on the handout. Discuss the scenario with students and help them identify clues they can use to answer questions and learn what is happening to Mya.
- **Explore** further what happened to Mya by having students continue their research. By the second session, students should be able to focus their research on diabetes, its symptoms, and its types. Pair students and have each pair conduct research on the Internet to answer the following questions, which also appear on the handout:
  - What are the symptoms of diabetes?
  - What is the difference between type I and type II diabetes? What is the cause of diabetes? What is pre-diabetes?
  - What is insulin, and what happens when a person has too much or too little?
  - What kinds of exercise and nutrition are helpful in controlling and preventing diabetes?
  - What do diabetics do to monitor their glucose levels?
  - What complications are associated with diabetes?
  - What can you do to prevent diabetes?
  - How can you help a person with diabetes?

Students should record their answers in their notebooks and cite the sources for their answers. Guide students in their research by reviewing Internet search strategies and how to navigate Web sites. Monitor student research closely and ask guiding questions as students work.

## Sessions 4–7: Explaining Mya's Case

### *What You Need*

❒ Handout 6: "What Happened to Mya?" Scenario (one per person)

❒ Computers with Internet access (at least one computer for every two students)

❒ Teacher computer with Internet access and projector

❒ Presentation software (optional)

### *What to Do*

- **Explain** the research findings. Using their notes, students will summarize their findings and then present them to the class. You might want to consider having students use presentation software and a projector to present their findings. Leave time for questions and answers after the presentations and encourage students to explain their answers and where they found them.
- **Extend** learning if time allows.
  - Invite someone who is diabetic or who works with diabetics to talk to students about nutrition and diabetes.
  - Have students plan healthy snacks for the afterschool center based on their new knowledge.
  - Collaborate with a local hospital or clinic to plan a family health night and include information on diabetes as well as free glucose testing.
  - Under the *Finding Math* promising practice in the math section of the Afterschool Training Toolkit, the sample lesson "What is the 'Best' Snack?" (www.sedl.org/afterschool/toolkits/math/pr_math_find.html) has a nutrition theme. Although the lesson is designed for lower elementary school students, it could be adapted for students in higher grades as an appropriate follow-up to "What Happened to Mya?"
- **Evaluate.** Look for the following outcomes:
  - Students working together to solve a problem
  - Answers that reflect students' ability to hypothesize (guess) about what happened to Mya and to develop follow-up questions to research
  - Exhibition of good reading and research skills and good note-taking
  - Presentations that reflect an understanding of diabetes and how it relates to Mya's symptoms

## Handout 6: "What Happened to Mya?" Scenario

**Day 1 Scenario:**

Some people saw a teenaged girl faint on the sidewalk by 42nd and E Street. One person said that before the girl fell, she was acting strangely—she seemed fearful, anxious, and beads of sweat were on her forehead. In an attempt to identify her, one woman opened her purse and saw a black kit with a meter and some strips, a needle and a bottle of something, and some wafers that said "glucose." The woman found an identification card and said the girl's name was Mya. Mya had a medical-alert bracelet around her right wrist. One of the bystanders called 911.

- What do you think happened to Mya?
- What clues can you find in the scenario?
- What questions do you have?
- What does your research reveal?
- Why do people faint?
- What is glucose, and what happens if you don't have enough?
- Summarize your findings.

**Day 2 Scenario:**

On the way to the hospital, the paramedics took Mya's glucose levels and got a reading of 47; they started an IV. Mya began to wake up. At the hospital, the doctors and nurses gave her some orange juice and monitored her overnight. The next day her glucose levels rose to 120.

- What are the symptoms of diabetes?
- What is the difference between type I and type II diabetes? What is the cause of diabetes? What is pre-diabetes?
- What is insulin, and what happens when a person has too much or too little?
- What kind of exercise and nutrition are helpful in controlling and preventing diabetes?
- What do diabetics do to monitor their glucose levels?
- What complications are associated with diabetes?
- What can you do to prevent diabetes?
- How can you help a person with diabetes?

# Reflection

## Preparation

- How well did the lesson planning help you prepare for this activity?
- What can you do to feel more prepared?

## Academic Enrichment

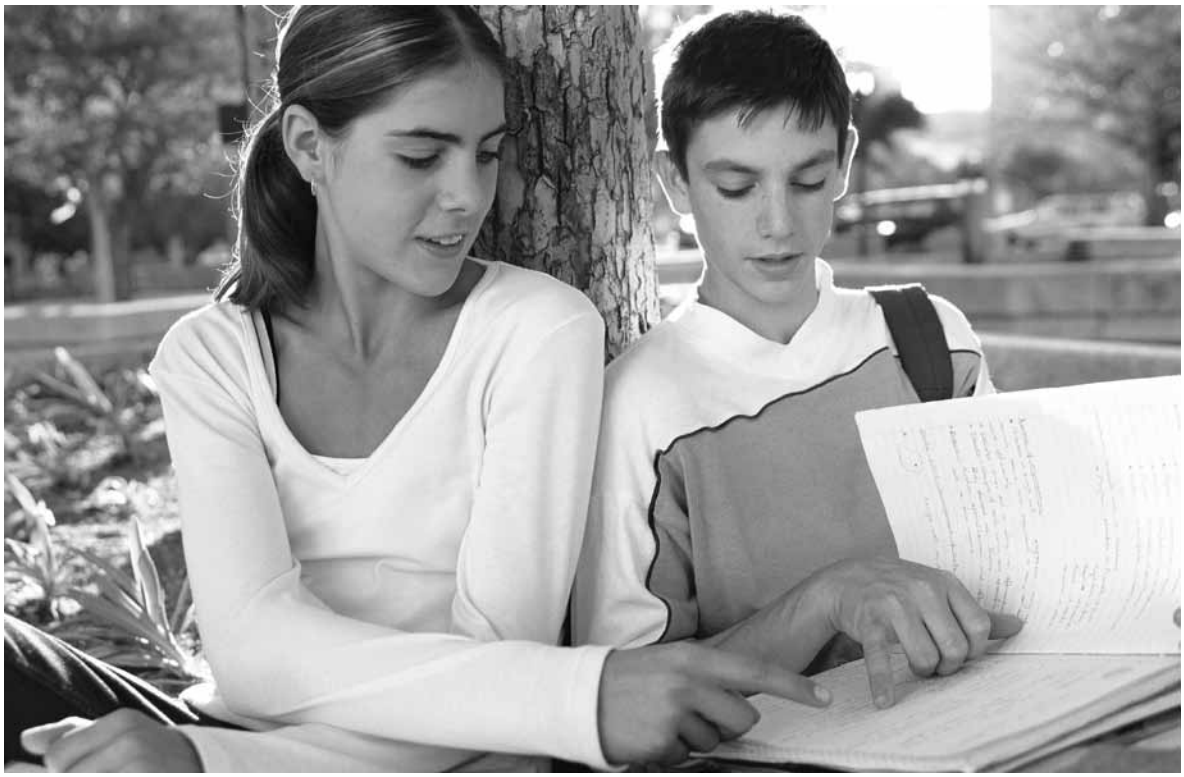
- How did this lesson support other academic content areas like math or literacy?
- What changes could you make to strengthen academic enrichment while still keeping the activity fun?

## Classroom Management

- What strategies did you use to make the lesson go smoothly?
- What changes would you make if you taught the lesson again?

## Expansion

- How can this activity be improved to include concepts from other content areas?
- What resources or connections can be made to the larger community to provide support for this activity?



# Lesson 3

## Heavy Weight

This sample lesson is one example of how you can implement the practice of *Exploring Science Through Projects and Problems*. In this activity, students gather data to explore the problem of adolescent obesity. They then develop potential solutions based on the observations they have made at their school.

**Grade Level(s):**

9–12

**Duration:**

6–8 weeks (45–60 minutes weekly)

**Student Goals:**

- Practice the problem-solving process through forming questions, making observations, recording and analyzing data, communicating results, and planning further investigations
- Measure using tools such as scales, tape measures, and calipers
- Keep journals or log records of scientific investigations
- Apply mathematical weight concepts
- Compare results and draw conclusions

## Imagine This!

Two students drop a large pile of papers on the instructor's desk. "Look at all the surveys we got completed!" the students boast. The teacher congratulates them and then asks how their analysis of the surveys is going. "We're getting ready to start that now," they say. The students along with the rest of their team begin the process of going through the surveys to identify the types of foods that students at their school eat the most. Next, the team will conduct an analysis of the nutritional value of the top-ranking foods. Over the next few weeks, the students will use their findings to propose a solution to the real-life problem of adolescent obesity. The team will then prepare a presentation describing the solution and present it to the class.

## What You Need

- ❒ Handout 3: USDA Food Pyramid (p. 28)
- ❒ Handout 4: MyPyramid Data Sheet (p. 29)
- ❒ Data and statistics about health and weight for the local area
- ❒ Weighted scales
- ❒ Measuring cups
- ❒ Clear rulers or plastic tape measures (centimeter)
- ❒ Journals or learning logs

### Teaching Tip

**Sensitivity in the Classroom**

Remind students that they should not use the information they learn during their research to judge or criticize their peers or others. Explain to students that they should examine the topic of obesity from a scientific and not a personal perspective and should show sensitivity for others.

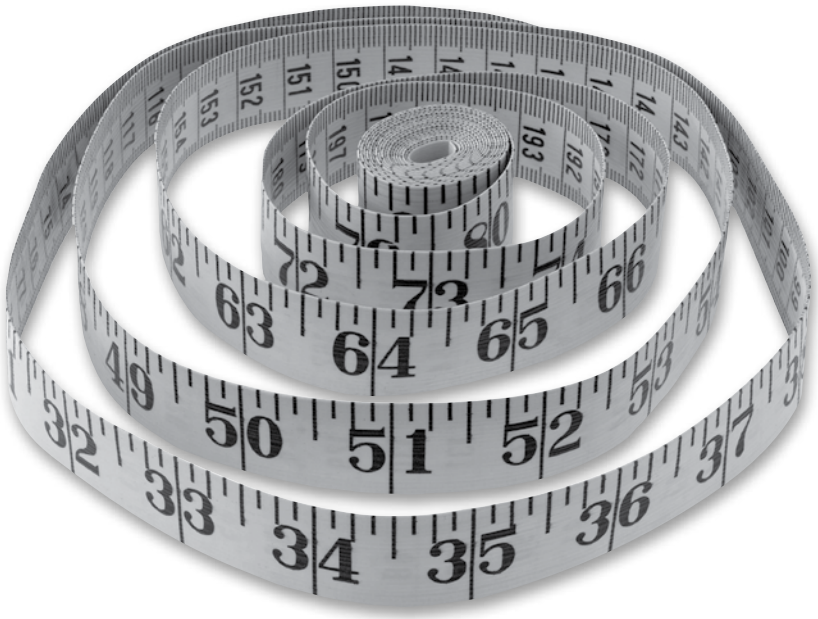
## Getting Ready

- Become familiar with the issue of adolescent obesity.
- Inform the school cafeteria staff or the school or district nutritionist of the planned activity.
- Research the topic by obtaining current scholarly and news articles about nutrition, the impact of food intake on health and weight, and foods and ingredients recommended for health (reasons provided should vary).
- Organize materials in team folders (one for each team). Include rulers, tape measures, pencils or pens, learning logs, calculators, scales, and metric conversion charts.
- Create a plan for storing all materials for the duration of the project.
- Consider connections! As this topic is relevant to the larger community, consider using the activity as part of a community or family science night.

## What to Do

- **Engage** students by introducing the study of adolescent obesity. Provide students with local and national statistics on adolescent obesity and its negative health impact. Have students work in groups to determine the key elements of the problem they will be investigating.
- **Explore** the subject of adolescent obesity. Instruct each group to select one student to serve as the reporter, who will be responsible for generating the final report on the group's findings. The reporter will also facilitate the group presentation. Then have each group work through the following steps in problem-solving and project-based learning:
  - Learn about the problem through research. Prepare a list of questions or issues related to adolescent obesity that need to be researched, and develop a research action plan for the group.
  - Develop and administer surveys to assess students' eating habits. This work entails generating questions, testing them, and administering them to a population within the school (for example, fellow students in their grade or a given class).
  - Use the survey results to identify the food and food types that students most frequently consume.
  - Conduct an analysis of the nutritional value of the top-ranking foods by checking the nutrition facts on the foods or through the use of other means.
  - Decide which information collected by the surveys is useful in helping to solve the problem of adolescent obesity.
  - Propose a solution. Then prepare a presentation describing the solution and explaining why it might work and how the data that the group gathered supports the solution.
- **Explain** the research findings. Instruct students to use their research to complete their data sheets (Handout 4) and to answer the questions they identified at the start of the project. Then ask each team to report the results and present their data sheets. The reporter should take the lead in the group presentation.
- **Extend** learning if time allows.
  - Expand the analysis and writing component by having students analyze the results and develop a written report or newsletter proposing solutions for distribution to all students.
  - Expand the research component by having students obtain popular diets to determine if such diets would aid in creating a solution for the problem.
  - Expand the scope of the project by having students also look at obesity figures for other age groups or for other countries.

- **Evaluate.** Look for the following outcomes:
  - Student participation and engagement
  - Students working together to solve a problem
  - Answers that reflect students' understanding of the problem-solving process—the ability to develop and test hypotheses and to collect and interpret data
  - Journals or learning logs that are completed correctly with accurate data tables and charts
  - Proper measuring, recording, and presentation of data
  - Answers that reflect an understanding of adolescent obesity



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## Preparation

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- What changes could you make to strengthen academic enrichment while still keeping the activity fun?

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## Expansion

- How can this activity be improved to include concepts from other content areas?
- What resources or connections can be made to the larger community to provide support for this activity?


Take
the
Read
G-J
K-M

## Practice 3

# Integrating Science Across the Curriculum

### What Is It?

*Integrating Science Across the Curriculum* combines science investigations with content or skills from other subject areas such as math, reading, writing, social studies, technology, and the arts. These projects are frequently, but not always, long-term investigations that require instructors to plan lessons that incorporate more than one subject and related standards.

### What Is the Content Goal?

The key goal of the *Integrating Science Across the Curriculum* practice is to reinforce skills in other subject areas by engaging students in science investigations. For example science projects that include reading build science knowledge while strengthening literacy skills.

### What Do I Do?

Begin by communicating with the day-school teachers to find out more about the language arts, mathematics, and science skills that are being taught, how you might help students improve specific skills, and how you might incorporate those skills into science activities. For example, a science project that asks students to measure, collect, and analyze data; create graphs; and express scientific relationships also builds math skills. You may want to begin simply by incorporating science trade books, journal writing, graphic organizers, Internet searches, and mathematics with science investigations. Later you can think about projects that could incorporate multiple areas of content knowledge such as a yearlong study of natural disasters, a butterfly garden with art mosaics of the ecosystems in your region, a robotics competition, or a health and nutrition fair.

## Tech Tips for *Integrating Science Across the Curriculum*

A great way to set up a science project for your afterschool participants is to use a WebQuest, an inquiry-oriented activity where learners find information on the Web. All you need is a computer with access to the Internet. When you explore the WebQuest Page at http://webquest.org/index.php, you'll find standards-based WebQuests that involve students in their own learning as they solve problems in real-world situations. The WebQuest Page provides detailed development instructions as well as templates to enable even technology beginners to put WebQuests online. But before you try to develop your own, check out the existing WebQuests to see if one already exists that addresses your needs. A WebQuest can be used in a learning center with one computer or in a computer lab.

## Why Does It Work?

*Integrating Science Across the Curriculum* works because students are engaged in their own learning; they use what they already know and construct new understandings; they are able to use different strategies, approaches, and learning styles; and they learn in a social context. The learning is not isolated, but rather it is a part of a whole.

## Getting Started


The video "Integrating Science with Art: Artist Boat" in the science section of the Afterschool Training Toolkit illustrates the practice of *Integrating Science Across the Curriculum*. In the video, second graders at Morales Elementary School in Houston, Texas, integrate science and art by creating a butterfly mosaic while learning about Texas Coastal butterflies and host plants.

Go to the *Integrating Science Across the Curriculum* practice found in the science section of the Afterschool Training Toolkit (www.sedl.org/afterschool/toolkits/science/pr_integrating.html). Then click on the video titled "Integrating Science with Art: Artist Boat."

**BEFORE YOU WATCH THE VIDEO,** write down what you think the teacher will do to help students learn about butterflies and their habitats and to connect this study to the art project.

**DURING THE VIDEO,** consider the following:

How does the instructor work with students to lay the groundwork for the activity, which is already in progress? How does the instructor promote the process of inquiry during the activity and keep the students on track and engaged? How does the instructor interact with the students? What materials does the instructor use for the activity?

How does the instructor overlap science and art in the activity? What academic skills does the activity reinforce? Be sure to give specific examples.

**AFTER YOU WATCH THE VIDEO,** write what modifications you might need to make to teach this lesson in your class.

# Lesson 1

## Learning About Tadpoles

This sample lesson is one example of how you can implement the practice of *Integrating Science Across the Curriculum*. The lesson combines life science with literacy. In this activity, students read *The Icky Sticky Frog* by Dawn Bentley and illustrated by Salina Yoon and then practice literacy skills as they develop an understanding of tadpoles.

**Grade Level(s):**

K–2

**Duration:**

1 week or longer (can be extended)

**Student Goals:**

- Understand the life cycle of frogs and what they need to live
- Practice scientific inquiry through questioning, predicting, observing, recording and interpreting data, and communicating results
- Keep journals or records of scientific investigations
- Use graphic organizers
- Develop group-work skills such as working together and listening to others

## Imagine This!

A student squeals and giggles as another student waves a tadpole in a net toward the student's face. "Hey, look, the tadpole has grown legs," the first student observes. Several other students gather around to note the changes that have occurred. The students carefully record the changes in their notebooks and draw illustrations of the maturing tadpole. The instructor comes over to check on the students' progress. Pointing at the word wall, she reviews with the students the meaning of the terms *tadpole* and *amphibian life cycle*. The activity enables the students to have fun while both increasing their literacy and learning about tadpoles and frogs.

## What You Need

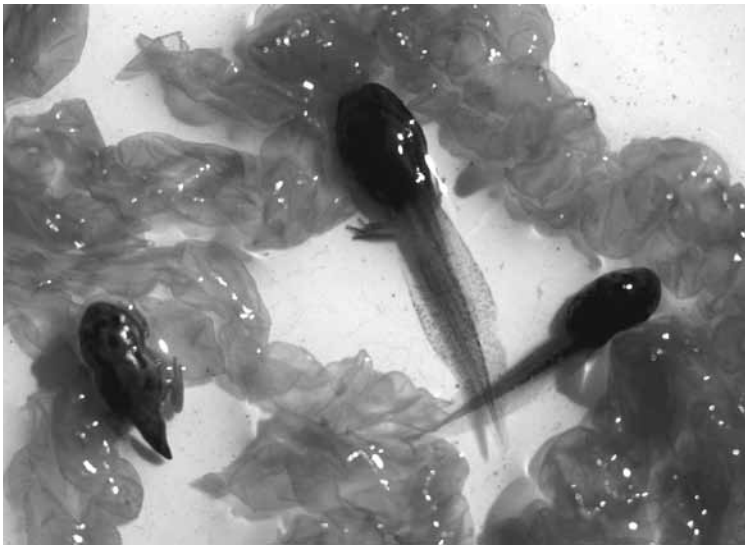
- ❒ Copy of *The Icky Sticky Frog* by Dawn Bentley and illustrated by Salina Yoon (Santa Monica, CA: Piggy Toes Press, 1999) and a variety of other age-appropriate books on frogs for each group
- ❒ An aquarium with tadpoles, rocks, and plants for each group (consider purchasing the Carolina Biological Raise-a-Frog Kits at www.carolina.com or purchasing individual aquariums, tadpoles, and plants from your local pet store)
- ❒ A magnifying glass (one per student)
- ❒ Drawing paper and colored pencils
- ❒ KWL chart (see p. 10) for recording students' prior knowledge, questions, and learned knowledge about tadpoles

## Getting Ready

- Identify a safe place to maintain aquariums with tadpoles.
- Collect materials—tadpoles, aquariums, library books, etc.
- Review instructions on how to set up an aquarium and care for tadpoles. For example, the kind of water you use and general care of the tadpoles is very important for their survival.
- Read the book *The Icky Sticky Frog* and develop questions for discussion.
- Begin a word wall or chart of the new vocabulary words the story introduces (see Teaching Tip on p. 38).

## Safety Considerations

- Talk with children about how to handle animals and their habitats in a way that demonstrates a respect for life.
- Local pond water and tadpoles may be used but take precautions to ensure that the water is not polluted. Seek assistance from local environmental resources.
- Identify a safe place within your afterschool facility to maintain the tadpoles.
- Practice good hand-washing techniques to protect the tadpoles and the students (e.g., count to 15 while scrubbing hands and fingernails with soap, rinse off thoroughly with water, use a paper towel to turn off the water, and wipe hands dry with a clean paper towel).
- Follow all guidelines for raising tadpoles to ensure safety for students and tadpoles.



## What to Do

- **Engage** students by asking what they know about frogs, tadpoles, and amphibians. You may want to record students' answers on a KWL chart (see Teaching Tip on p. 9), post the chart on the board or on a wall, and then add to the chart as students learn more.
  - Review sounds that frogs make and then, with enthusiasm and expression, read aloud the story of *The Icky Sticky Frog*. (See Teaching Tip on p. 10 for information on leading read alouds.)
  - Use your word wall or word chart to review new vocabulary words.
- **Explore** tadpoles. Divide students into groups of four to five. Set up aquariums for each group and instruct students to observe the tadpoles and record their observations by writing about what they see and by making drawings of the tadpoles at various stages. Check in with each group and ask guiding questions such as: How do the tadpoles change as they grow? What do they need to survive?

- **Explain** observations. Ask students to explain what they learned by sharing their observations and questions about tadpoles. Have students research information about tadpoles and create a story chart to illustrate what they have learned.
- **Extend** learning if time allows. Continue to read books about frogs, build vocabulary word walls, create frog books or PowerPoint presentations based on what students have learned, or compare and contrast what students know about living things with what they have learned about tadpoles and frogs.
- **Evaluate.** Look for the following outcomes:
  - Student participation and engagement
  - Student understanding of the story *The Icky Sticky Frog* and of the new vocabulary introduced in the story
  - Questions and answers that reflect an understanding of what tadpoles need to survive as well as an understanding of the life cycle of frogs
  - Student ability to pose questions, hypothesize, observe, collect and record data, and communicate results
  - Students working together to gain a better understanding of tadpoles

# Reflection

## Preparation

- How well did the lesson planning help you prepare for this activity?
- What can you do to feel more prepared?

## Academic Enrichment

- How did this lesson support other academic content areas like math or literacy?
- What changes could you make to strengthen academic enrichment while still keeping the activity fun?

## Classroom Management

- What strategies did you use to make the lesson go smoothly?
- What changes would you make if you taught the lesson again?

## Expansion

- How can this activity be improved to include concepts from other content areas?
- What resources or connections can be made to the larger community to provide support for this activity?

# Lesson 2

## Exploring Earthquakes

This sample lesson is one example of how you can implement the practice of *Integrating Science Across the Curriculum*. The lesson combines earth and space science with the arts, language arts, mathematics, and technology. In this activity, students learn about earthquakes and how they affect people. Students use technology skills to conduct research and gather data on the Internet, language arts skills to generate ideas and questions and to communicate and interpret data, math skills to measure and find locations with coordinate map systems, and art skills to create foldable graphic organizers. The 3-D graphic organizers (called "foldables") presented in this lesson were adapted from the work of Dinah Zike (www.dinah.com).

**Grade Level(s):**

3–8

**Duration:**

Three sessions of 45–60 minutes each

**Student Goals:**

- Gather, read, and understand data about real-world scenarios involving earthquakes
- Understand earthquakes, how they are measured, where they occur, and how they affect people
- Work collaboratively
- Create graphic organizers
- Maintain a journal

## Imagine This!

"First I heard a low rumble, then the floor began to roll, and suddenly everything was shaking and books and vases were crashing to the floor." The afterschool student holds his peers spellbound as he describes his experience in an earthquake. Later, after discussing and reading about earthquakes, the students create graphic organizers and plot major earthquakes on a world map. Soon, the students notice a pattern emerging around the Pacific Ocean—the ring of fire. By this point in the activity, students can clearly explain why earthquakes occur more often in certain areas.

## What You Need

- ❒ A copy of either *The Restless Earth* by Melvin Berger (Delran, NJ: Newbridge Educational Publishing, 1995) or *The Magic School Bus Inside the Earth* by Joanna Cole and Bruce Degen (New York: Scholastic Press, 1987)
- ❒ Journals or learning logs

*For the vocabulary foldable activity:*

- ❒ Handout 7: Vocabulary Foldable
- ❒ 8.5" x 11" paper (two per student)
- ❒ 8.5" x 11" card stock (3-hole punch)
- ❒ Glue
- ❒ Colored pencils or crayons
- ❒ Scissors

*For the Earth foldable activity:*

- ❒ Handout 8: Earth Foldable
- ❒ 11" x 17" paper folded in shutter fold
- ❒ Colored pencils
- ❒ Scissors
- ❒ Picture of world continents and oceans with a cross-section of the Earth diagram

*For the mapping activity:*

- ❒ Individual student maps, enlarged and printed on 11" x 17" paper
- ❒ Large world map (Pacific view preferred)
- ❒ Small colored dots (or colored straight pins) in blue, yellow, orange, and red
- ❒ Colored pencils or crayons (one set per student)
- ❒ Rulers (clear preferred)
- ❒ Computer with Internet connection
- ❒ Handout 9: Earthquake Magnitude Scale (A color version of this handout is available online at www.sedl.org/afterschool/toolkits/science/pdf/ast_sci_largest_earthquake.pdf.)
- ❒ Handout 10: Largest Earthquakes in the World Since 1900

## Getting Ready

- Obtain a copy of either *The Restless Earth* by Melvin Berger or *The Magic School Bus Inside the Earth* by Joanna Cole and Bruce Degen.
- Identify Web sites and collect books on earthquakes, volcanoes, and tsunamis.
- Gather materials for the three activities.
- Identify vocabulary words for the vocabulary foldable activity.
- Make vocabulary and Earth foldables (Handouts 7 and 8) to provide as models for students; make individual student copies of the handout instructions and foldable templates.
- Obtain a large world map with latitude and longitude lines as well as country names.
- Download and photocopy world maps for individual student use.
- Make copies of Earthquake Magnitude Scale and Largest Earthquakes in the World Since 1900 (Handouts 9 and 10, one per student).
- Plot the world's ten largest earthquakes and keep as a model.

## Safety Considerations

If you use colored straight pins instead of colored dots, as some teachers suggest, take care to ensure that students do not injure themselves when handling the pins.

## Session 1: Learning the Vocabulary of Earthquakes

### *What You Need*

❒ Handout 7: Vocabulary Foldable

❒ 8.5" x 11" paper (two per student)

❒ 8.5" x 11" card stock (3-hole punch)

❒ Glue

❒ Colored pencils or crayons

❒ Scissors

### *What to Do*

- **Engage** students in the study of earthquakes by reading aloud either *The Restless Earth* by Melvin Berger or *The Magic School Bus* Inside the Earth by Joanna Cole and Bruce Degen. (See Teaching Tip on p. 10 for information on leading read-alouds.) While reading the books, list relevant vocabulary words on the board or a white board.
- **Explore** earthquakes through vocabulary words associated with them. Distribute copies of the vocabulary foldable instructions (Handout 7). Have students follow the instructions to create their vocabulary foldables. For each vocabulary word, students should provide a definition and a picture or illustration to help them visualize what the word means.

## Session 2: Exploring the Earth

### *What You Need*

- ❒ Handout 8: Earth Foldable
- ❒ 11" x 17" paper folded in shutter fold
- ❒ Colored pencils
- ❒ Scissors
- ❒ Picture of world continents and oceans with a cross-section of the Earth diagram

### *What to Do*

- **Explore** earthquakes further by having students study the Earth. Distribute copies of the Earth foldable instructions and templates (Handout 8). Have students follow the instructions to create their Earth foldables. These foldables are an extension of the information covered in *The Restless Earth* and *The Magic School Bus Inside the Earth*. Allow students to personalize their foldables by
  - coloring and labeling the oceans and continents;
  - drawing, coloring, and labeling the sun, planets, and asteroid belt; and
  - coloring the crust, mantle, outer core, and inner core of the Earth.

## Session 3: Plotting Earthquakes

### *What You Need*

- ❒ Individual student maps, enlarged and printed on 11" x 17" paper
- ❒ Large world map (Pacific view preferred)
- ❒ Small colored dots (or colored straight pins) in blue, yellow, orange, and red
- ❒ Colored pencils or crayons (one set per student)
- ❒ Rulers (clear preferred)
- ❒ Computer with Internet connection
- ❒ Handout 9: Earthquake Magnitude Scale
- ❒ Handout 10: Largest Earthquakes in the World Since 1900

### *What to Do*

- **Explore** earthquakes further by having students plot major historical earthquakes on a map.
  - Have students explore the FEMA for Kids and other Web sites to learn more about earthquakes (see the Lesson Resources for useful Web sites).
  - Distribute copies of the Earthquake Magnitude Scale and the Largest Earthquakes in the World Since 1900.
  - Model for students how to plot earthquake data on the large world map—call out the latitude and longitude of a historic earthquake, locate the intersection point on the map, and then place a small colored dot on that point. Match the color of the dot to the color-scale in the Earthquake Magnitude Scale.
  - Have students work in groups to find the correct coordinates to map the 10 largest earthquakes in the world since 1900.
  - Have individual students plot the 10 largest earthquakes on 11" x 17" world maps.
  - Have teams of students download earthquake data for the past week and plot the data on the large map. Have teams take turns plotting daily data over a month or longer period of time using the colored dots on the large map. You may also choose to have individual students plot the data on their world maps.
  - Have students keep a journal of Internet searches and reflections on what they are learning.

### Teaching Tip

**Connecting to History**

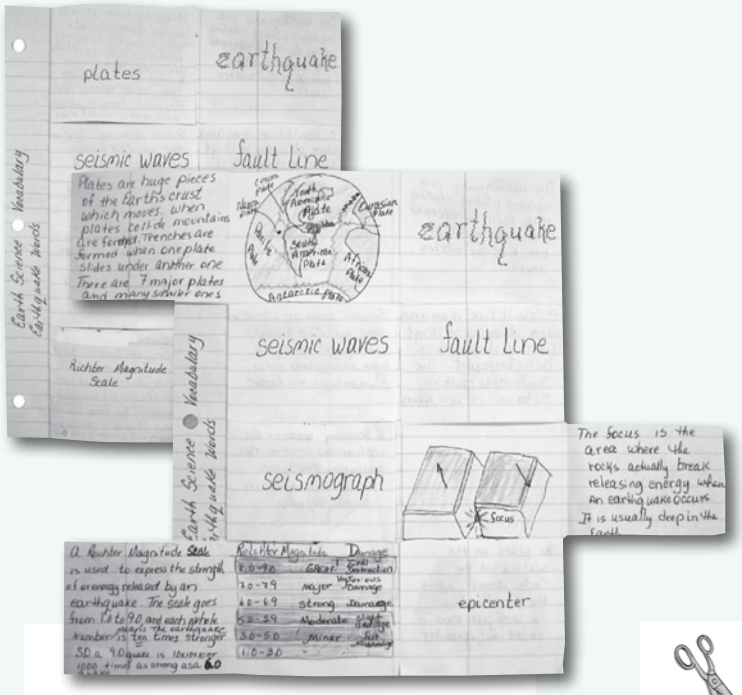
You might want to contact your students' day-school history teacher to discuss ways of linking the scientific study of earthquakes with how they have affected people at different points in history. If possible, see if you can have your activity coincide with a history lesson that might relate in some way. This connection will strengthen students' understanding of earthquakes and their effects on society.

- **Explain** the data. Once the relevant tectonic plates are clearly visible from the plotted data, have students explain what they have learned through illustrations, writing, or PowerPoint presentations.
- **Extend** learning if time allows. Watch the DVD "Ring of Fire," organize a relief drive for earthquake victims, invite a geologist to speak, plot volcano locations, or plot additional earthquake data.
- **Evaluate.** Look for the following outcomes:
  - Student participation and engagement
  - Answers that reflect an understanding of earthquakes, where they occur, how they are measured, and how they affect people
  - Student ability to record and interpret data and use that data to plot earthquakes on a map
  - Learning logs or journals that reflect students' ability to summarize what they have learned

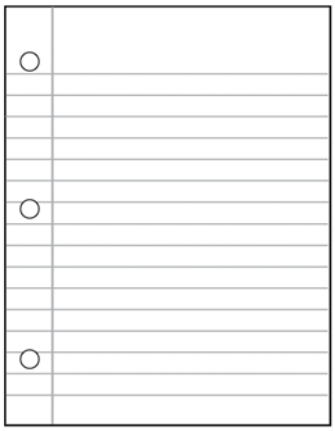
## Handout 7: Vocabulary Foldable

**Description:**

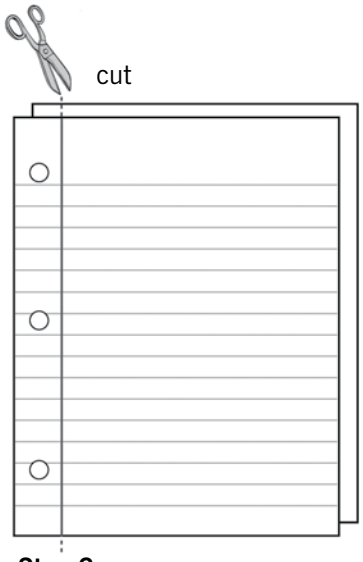
This 3-D graphic organizer is called a foldable. It can help you visualize and categorize complex concepts and information. In this example, vocabulary words associated with earthquakes were chosen: plates, earthquake, seismic waves, fault line, seismograph, focus, Richter Magnitude Scale, and epicenter.



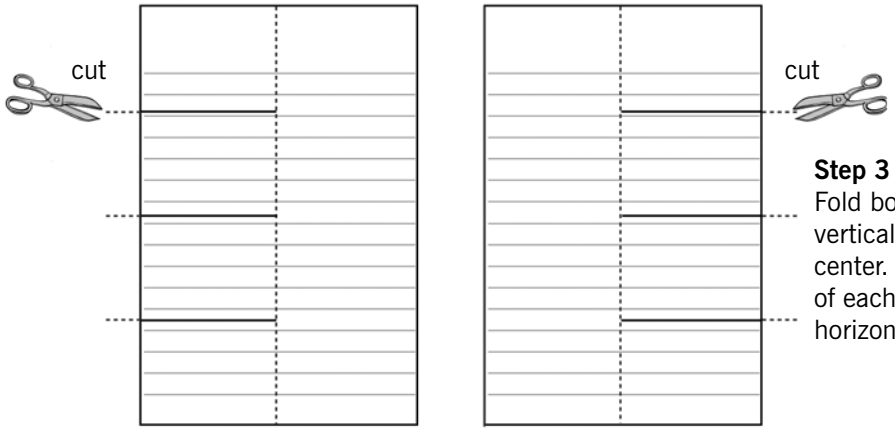

You can create the foldable by cutting and gluing notebook paper as illustrated. Then write the vocabulary word on the outside of the flap and its definition on the inside. Create a picture or illustration that will help you visualize what the word means.



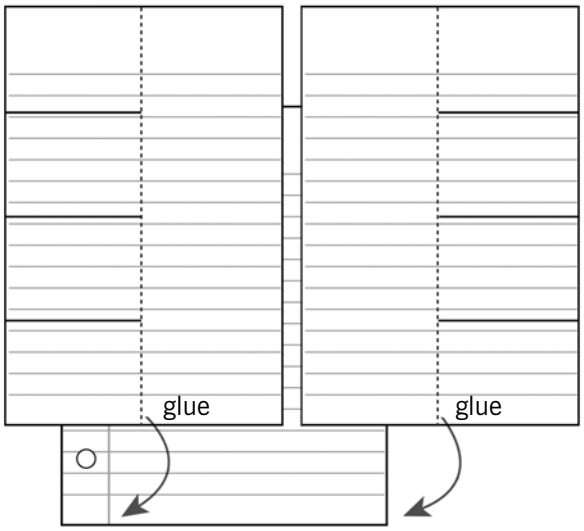
**Step 1**
Start with a sheet of lined notebook paper for the backing.



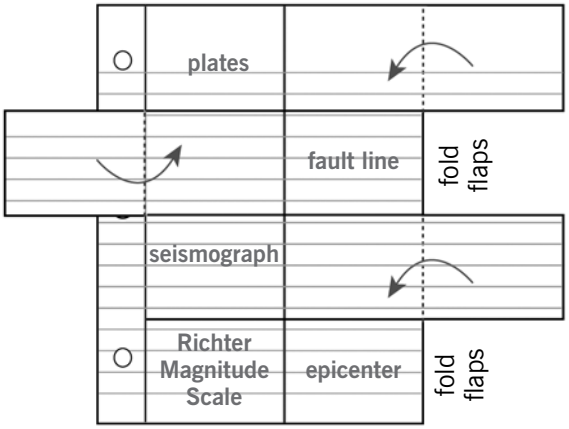

**Step 2**
Trim the left edge off two additional sheets of paper. You may use the vertical margin line as a guide.



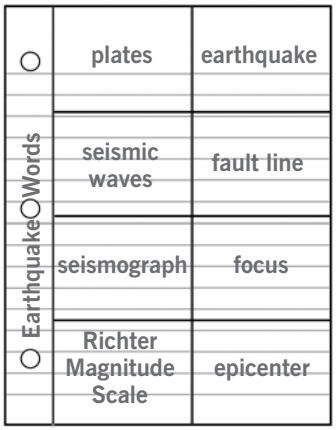

**Step 3**
Fold both sheets vertically down the center. Cut one side of each into four even horizontal sections.




**Step 4**
Glue the two sheets onto the backing page. Line up the fold of the left page about 1" from the left edge of the backing page. Line up the right page fold with the right edge.




**Step 5**
Fold the eight flaps into the middle and label.



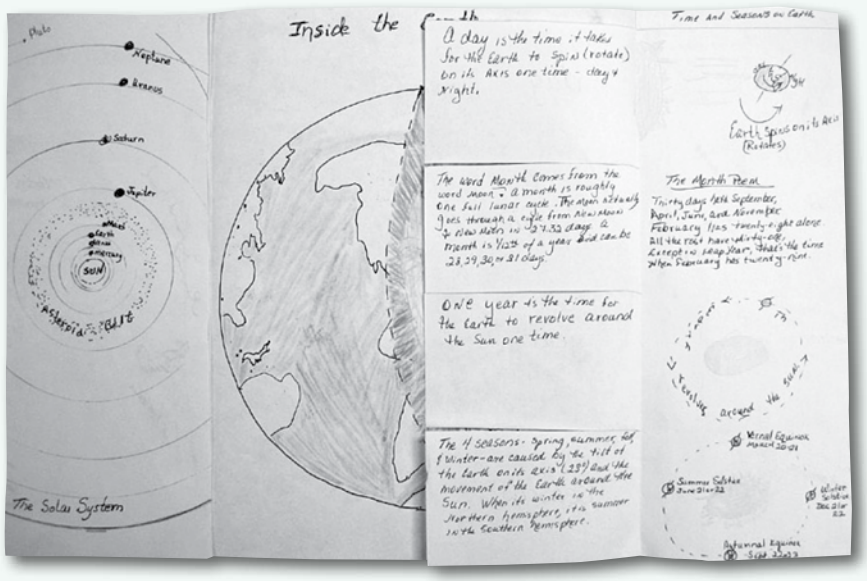

Outside completed view.

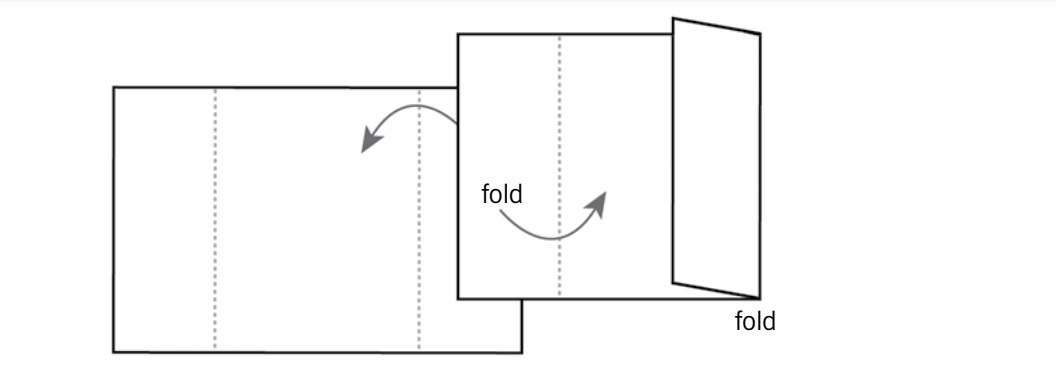
## Handout 8: Earth Foldable

**Description:**

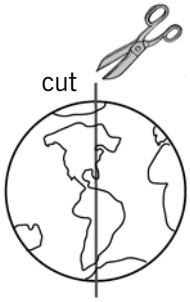
This foldable is a powerful learning tool to help you visualize complex information about the Earth, including what scientists think a cross-section of the Earth looks like, time on Earth, the reason for the seasons, and Earth's place in the solar system. You should complete a vocabulary foldable prior to attempting this more complex foldable. Read the instructions carefully before you begin. You can personalize your foldable by

- coloring and labeling the oceans and continents;
- drawing, coloring, and labeling the sun, planets, and asteroid belt;
- coloring the crust, mantle, outer core, and inner core of the Earth; and
- creating a time and seasons vocabulary foldable with personalized definitions and illustrations for the day, month, year, and seasons.

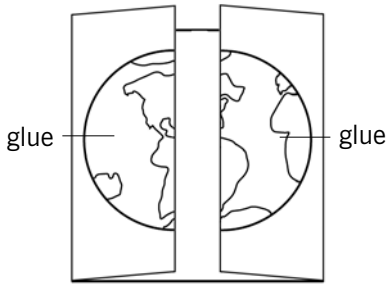


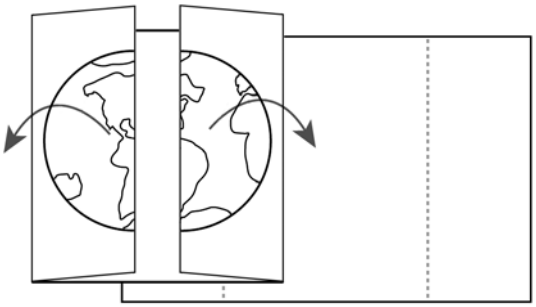

**Step 1**
Fold an 11" x 17" piece of paper from each outside edge into the middle.



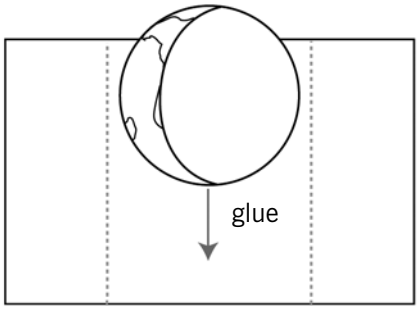

**Step 2**
Print out page 77 onto an 8-1/2" x 11" piece of paper. Cut in half, then cut out the image of the earth.



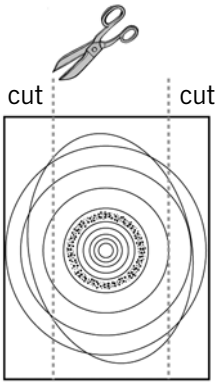

**Step 3**
Glue the two halves of the Earth from Step 2 onto the folded flaps of the 11" x 17" paper from Step 1.

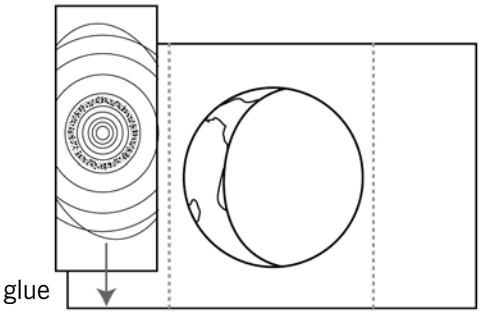


**Step 4**
Open the 11" x 17" paper.



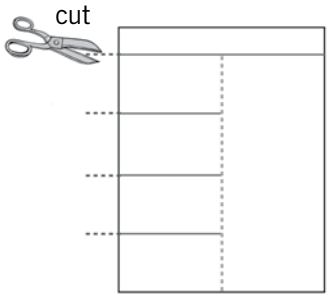

**Step 5**
Cut around the image on page 78 and glue to the middle section inside the 11" x 17" paper.



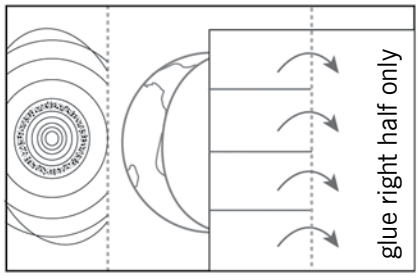




**Step 6**
Cut the image on page 79 where indicated, discarding the edges, and glue image to the inside left flap of the 11" x 17" paper.

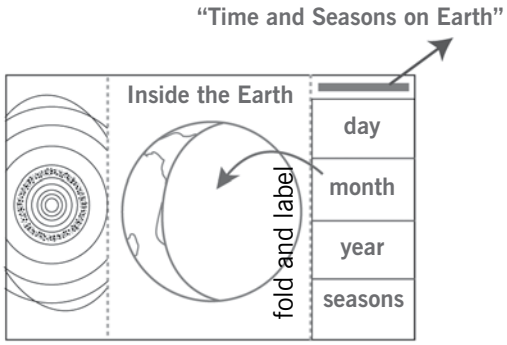
**Handout 8: Earth Foldable, continued**



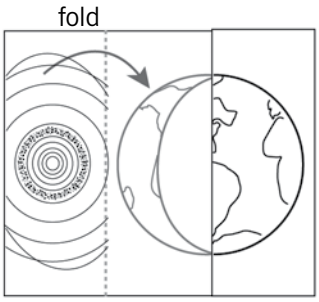

**Step 7**
Trim 1/2" off the top of a new 8-1/2" x 11" page. Fold in half lengthwise. Cut left half into four even horizontal sections.




**Step 8**
Glue right half of page onto right side of 11" x 17" spread. Match up the bottom right corner for positioning.

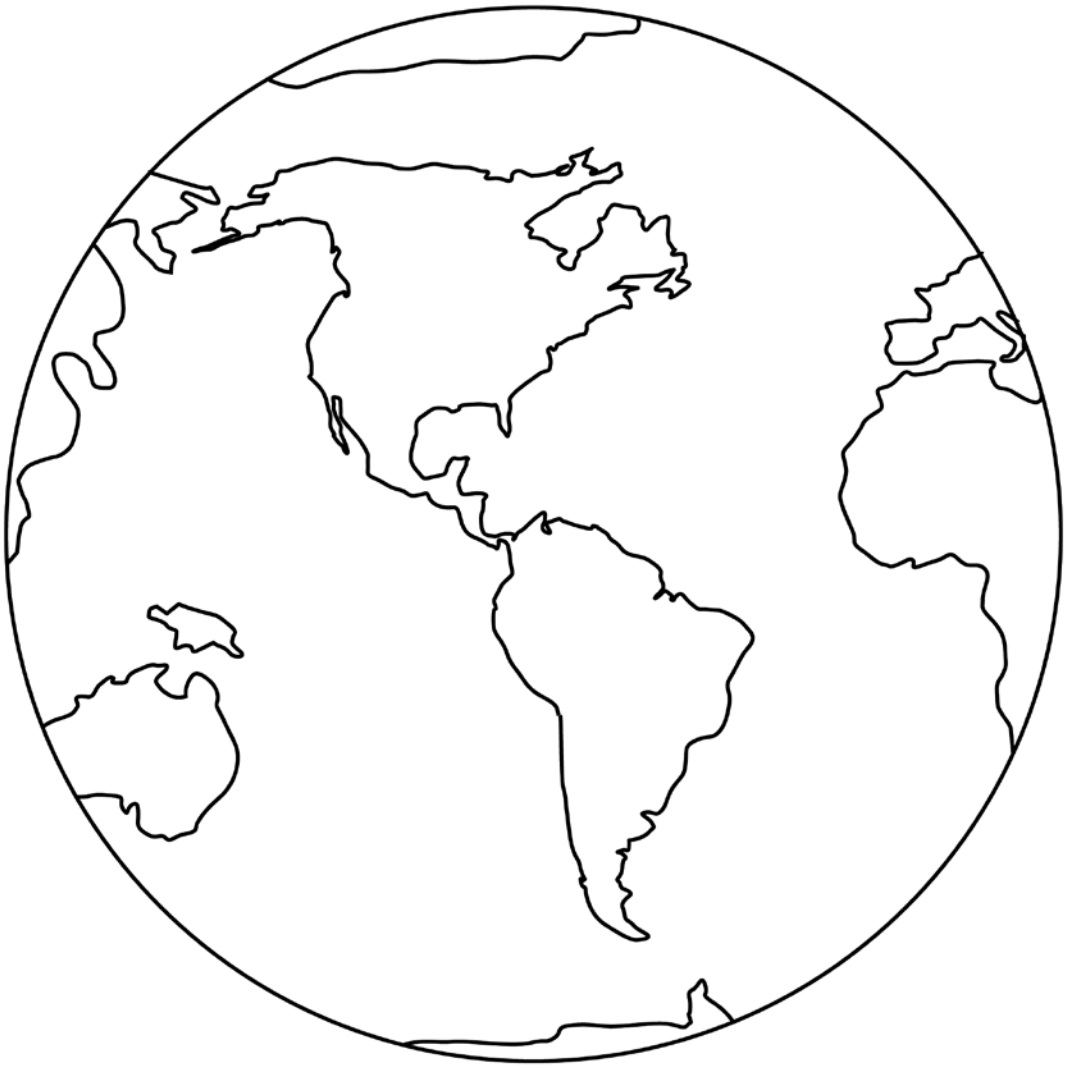



**Step 9**
Fold over flaps and label. Add titles.

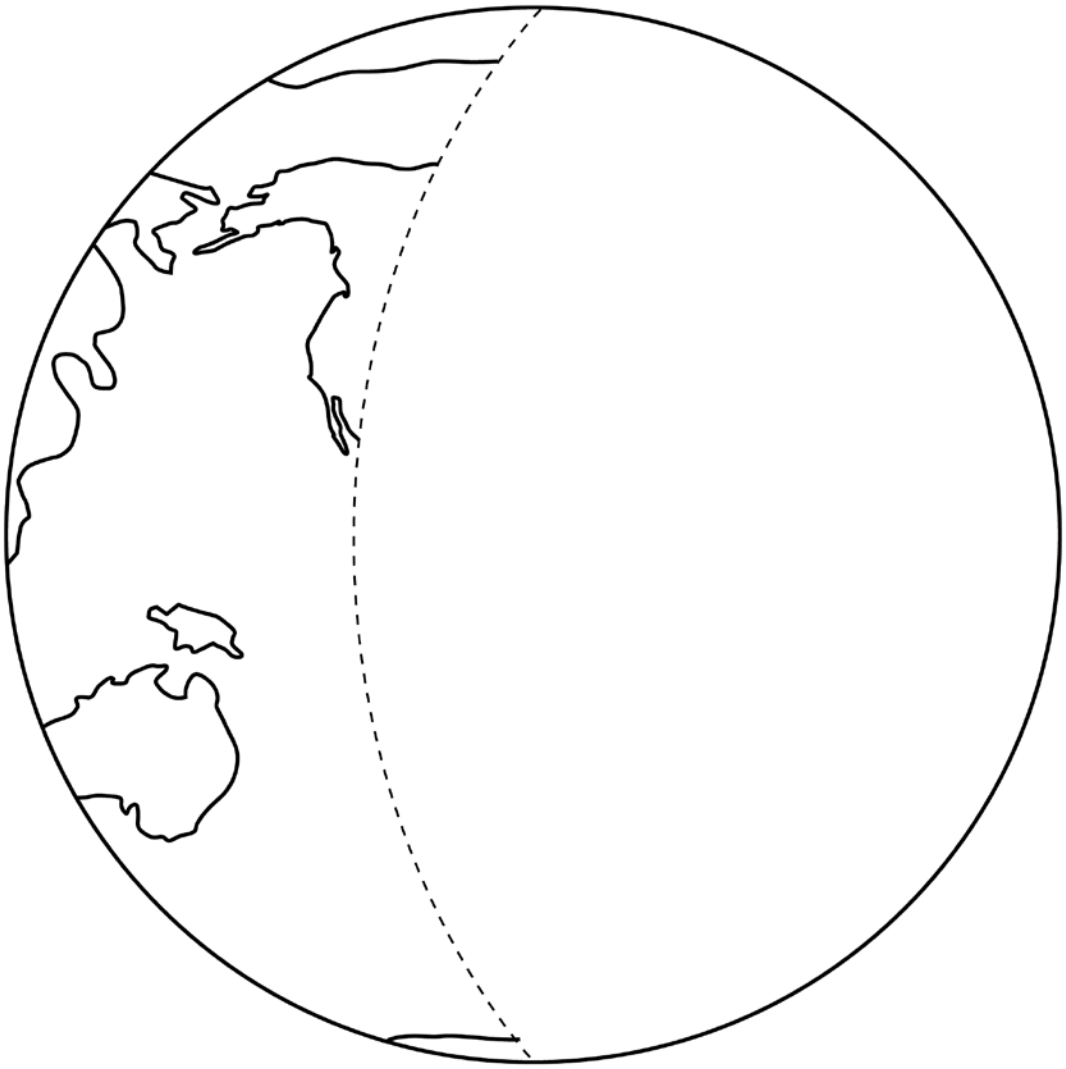


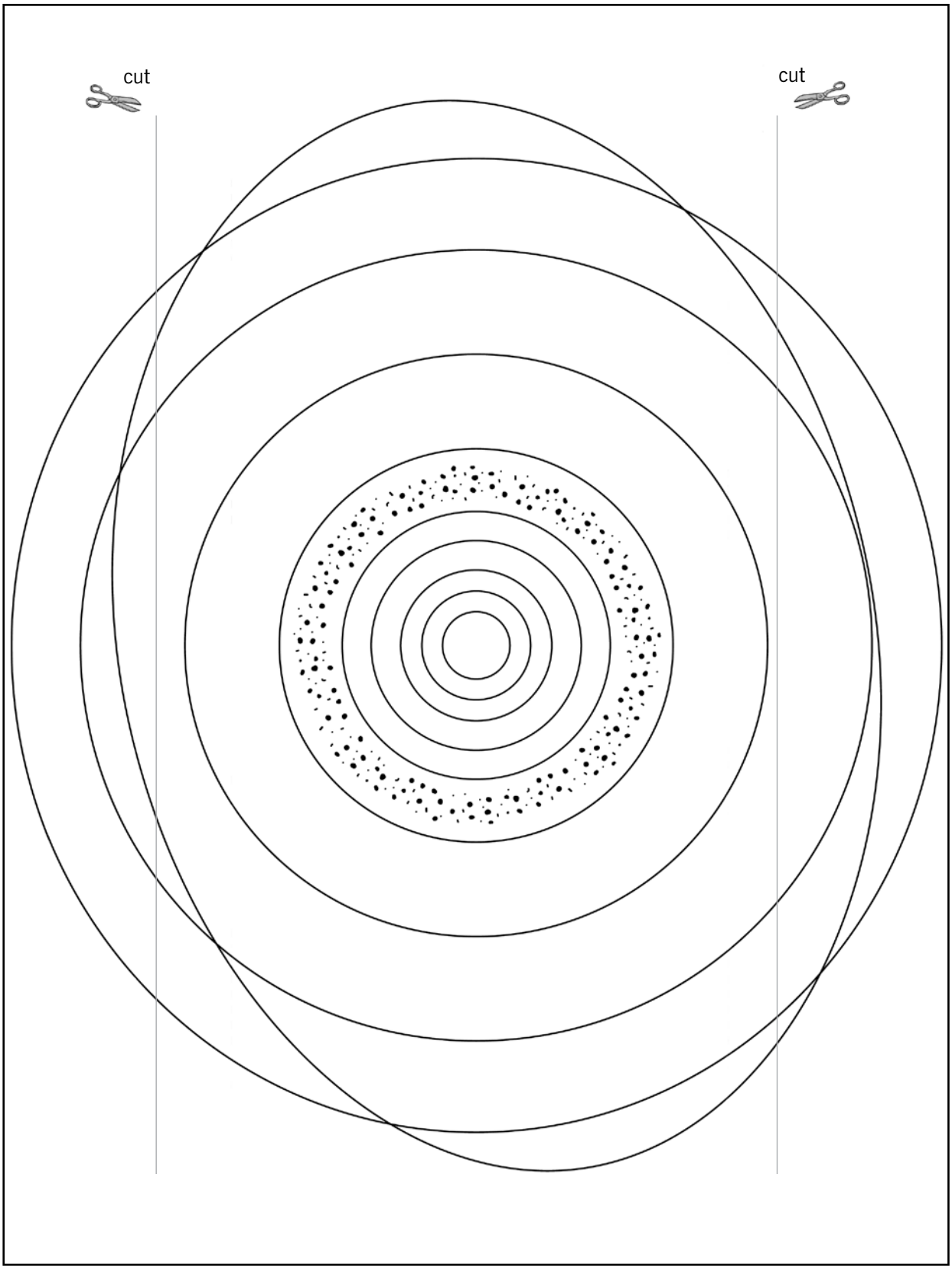

**Step 10**
To close, fold left and right flaps into the middle.


Outside view.



Handout 8: Earth Foldable, continued




cut
cut

## Handout 9: Earthquake Magnitude Scale

| Severity of Earthquake | Measure on Richter Scale | Color | Level of Damage |
|---|---|---|---|
| Great | 8.0 and > | Royal Blue | Total Destruction at Epicenter |
| Major | 7.0–7.0 | Light Blue | Serious Damage |
| Strong | 6.0–6.9 | Yellow | Damage to Populated Area |
| Moderate | 5.0–5.9 | Yellow-Orange | Slight Damage |
| Light | 4.0–4.9 | Orange | Felt, Minor Damage |
| Minor | 3.0–3.9 | Red | |

## Handout 10: Largest Earthquakes in the World Since 1900

| Date (Year/Month/Day), Time UTC* | Latitude | Longitude | Magnitude | Location |
|---|---|---|---|---|
| 1960/05/22, 19:11 | -38.24 | -73.05 | 9.5 | Chile |
| 1964/03/28, 03:36 | 61.02 | -147.65 | 9.2 | Prince William Sound, Alaska |
| 2004/12/26, 00:58 | 3.30 | 95.78 | 9.1 | Off the West Coast of Northern Sumatra |
| 1952/11/04, 16:58 | 52.76 | 160.06 | 9.0 | Kamchatka |
| 1906/01/31, 15:36 | 1.00 | -81.5 | 8.8 | Off the coast of Ecuador |
| 1965/02/04, 05:01 | 51.21 | 178.50 | 8.7 | Rat Islands, Alaska |
| 2005/03/28, 16:09 | 2.08 | 97.01 | 8.6 | Northern Sumatra, Indonesia |
| 1950/08/15, 14:09 | 28.5 | 96.5 | 8.6 | Assam - Tibet |
| 1957/03/09, 14:22 | 51.56 | -175.39 | 8.6 | Andreanof Islands, Alaska |
| 2007/09/12, 11:10 | -4.438 | 101.367 | 8.5 | Southern Sumatra, Indonesia |
| 1938/02/01, 19:04 | -5.05 | 131.62 | 8.5 | Banda Sea, Indonesia |
| 1923/02/03, 16:01 | 54.00 | 161 | 8.5 | Kamchatka |
| 1922/11/11, 04:32 | -28.55 | -70.50 | 8.5 | Chile-Argentina Border |
| 1963/10/13, 05:17 | 44.9 | 149.6 | 8.5 | Kuril Islands |

***UTC** (Coordinated Universal Time) is the international standard of time that is kept by atomic clocks around the world.

Source: United States Geological Survey (2008). Largest earthquakes in the world.
Available from http://earthquake.usgs.gov/regional/world/10_largest_world.php

# Reflection

## Preparation

- How well did the lesson planning help you prepare for this activity?
- What can you do to feel more prepared?

## Academic Enrichment

- How did this lesson support other academic content areas like math or literacy?
- What changes could you make to strengthen academic enrichment while still keeping the activity fun?

## Classroom Management

- What strategies did you use to make the lesson go smoothly?
- What changes would you make if you taught the lesson again?

## Expansion

- How can this activity be improved to include concepts from other content areas?
- What resources or connections can be made to the larger community to provide support for this activity?

## Practice 4

# Engaging Families and Communities

### What Is It?

*Engaging Families and Communities* involves parents in afterschool and makes the most of community-based partnerships and resources. Actively engaging families in science learning fosters positive attitudes and enhances science literacy. Community partnerships help build innovative curriculum through local and relevant science activities. When afterschool programs collaborate with families and community partners, they promote social, emotional, cultural, and academic growth.

### What Is the Content Goal?

The key goal of *Engaging Families and Communities* is to increase student achievement, aptitude, and interest in science by involving families in the learning process and making the most of community resources. Specific content goals will vary depending on the activity.

### What Do I Do?

Engage families in afterschool science projects, family science nights, and career fairs. Family events can engage parents and students in a typical afterschool science activity, or they can be led by a science expert in the community. Keep in mind that some parents, based on their familiarity with science content, may need to be encouraged and welcomed more than others. Consider parents who work in a science-related field, invite them to speak, or involve them in planning an event or project.

Plan activities that are realistic for your students to conduct such as cleaning out a section of stream banks, collecting water for testing by local authorities, testing water with sensors or water-testing kits, removing nonnative plants, and replanting native species. Begin with a small project; you can always expand the scope of the project as you and your students become more experienced and as you get additional resources.

Utilize community resources by contacting public relations officers or other key people at science museums, science centers, nature gardens, zoos, waste-treatment plants, parks and recycling centers, engineering organizations, chemical plants, power companies, or hospitals and other health agencies. Once you have a sense of parental and community resources, plan a project such as restoring a stream or natural habitat, recycling, improving county trails and parks, or a health project such as a nutrition and exercise fair. Be sure to include parents and community science experts in the planning process, to identify learning goals, and to evaluate the event or activity afterwards.

## Tech Tips for *Engaging Families and Communities*

Bring your afterschool community together by involving both children and adults in a get fit program. Use pedometers and good health as incentives for involvement as participants track their steps. An inexpensive technology, pedometers are fun to use and also afford opportunities for integrating health science into language arts, literacy, math, and social studies.

The following Web sites provide examples of successful efforts to use pedometers to get people walking and students learning:

- Pedometer Activities to Enhance Cross-Curricular Learning (www.pen.k12.va.us/VDOE/Instruction/PE/walksmart/lessonplans.pdf )
- PE Central's Pedometer Site (www.pecentral.org/pedometry/index.html)
- Safe Routes to Schools (www.walkboston.org/documents/srsCurric_part2.pdf)

## Why Does It Work?

Children whose parents are involved in their education perform at higher levels than those whose parents are not involved. Parents pass on to their children their attitudes toward science and math. Positive science and math experiences can stimulate enthusiasm and curiosity in both parents and children. Using community resources engages students in real-world activities, emphasizes the relevance of learning science, and exposes students to careers in science, technology, engineering, and mathematics.

## Getting Started

video

The literacy section of the Afterschool Training Toolkit contains a slide show that illustrates strategies that are applicable to the science practice of *Engaging Families and Communities*. The literacy slide show provides information about a family literacy event and an expo night.

Go to the *Family Literacy Events* practice found in the literacy section of the Afterschool Training Toolkit (www.sedl.org/afterschool/toolkits/literacy/pr_family_literacy.html). Then click on the slide show.

**BEFORE YOU WATCH THE VIDEO,** write down what sorts of activities you think will take place at the family literacy event and expo night.

**DURING THE VIDEO,** consider the following:

How do family and community events help engage parents in their children's progress and reinforce learning at home? How do such events help get people in the community more involved in afterschool programs? How can themes be incorporated into family and community events? How can you highlight student projects and activities at such events?

How can you apply what you learned about family literacy events to science family and community events? What types of activities might you include at such events? Be sure to give specific examples.

**AFTER YOU WATCH THE VIDEO,** write what modifications you might need to make to use the ideas you saw in science family and community events that you might hold.

# Lesson 1

## Family Science Night

This sample lesson is one example of how you can implement the *Engaging Families and Communities* practice and involve parents in inquiry-based learning. In this activity, students and parents work together with different materials to investigate what makes a good bubble blower.

**Grade Level(s):**

K–2

**Duration:**

1–2 hours

**Student Goals:**

- Practice scientific inquiry through questioning, hypothesizing, observing, recording and analyzing data, communicating results, and planning further investigations
- Keep journals or records of scientific investigations
- Compare results from multiple groups and draw conclusions
- Work with parents to understand the relevance of science in people's lives

## Imagine This!

Bubbles and laughter fill the air of the school gymnasium. At scattered tables, groups of parents and students use an array of objects to try to produce bubbles. One man waves a slotted spoon through the air, while a boy blows through a plastic funnel and a woman squeezes a turkey baster. Some objects produce streams of bubbles; others, nothing more than soapy fizz. "Throw this thing in the 'Doesn't Work' box, son," says a man as the boy adds the object to a growing pile of failed bubble blowers. The instructor mingles among the parent-student teams to offer advice and ask guiding questions. Later, as the family science night draws to a close, the crowd assembles to share what they have learned about what makes a good bubble blower.

## What You Need

- ❒ 1 gallon of bubble solution (1 gallon of water with 1 cup of water removed, 1 cup of dishwashing liquid, 50 to 60 drops of glycerin)
- ❒ Plastic tablecloths or large trash bags
- ❒ Newspapers (to cover floor and tables)
- ❒ Bucket, squeegees, sponges, paper towels, and vinegar (for cleanup)
- ❒ Bubble-blower materials such as straws, wire mesh, strainers, scissors, spools, plastic/styrofoam cups, funnels, slotted spoons, spatulas, paper towel and tissue rolls, wire of different gauges, pipe cleaners, different-sized washers, rubber bands, rubber rings for glass jars, and turkey basters
- ❒ Aluminum pie pans or flat plastic containers (for bubble solution, 1 per table)
- ❒ Signs labeled "Works" and "Doesn't Work"

## Getting Ready

*2–3 weeks before the event:*

- Work with parents and staff to plan the activity and create a program.
- Collect and organize materials.
- Write and distribute invitations to families or have students write personal invitations.
- Notify day-school teachers and administrators and ask for their support.

*Day of the event:*

- Place containers of bubble solution, plastic table cloths (if necessary), and newspapers on each table.
- Place bubble blowers and cleanup materials in a central area that is easy to access.
- Post signs on side tables or provide two boxes labeled "Works" and "Doesn't Work."

## Safety Considerations

- Participants may wear safety goggles or glasses to protect their eyes.
- Participants should wear clothing that can get wet and slip-resistant shoes.
- If solution gets in a participant's eyes, instructors should flush the eyes with clear water.
- Instructors should have a bottle of vinegar and a mop or towel handy to clean up any spills on the floor. Newspapers can also be used to clean up spills.
- After the investigations, participants should wash their hands to remove any soap solution.

## What to Do

- **Engage** students and families by introducing the lesson and asking guiding questions: Who has blown bubbles? What makes a good bubble blower? Students should be encouraged to introduce and lead the investigations without giving away the answers if they have done this activity before. Distribute materials and explain that each table will have bubble solution and a set of materials so that participants can see what makes a good bubble blower.
- **Explore** the various bubble blowers with students and parents. Once an object has been tried, it should go in either the "Works" or "Doesn't work" box or area. Circulate among the teams to check in and ask questions. How do they determine what works and what doesn't work? How many times do they try each bubble blower?
- **Explain** the results. After each team has had an opportunity to work with several blowers, assemble the whole group and ask each team to explain what makes a good bubble blower. Did every team come up with the same answer? How did they reach their conclusions? What do the most effective and least effective bubble blowers have in common?
- **Extend** learning if time allows.
  - Students and parents may record their findings, write about what they learned, and draw pictures of the more effective bubble blowers.
  - Family teams can design and build a bubble-making machine or explore other objects in their home that will serve as good bubble blowers.
- **Evaluate.** Look for the following outcomes:
  - Parent involvement in planning
  - Parent and student attendance and participation
  - Answers and questions that reflect an understanding of inquiry and investigation
  - Answers and questions that reflect an understanding of what materials do and do not make a good bubble blower and some ideas why

# Reflection

## Preparation

- How well did the lesson planning help you prepare for this activity?
- What can you do to feel more prepared?

## Academic Enrichment

- How did this lesson support other academic content areas like math or literacy?
- What changes could you make to strengthen academic enrichment while still keeping the activity fun?

## Classroom Management

- What strategies did you use to make the lesson go smoothly?
- What changes would you make if you taught the lesson again?

## Expansion

- How can this activity be improved to include concepts from other content areas?
- What resources or connections can be made to the larger community to provide support for this activity?

# Lesson 2

## Creek Restoration Project

This sample lesson is one example of how you can implement the practice of *Engaging Families and Communities*. In this project, afterschool instructors and students work with community members and parents to understand the local environment and restore a creek. Technology also plays a role as students use the online community to collaborate with other students and environmental experts to address similar issues on a global scale. This activity is based on an online collaborative project, the Global Water Sampling Project: An Investigation of Water Quality. This project runs twice a year for 2 months.

### Grade Level(s):

9–12 (can work with 5–8 as well)

### Duration:

This project is flexible and can be done in a couple of weeks or over the course of the year. A preferred length for the project is at least 2 months. Daily session length can vary according to your time line.

### Student Goals:

- Understand the local environment and issues that affect it
- Compare local environmental issues to other communities' environmental issues
- Practice scientific inquiry through questioning, hypothesizing, observing and recording data, and analyzing and communicating results
- Use scientific tools to measure
- Keep journals or records of scientific investigations
- Work collaboratively to solve a problem

## Imagine This!

Several teenagers gather on the banks of a creek with their afterschool instructor. Approaching a shallow part of the creek, they dip test tubes into the water to collect samples. They test the water temperature, measure its pH level (acidity), and examine other characteristics of the water. One student takes photos of the team while they perform the tests. Another one records the data in a handheld computer. After the students have finished collecting samples and testing the water, they return to the classroom. There, they log on to a Web site for a water sampling project, enter their data, and upload their photos. They also discuss how a nearby construction project might be affecting the water quality. Some of the students think the construction is affecting water quality, while others do not. Regardless of their opinions, all of the students are engaged in the project. They record their thoughts in journals and post their opinions on the project's online discussion forum.

## What You Need

- ❒ Safety goggles or spectacles
- ❒ Gloves
- ❒ Collection bags
- ❒ Water-testing kits
- ❒ Probes (optional)
- ❒ Digital camera
- ❒ Handheld or laptop computers with spreadsheet software (optional)
- ❒ Computer with Internet access and a projector or interactive whiteboard
- ❒ Adult or older student volunteers to help with technology and field trips

### Teaching Tip

**How Much Technology?**

This activity is flexible enough to allow afterschool instructors decide how much technology to incorporate into the lesson. If your program has the equipment or resources to purchase equipment, students can use water probes to test water and record their results on personal digital assistants (PDAs) or laptops. If this is the first time you are completing this project, you can start with simpler, less-expensive materials. Once you decide whether the project is suitable for your program, you can invest in more expensive materials. See the project's Web page on equipment for more information to help you make a decision (www.k12science.org/curriculum/waterproj/equipment.shtml).

## Getting Ready

- Study thoroughly the collaborative online project the Global Water Sampling Project: An Investigation of Water Quality (www.k12science.org/curriculum/waterproj/index.shtml). This project is the basis for this lesson.
- Arrange for a community member to come talk to students about water quality on the first day of the project. This individual may be an environmental scientist, chemist, or biologist from the city parks department, a college, a city or state water quality board, or the Environmental Protection Agency.
- Use this lesson plan as well as the online project plan and dates to set up a project time line.
- Spend time researching local environmental issues and identifying some potential locations to collect water samples.
- Communicate with parents regarding project plans, including the time line and field trips.
- Collect necessary materials for both the science and the technology portion of the activity. Practice using the materials.

## Safety Considerations

- Adults must supervise all data collection and cleanup. Choose the area wisely, looking for the safest environment for students.
- Students must wear gloves for cleanup and wear goggles when using any water-testing chemicals.
- Do not collect data when a storm is forecast; observe the sky for rain showers and thunderstorms. Avoid streams in high water.
- Have a first-aid kit available for all outings. Also make sure to wear sturdy shoes and proper clothing and to bring sunscreen and mosquito repellent.

## Session 1: Engaging Students in Environmental Study

### *What You Need*

❒ Computer with Internet access and projector or interactive whiteboard

❒ Arrangements with a community member to speak to afterschool students about the local environment

*What to Do*

- **Engage** students in the study of water quality and restoration.
  - Invite a guest speaker to discuss and share pictures of local streams, creeks, and ponds that show the environmental conditions of the area and explain the impact of water quality on the community. In addition, consider taking students to a local meeting for creek restoration, if one is available in your area.
  - Introduce students to the Web site for the Global Water Sampling Project: An Investigation of Water Quality (www.k12science.org/curriculum/waterproj/). Have students become familiar with the project and its Web site.
  - Discuss with your students and their parents the collaborative project and what it entails.

## Session 2: Investigating Water Quality Online

*What You Need*

❒ Instructor computer and projector or interactive whiteboard

❒ Student computers (at least one for every two students)

❒ Adult or older student volunteers

*What to Do*

- **Explore** water resources in your area and creek restoration projects.
  - Lead students in conducting Internet research about the site where they will complete the project. If your students will be participating in creek restoration or cleanup as part of the project, encourage them to research that topic as well.
  - To create a record of their work, students can keep electronic journals, either with word processing software or blogs.
  - Have students look at the online project Web site and plan for their field testing.
  - Develop a hypothesis (a proposal that students will try to prove or disprove with the data) on water quality and what students expect to see in the data.

## Session 3: Field Testing Water Quality

### *What You Need*

- ❒ Safety goggles or spectacles
- ❒ Gloves
- ❒ Collection bags
- ❒ Water-testing kits
- ❒ Probes (optional; see Teaching Tip on integrating technology on p. 93)
- ❒ Laptops or personal digital assistants (PDAs) for water testing and data recording (optional)
- ❒ Materials for recording data if you are not using laptops or PDAs
- ❒ Digital camera
- ❒ Arrangements for field trip as required by your program
- ❒ Signed parent permission slips
- ❒ Volunteers to help with management

### *What to Do*

- **Explore** water quality at the selected site.
  - Have students test water for the pH level (acidity), nitrates, dissolved oxygen, and other physical parameters.
  - Follow the online project guide for specifics on sample collection.
  - Record data on PDAs or laptop computers or in project notebooks.
  - Document your field testing by taking photos with a digital camera.

## Session 4: Submitting Data to Project Web Site

### *What You Need*

❒ Instructor computer with Internet access

❒ Student computers with Internet access

❒ Data from water tests

❒ Digital photos from water testing

### *What to Do*

- **Explain** the data.
  - Log on to the Global Water Sampling Project Web site (www.k12science.org/curriculum/waterproj/) and submit the data you collected.
  - Upload photos to the Web site.
  - As a class, analyze the data you collected and decide whether it proves or disproves your hypothesis.
  - Have students share their findings by creating a presentation, using computer-generated spreadsheets and charts, posting comments in the project discussion area, writing in their electronic journals, or contacting an expert listed on the project Web site.
- **Extend** learning if time allows.
  - Investigate opportunities for students to participate in creek restoration projects and measure the impact of their work.
  - Expand the scope of the project to include tracing energy flows in the creek ecosystem and researching and restoring native plants to the stream banks.
  - Invite representatives from local or state environmental agencies to talk to students about careers in environmental sciences.
  - Have students create final reports and displays, and invite family and community members to see their work.
- **Evaluate.** Look for the following outcomes:
  - Student participation and engagement
  - An understanding of creeks in the local environment
  - Questions and answers that reflect an ability to practice scientific inquiry (questioning, hypothesizing, observing and collecting data, and communicating results)
  - Written answers or illustrations that reflect an understanding of environmental issues, how to measure chemicals in water, and how to display data

# Reflection

## Preparation

- How well did the lesson planning help you prepare for this activity?
- What can you do to feel more prepared?

## Academic Enrichment

- How did this lesson support other academic content areas like math or literacy?
- What changes could you make to strengthen academic enrichment while still keeping the activity fun?

## Classroom Management

- What strategies did you use to make the lesson go smoothly?
- What changes would you make if you taught the lesson again?

## Expansion

- How can this activity be improved to include concepts from other content areas?
- What resources or connections can be made to the larger community to provide support for this activity?

## Practice 5

# Tutoring to Enhance Science Skills

### What Is It?

*Tutoring to Enhance Science Skills* focuses on helping students master science concepts they are struggling to understand or on targeting specific skills to develop such as observing, predicting, classifying, experimenting, organizing data, or graphing. Science tutoring can take the form of one-on-one instruction or small-group sessions in which students are grouped by skill level and need.

### What Is the Content Goal?

The key goals of science tutoring are to help extend students' understanding of the content and skills they are learning during the school day, to connect to state and national science standards, and ultimately to increase students' desire to learn. Specific content standards will vary based on individual students' needs.

### What Do I Do?

Begin by talking to the day-school teacher to find out what science concepts and skills students are learning, the standards for each grade level, and which students need help. For each student, identify with the day-school teacher specific science concepts or skills that are difficult and activities that could help clarify a concept and build understanding. Talk to the individual students as well and ask them what science concepts and skills are difficult for them, what their strengths are, and what science activities interest them. Fun, yet challenging activities engage students and increase their desire to learn. For example, reading and discussing real-world problems can help students break down challenging informational text found in science. Creating activities that let students measure and represent data using tables and graphs helps students develop the math skills that are critical to success in science.

If you don't have a science background, make the most of the resources in your community to identify tutors. Contact local high school and college students and teachers, scientists and engineers, health care workers, and retired science teachers. Consider the Experience Corps, whose 1,800 members in 14 cities mentor and tutor students in school and afterschool programs.

Review "Tips for Tutoring Students in Science" (p. 104) for more information on using the tutoring lessons in this section. The following online documents may also be helpful in organizing and managing your tutoring activity:

- Science Tutoring Receipt (www.sedl.org/afterschool/toolkits/science/pdf/ast_hw_tool _receipt.pdf)
- Science Tutoring Log (www.sedl.org/afterschool/toolkits/science/pdf/ast_hw_tool_tutoring.pdf)

## Why Does It Work?

Tutoring works because the tutor provides relevant, understandable help that is targeted to the individual student's needs and delivers it in a timely manner. Effective tutoring practices include sessions that occur at least three times a week for at least 1.5 hours per week for four weeks or more, close collaboration with classroom teachers, and quality tutor training.

## Getting Started

video

The literacy section of the Afterschool Training Toolkit contains a video that illustrates strategies that are applicable to the science practice of *Tutoring to Enhance Science Skills*. In the literacy video titled "One-on-One Tutoring: Preparing Early Readers," an instructor leads a one-on-one literacy tutoring session at the Delaware Elementary School afterschool program in Evansville, Indiana.

Go to the *One-on-One and Small Group Tutoring* practice found in the literacy section of the Afterschool Training Toolkit (www.sedl.org/afterschool/toolkits/literacy/pr_tutoring.html). Then click on the video titled "One-on-One Tutoring: Preparing Early Readers."

**BEFORE YOU WATCH THE VIDEO,** write down what approaches and strategies you think the teacher will use during the tutoring session to help the student and reinforce learning.

**DURING THE VIDEO,** consider the following:

How does the instructor find out what specific areas to focus on with the student? How does the instructor engage the student and keep him focused? How does the instructor interact with the student?

What strategies and activities does the instructor use and how does she integrate games into the tutoring session? Be sure to give specific examples.

**AFTER YOU WATCH THE VIDEO,** write what modifications you might need to make to apply the strategies in your tutoring sessions.

## Tips for Tutoring Students in Science

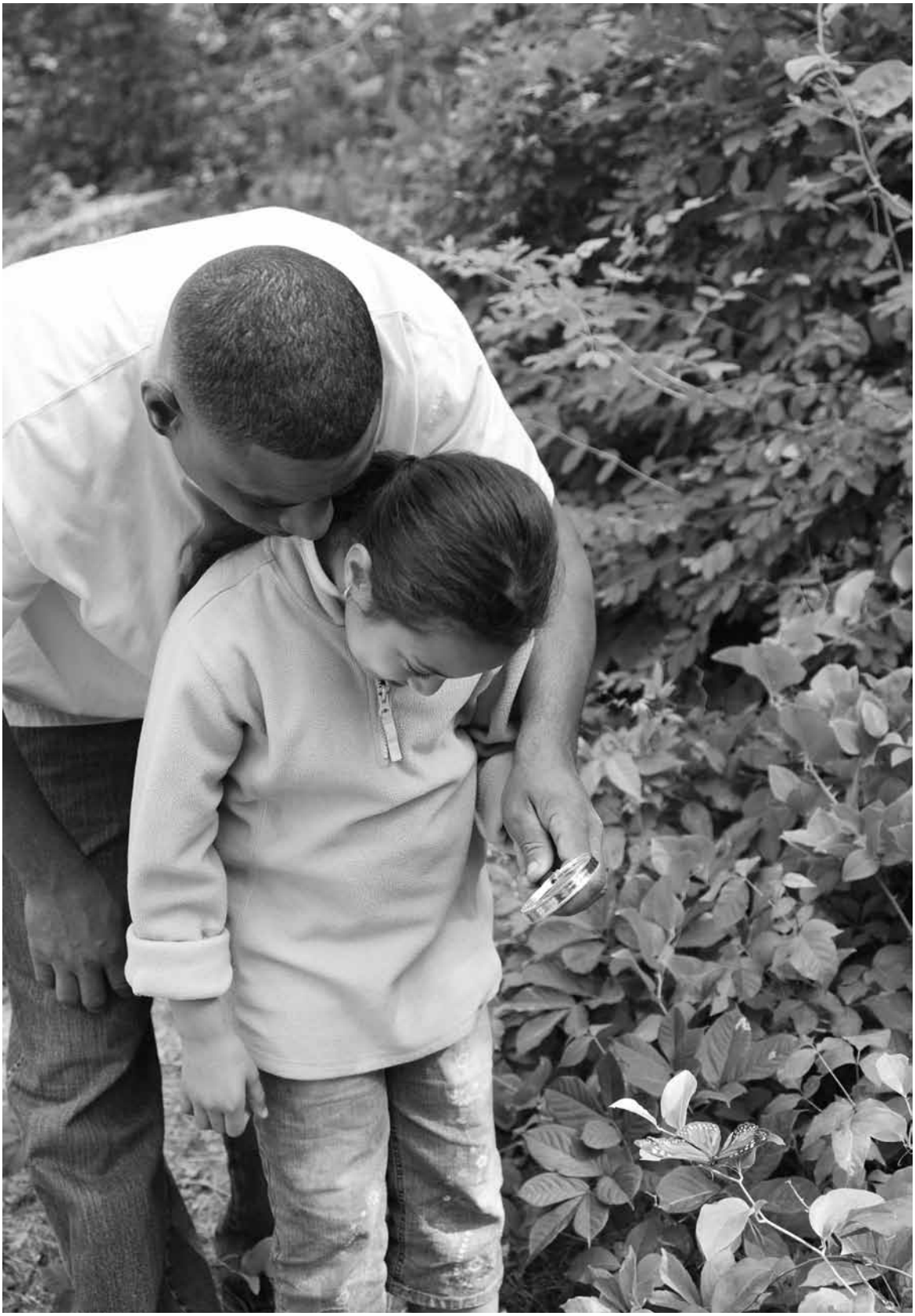
The sample lessons provided here build on one another and help students build on their own skills. ***Note:*** **These lessons work best in sequential order**. These tips will help you make the most of this lesson series:

- Begin with the "Interpreting Data From Birdfeeders" lesson.
- Next complete the "Learning to Make Data Tables" lesson.
- Use the data tables that students create to complete the lessons' online graphs and bar graphs.
- The "Learning to Make Bar Graphs" lesson is ideal for students in the primary and upper-elementary grades but can be used for older students who struggle with the concept.
- The "Learning to Make Line Graphs" lesson is ideal for students in upper-elementary grades, middle school, and high school.

Here are some things to think about when helping students increase their understanding of science content and improve their skills.

- Complete each lesson on your own before working with students. Use the guidelines provided in each lesson.
- Don't hesitate to ask for help from teachers or colleagues to maximize your own understanding of the material before you begin a tutoring session.
- Talk with day-school teachers and parents to understand the needs of your student and to plan tutoring sessions that target those needs.
- Examine student work. Ask students to show you graphs and data tables that they have made or that are in their texts and day-school science work.
- Provide encouragement. Remind students that science is fun, that it is for all students, and that everyone can succeed.
- Set the tone in the tutoring session by asking questions that keep the students thinking and learning for themselves, and that assess their progress. Remember that giving the answers without asking students to reason and think for themselves inhibits learning. Give information as often as is needed to clarify or redirect thinking.
- Provide positive feedback and be generous with praise.
- As students' confidence increases, tutor supervision should decrease. Challenge students to use what they know to solve a problem.

Use the materials in these lessons to help students with a common problem—recording, displaying, graphing, analyzing, and interpreting data.



# Lesson 1

## Interpreting Data From Birdfeeders

*Note:* This is the first lesson in a series.

This sample lesson is one example of how you can implement the practice of *Tutoring to Enhance Science Skills*. The lesson is designed to give students practice interpreting data tables and bar graphs, important skills in science that many elementary students find challenging. In this lesson, students look at data tables and bar graphs showing patterns among different birds at birdfeeders. The lesson can be done in one-on-one or small-group sessions.

**Grade Level(s):**

2–5

**Duration:**

One or two 45-minute sessions

**Student Goals:**

- Understand and interpret data from tables and bar graphs
- Identify the parts of a graph and data table including title, independent variable, dependent variable, scale, and *x*- and *y*-ordered pairs
- Work cooperatively with a tutor

## Imagine This!

A bright glow of success appears on the afterschool student's face. "I get it. These numbers in the bar graph tell me how many birds ate each type of birdfeed. I never understood it before." The student smiles at the afterschool tutor sitting across the table. A science activity about identifying patterns among different birds at birdfeeders makes a tutoring session about reading data tables and bar graphs more engaging and meaningful.

## What You Need

❒ Handout 11: Interpreting Data From Birdfeeders

❒ Pencils and paper

❒ Materials as needed for building birdfeeders (if lesson is extended)

## Getting Ready

- Collect informational books on birds.
- Review the lesson, handout, and "Tips for Tutoring Students in Science" (p. 104).
- Copy the handout for this lesson. If you are working with more than one student, make copies as needed.

## Safety Considerations

None in this lesson; precaution should be taken with tools if making birdfeeders.

## What to Do

- **Engage** students in the lesson by reading a book together on birds and talking about the different kinds of birds in your area. Ask questions such as: What do birds need to survive? Do you think all birds eat the same thing? How might you find out what different birds eat?
- **Explore** the data in Handout 11. The data tables provide information about birdfeeding habits and the bar graph illustrates patterns at birdfeeders. Use the guiding questions to help students make sense of the data tables and the bar graph. For example, students should be able to identify what kinds of birdfeed different birds prefer, what the most and least popular kind of birdfeed is, and other patterns.
- **Explain** the data. Students should be able to interpret the data based on their answers to the questions.
  - Help students understand that an independent variable—in this case the birdfeed—is something that the person doing the experiment can control or vary. Likewise, help students understand that a dependent variable—in this case the number of birds that eat each kind of birdfeed—is something that the experimenter doesn't control or something that depends on the way the experiment is done.
  - Discuss the patterns that students noticed, questions they can use to help them interpret data tables and bar graphs, and what they learned from this activity.

- **Extend** learning if time allows by building birdfeeders or conducting a bird field study. Design an investigation to identify and count the number of birds in your area. Then display the data in data tables and in a bar graph.
- **Evaluate.** Look for the following outcomes:
  - Student participation and engagement
  - Questions and answers that reflect an understanding of the data
  - Answers that reflect an understanding of how data can be represented in tables and bar graphs
  - Student understanding of independent and dependent variables, and how they are represented on *x* and *y* axes

## Handout 11: Interpreting Data From Birdfeeders

### Birds Attracted to Different Types of Birdfeed

| Team Name | Number of Birds | | | | | Average Number of Birds |
|---|---|---|---|---|---|---|
| | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | |
| Millet | 10 | 15 | 17 | 18 | 15 | 15 |
| Milo | 2 | 4 | 5 | 5 | 4 | 4 |
| Cracked Corn | 3 | 6 | 8 | 7 | 6 | 6 |
| Safflower | 15 | 10 | 13 | 11 | 11 | 12 |
| Sunflower | 26 | 28 | 26 | 22 | 28 | 26 |
| Nyjer (Thistle) | 4 | 2 | 5 | 4 | 4 | 4 |
| Suet | 17 | 13 | 15 | 16 | 14 | 15 |

Using the data table, answer the following questions:

1. Which type of birdfeed was the favorite choice of most of the birds?

2. Which type of birdfeed was the least favorite choice?

3. Which combination of three types of feed would probably attract the most birds to the birdfeeder?

4. How many days did the students collect data?

5. What were some things that should have been held constant (for example, the weather, the time of day that the birdfeed was put out, or anything else that might have affected the outcomes)?

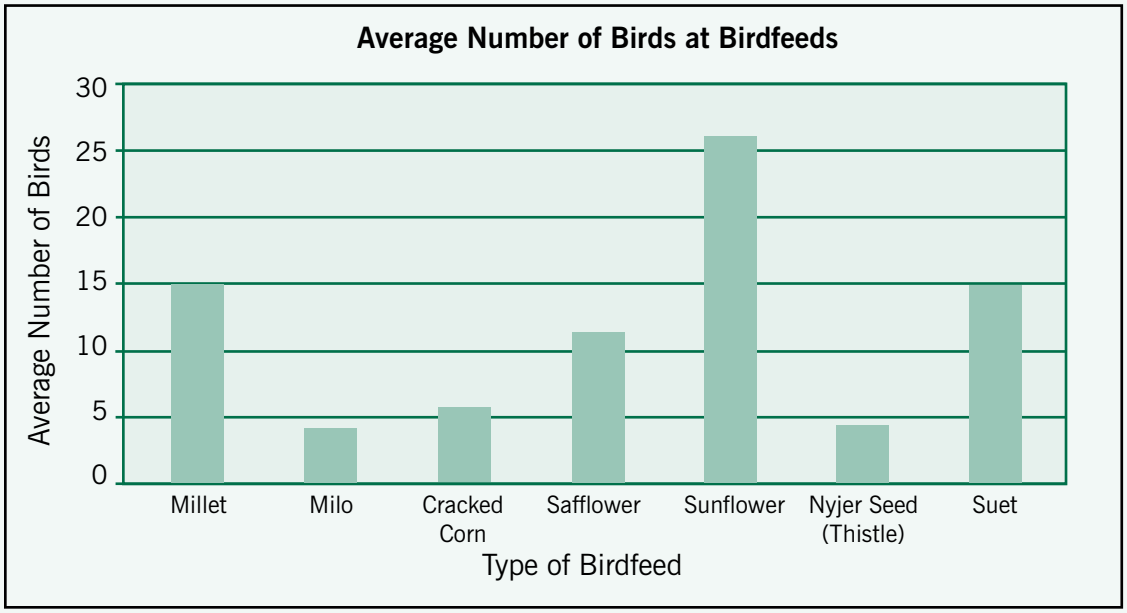
6. What is the independent variable in this investigation? (Hint: an independent variable is something that the investigator can control or vary.)

7. What is the dependent variable in this investigation? (Hint: a dependent variable is something that the investigator can't control or is dependent on the experiment.)

8. How many trials were there?

9. What is the title of the data table? Can you think of a better title?

The following bar graph was made using the birdfeed data.




Answer the following questions using this graph:

1. Which type of birdfeed was the favorite choice of most of the birds?
2. Which type of birdfeed was the least favorite choice?
3. Which combination of three types of feed would probably attract the most birds to the birdfeeder?
4. Which two types of birdfeed attracted the same number of birds?
5. Does the graph help you answer the questions? What could you do to the graph to make it easier to read?
6. What is the title of the graph?
7. What is value of each line on the *y* axis? (Hint: the *y* axis is vertical.)
8. What is the label on the *x* axis? (Hint: the *x* axis is horizontal.)
9. What is the label on the *y* axis?

Handout 11: Interpreting Data From Birdfeeders, continued

## Food Preferences of Common Feeder Birds

| Kinds of Birds | Food Preferences | | | | | | |
|---|---|---|---|---|---|---|---|
| | Sunflower | Safflower | Corn | Millet | Milo | Nyjer | Suet |
| Chickadees, Titmice, Nuthatches | X | X | | | | | X |
| Finches | X | X | | X | | X | |
| Cardinals, Grosbeaks | X | X | | | | | |
| Sparrows, Blackbirds | X | | X | X | | | |
| Jays | X | | X | | X | | X |
| Woodpeckers | X | | | | | | X |
| Orioles, Tanagers | | | | | | | X |
| Pigeons, Doves | | | X | X | X | | |
| Indigo Buntings | X | | | X | | X | |

Answer the following questions based on the information in the data table above:

1. Which birdfeed do most birds prefer?

2. What foods do finches prefer?

3. If you want to attract orioles to a birdfeeder, what food must be available?

4. Which birds like suet?

5. What foods do both chickadees and cardinals prefer?

6. If you were going to make a mix of three kinds of feed to attract the most birds, what would you choose? Explain your answer. What kinds of birds would come to the feeder?

7. What other patterns do you find in the data?

# Reflection

## Preparation

- How well did the lesson planning help you prepare for this activity?
- What can you do to feel more prepared?

## Academic Enrichment

- How did this lesson support other academic content areas like math or literacy?
- What changes could you make to strengthen academic enrichment while still keeping the activity fun?

## Classroom Management

- What strategies did you use to make the lesson go smoothly?
- What changes would you make if you taught the lesson again?

## Expansion

- How can this activity be improved to include concepts from other content areas?
- What resources or connections can be made to the larger community to provide support for this activity?

# Lesson 2

## Learning to Make Data Tables

*Note:* This is the second lesson in a series. Complete the first lesson, "Interpreting Data From Birdfeeders," before starting this one.

This lesson is one example of how you can implement the practice of *Tutoring to Enhance Science Skills*. In this activity, students take the results, or data, from different experiments and learn to make data tables.

**Grade Level(s):**

3–10

**Duration:**

Two 45-minute sessions

**Student Goals:**

- Understand data as pieces of information
- Learn how data can be represented in a table
- Construct a data table from experiment results
- Interpret data from a data table

## Imagine This!

The afterschool student and tutor are developing a good rapport as their sessions continue. Using a set of provided guidelines, the student starts making a data table showing the results of a pet survey. "Now that I really understand how to read data tables," the student tells the tutor, "making them is much easier." By building on previous learning, the science skills activity helps the student make connections and deepen understanding. Success is more likely, making the tutoring session more enjoyable for everyone.

## What You Need

- ❒ Notebook paper
- ❒ Pencils
- ❒ Clear ruler
- ❒ Graphing paper (optional)
- ❒ Large chart paper for K–2 students (optional)
- ❒ Handout 12: Sample Data for Data Tables
- ❒ Handout 13: Guidelines for Making a Data Table
- ❒ Handout 14: Checklist for a Data Table

## Getting Ready

- Connect with the day-school teacher to review student's needs.
- Review the lesson, handouts, and "Tips for Tutoring Students in Science" (p. 104).
- Copy all handouts for this lesson. If you are working with more than one student, make copies as needed.

## Safety Considerations

There are no safety precautions for this lesson. However, if simple experiments are conducted in expanding this lesson, follow appropriate safety precautions such as using goggles or safety spectacles.

## What to Do

- **Engage** students by identifying what they already know about displaying data.
  - Begin by reviewing data as pieces of collected information. Typically, data represents something that can be observed and measured, from how often it rained in the last week to how much chlorine is in local pools.
  - Ask students to show you a sample of a data table or graph they have made. This may be a crumpled sheet of paper with numbers clustered randomly, representing something they have observed and measured.
  - Review Handout 12: Sample Data for Data Tables and ask the student to make a data table from one of the examples. Note what the student understands and where the student needs to modify her or his thinking.
- **Explore** the process of making data tables. Review Handout 13: Guidelines for Making a Data Table and Handout 14: Checklist for a Data Table.
  - Ask students to select an example from the sample data and create a data table.
  - As students work, review any vocabulary associated with data representations. Watch for typical errors and help students learn to identify them, check their work, and correct errors independently.
- **Explain** the results. Ask students to explain how they organized the data in their data tables. Review students' data tables using the data table checklist. If you think that sufficient progress has been made, ask students to continue with other sample data sets.
- **Extend** learning if time allows. Use day-school science lessons or the Internet to collect additional data for more data tables.
- **Evaluate.** Look for the following outcomes:
  - Student participation and engagement
  - Answers that reflect an understanding of what data are and that they represent pieces of information
  - Answers that reflect an understanding of how data can be organized in a table (use the data table checklist)

### Teaching Tip

**Using Graphing Software**

Have older students use graphing software, such as Microsoft Excel, to create electronic data tables, bar graphs, and line graphs on a computer. The following two Web sites provide tips for using graphing software:

- Directions for Making Scientific Graphs Using Excel www.howe.k12.ok.us/~jimaskew/excelgra.htm
- Graphing with Excel for High School Students (North Carolina State University) www.ncsu.edu/labwrite/res/gt/gt-menu.html


SPORTS SPORTS SPORTS

## Handout 12: Sample Data for Data Tables

Use these data to create data tables following Handout 13: Guidelines for Making a Data Table and Handout 14: Checklist for a Data Table.

### Example 1: Pet Survey (grades 2–3)

Ms. Hubert's afterschool students took a survey of the 600 students at Morales Elementary School. Students were asked to select their favorite pet from a list of eight animals. Here are the results.

Lizard 25, Dog 250, Cat 115, Bird 50, Guinea Pig 30, Hamster 45, Fish 75, Ferret 10

### Example 2: Electromagnets: Increasing Coils (grades 3–5)

The following data were collected using an electromagnet with a 1.5 volt battery, a switch, a piece of #20 insulated wire, and a nail. Three trials were run. Safety precautions in repeating this experiment include using safety goggles or safety spectacles and avoiding short circuits.

| Number of Coils | Number of Paperclips |
|---|---|
| 5 | 3, 5, 4 |
| 10 | 7, 8, 6 |
| 15 | 11, 10, 12 |
| 20 | 15, 13, 14 |

### Example 3: pH of Substances (grades 5–10)

The following are pH values of common household substances taken by three different teams using pH probes. Safety precautions in repeating this experiment include hooded ventilation, chemical-splash safety goggles, gloves, and apron. Do not use bleach, ammonia, or strong acids.

Lemon juice 2.4, 2.0, 2.2; Baking soda (1 Tbsp) in Water (1 cup) 8.4, 8.3, 8.7; Orange juice 3.5, 4.0, 3.4; Battery acid 1.0, 0.7, 0.5; Apples 3.0, 3.2, 3.5; Tomatoes 4.5, 4.2, 4.0; Bottled water 6.7, 7.0, 7.2; Milk of magnesia 10.5, 10.3, 10.6; Liquid hand soap 9.0, 10.0, 9.5; Vinegar 2.2, 2.9, 3.0; Household bleach 12.5, 12.5, 12.7; Milk 6.6, 6.5, 6.4; Household ammonia 11.5, 11.0, 11.5; Lye 13.0, 13.5, 13.4; and Sodium hydroxide 14.0, 14.0, 13.9; Anti-freeze 10.1, 10.9, 9.7; Windex 9.9. 10.2, 9.5; Liquid detergent 10.5, 10.0, 10.3; and Cola 3.0, 2.5, 3.2

**Example 4: Automobile Land Speed Records (grades 5–10)**

In the first recorded automobile race in 1898, Count Gaston de Chasseloup-Laubat of Paris, France, drove 1 kilometer in 57 seconds for an average speed of 39.2 miles per hour (mph) or 63.1 kilometers per hour (kph). In 1904, Henry Ford drove his Ford Arrow across frozen Lake St. Clair, MI, at an average speed of 91.4 mph. Now, the North American Eagle is trying to break a land speed record of 800 mph. The Federation International de L'Automobile (FIA), the world's governing body for motor sport and land speed records, recorded the following land speed records. (Retrieved on February 5, 2006, from www.landspeed.com/classroom/classlsrbasics.html)

| Speed (mph) | Driver | Car | Engine | Date |
|---|---|---|---|---|
| 407.447 | Craig Breedlove | Spirit of America | GE J47 | 8/5/63 |
| 413.199 | Tom Green | Wingfoot Express | WE J46 | 10/2/64 |
| 434.22 | Art Arfons | Green Monster | GE J79 | 10/5/64 |
| 468.719 | Craig Breedlove | Spirit of America | GE J79 | 10/13/64 |
| 526.277 | Craig Breedlove | Spirit of America | GE J79 | 10/15/65 |
| 536.712 | Art Arfons | Green Monster | GE J79 | 10/27/65 |
| 555.127 | Craig Breedlove | Spirit of America, Sonic 1 | GE J79 | 11/2/65 |
| 576.553 | Art Arfons | Green Monster | GE J79 | 11/7/65 |
| 600.601 | Craig Breedlove | Spirit of America, Sonic 1 | GE J79 | 11/15/65 |
| 622.407 | Gary Gabelich | Blue Flame | Rocket | 10/23/70 |
| 633.468 | Richard Noble | Thrust 2 | RR RG 146 | 10/4/83 |
| 763.035 | Andy Green | Thrust SSC | RR Spey | 10/15/97 |

**Example 5: Distance and Time (grades 8–10)**

The following data were collected using a car with a water clock set to release a drop in a unit of time and a meter stick. The car rolled down an inclined plane. Three trials were run. Create a data table with an average distance column and an average velocity column, create an average distance-time graph, and draw the best-fit line or curve. Estimate the car's distance traveled and velocity at six drops of water. Describe the motion of the car. Is it going at a constant speed, accelerating, or decelerating? How do you know?

| Time (drops of water) | Distance (cm) |
|---|---|
| 1 | 10, 11, 9 |
| 2 | 29, 31, 30 |
| 3 | 59, 58, 61 |
| 4 | 102, 100, 98 |
| 5 | 122, 125, 127 |

## Handout 13: Guidelines for Making a Data Table

In most cases, the independent variable (that which you purposefully change) is in the left column, the dependent variable (that which you measure) with the different trials is in the next columns, and the derived or calculated column (often average) is on the far right. Reaffirm that rows are a series of horizontal cells and that columns are a series of vertical cells.

**Title:** Clearly state the purpose of the experiment (e.g., The effect of ____ [independent variable] on _____ [dependent variable]).

| Independent Variable (unit) | Dependent Variable (unit) | | | Derived Quantity (unit) |
|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | |
| | | | | |
| | | | | |
| | | | | |

Have students practice creating data tables first with paper, pencil, and rulers, and later with Excel if computers are available. Use sample data, experimental data from investigations, or create data sets to allow for ample practice.

### Example

Title: The pH of Common Household Substances

| Substance | pH | | | Average pH |
|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | |
| Lemon juice | 2.4 | 2.0 | 2.2 | 2.2 |
| Baking soda | 8.4 | 8.3 | 8.7 | 8.5 |
| Orange juice | 3.5 | 4.0 | 3.4 | 3.6 |

## Handout 14: Checklist for a Data Table

| Criteria | Self | | Tutor | |
|---|---|---|---|---|
| | Yes | No | Yes | No |
| Is there a title? Is the source of the data noted? Does the table have a name and a date? | | | | |
| Is the title clear and does it reflect the purpose of the data table? | | | | |
| Is the independent variable in the first column? | | | | |
| Is the independent variable named? | | | | |
| Is the independent variable unit included, if appropriate? | | | | |
| Is there a column (sometimes with sub-columns) for the dependent variable? | | | | |
| Is the dependent variable named? | | | | |
| Is the dependent variable unit included, if appropriate? | | | | |
| Are there trial sub-columns under the dependent variable (one for each trial)? | | | | |
| Is there a column for a derived or calculated quantity? | | | | |
| Is the derived (e.g., average) column on the far right? | | | | |
| Is the derived quantity named? | | | | |
| Is the derived quantity unit included, if appropriate? | | | | |
| Are the derived calculations correct? | | | | |
| Are data recorded correctly? | | | | |

# Reflection

## Preparation

- How well did the lesson planning help you prepare for this activity?
- What can you do to feel more prepared?

## Academic Enrichment

- How did this lesson support other academic content areas like math or literacy?
- What changes could you make to strengthen academic enrichment while still keeping the activity fun?

## Classroom Management

- What strategies did you use to make the lesson go smoothly?
- What changes would you make if you taught the lesson again?

## Expansion

- How can this activity be improved to include concepts from other content areas?
- What resources or connections can be made to the larger community to provide support for this activity?

# Lesson 3

## Learning to Make Bar Graphs

*Note:* This is the third lesson in a series. Complete the first lesson, "Interpreting Data From Birdfeeders," and the second lesson, "Learning to Make Data Tables," before starting this one.

This lesson is one example of how you can implement the practice of *Tutoring to Enhance Science Skills*. In this activity, students take the results, or data, from different experiments and learn to make bar graphs.

**Grade Level(s):**

3–10

**Duration:**

Two 45-minute sessions

**Student Goals:**

- Learn how data can be represented in a bar graph
- Construct a bar graph from experiment results
- Interpret data from a bar graph

## Imagine This!

The afterschool student places a bar graph of pH values of common household substances next to a data table showing the same information, which she made in a previous tutoring session. "I prefer the bar graph," the student tells her tutor. "I think it's easier to see which household substances have the highest pH values in it. Plus, the bar graph's prettier." The tutor smiles, remembering how the student struggled to understand that a bar graph can often show the same information as a data table. But by building on the skills she already had, the student has now learned to read and make bar graphs. Her newfound skills will serve her well in her day-school science class.

## What You Need

- ❒ Notebook paper
- ❒ Pencil
- ❒ Clear ruler
- ❒ Graphing paper (optional)
- ❒ Large chart paper (optional)
- ❒ Handout 15: Sample Data for a Bar Graph
- ❒ Handout 16: Guidelines for Making a Bar Graph
- ❒ Handout 17: Checklist for a Bar Graph

## Getting Ready

- Connect with the day-school teacher to review student's needs.
- Review the lesson, handouts, and "Tips for Tutoring Students in Science" (p. 104).
- Copy all of the handouts for this lesson. If you are working with more than one student, make copies as needed.

## Safety Considerations

There are no safety precautions for this lesson. However, if simple experiments are conducted in expanding this lesson, follow appropriate safety precautions such as using goggles or safety spectacles.

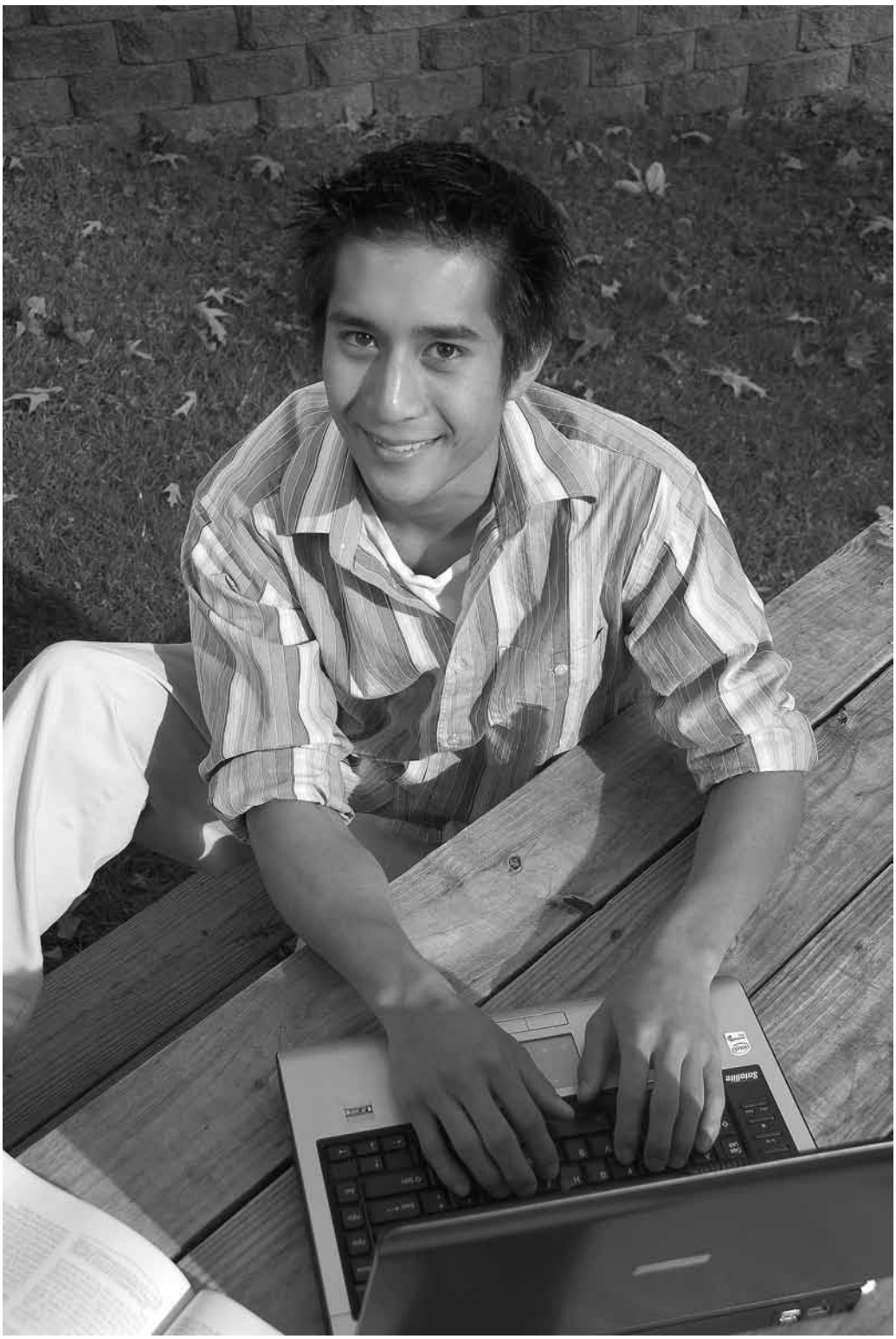
## What to Do

- **Engage** students by asking them what they already know about bar graphs or to show you a sample of any bar graphs they have made. Or, review Handout 15: Sample Data for a Bar Graph or the data table the students made in the previous lesson, Learning to Make Data Tables. Select one data set and ask students how they might represent the results in a bar graph. Note what students understand and where they need to modify their thinking.
- **Explore** bar graphs.
  - Review Handout 16: Guidelines for Making a Bar Graph and Handout 17: Checklist for a Bar Graph. Ask students to select an example from the sample data and create a bar graph.
  - As students work, review any vocabulary associated with data representations. Watch for typical errors and help students learn to identify them, check their work, and correct errors independently.
- **Explain** the results. Ask students to explain how they organized the data in their bar graphs. Review students' bar graphs using the bar graph checklist. If you think that sufficient progress has been made, ask students to continue using other sample data sets to create additional bar graphs.
- **Extend** learning if allows. Ask students for ideas or use day-school science lessons or the Internet to collect additional data for more bar graphs.
- **Evaluate.** Look for the following outcomes:
  - Student participation and engagement
  - Answers that reflect an understanding of how data can be organized in a bar graph (use the bar graph checklist)
  - Understanding of *x* axis, *y* axis, and variables

### Teaching Tip

**Making It Matter**

To help interest students in learning about bar graphs, first have students create a simple bar graph of personal data, such as a chart of how much time they spend on their favorite activities each week or of the heights of the people in their family. Then have students focus on creating graphs of more academic and complex data.



## Handout 15: Sample Data for a Bar Graph

### Example 1: Pet Survey (grades 2–3)

Ms. Hubert's afterschool students took a survey of the 600 students at Morales Elementary School. Students were asked to select their favorite pet from a list of eight animal. Here are the results.

Lizard 25, Dog 250, Cat 115, Bird 50, Guinea Pig 30, Hamster 45, Fish 75, Ferret 10

### Example 2: Bubble Sizes (grades 3–5)

One of Mr. Tongy's teams of students in an afterschool science class had the following bubble-sizes data in the "Festival of Bubbles" lesson.

Brand A: 44.0 cm, 38.9 cm, 30.8 cm, 29.4 cm
Brand B: 25.6 cm, 30.2 cm, 23.3 cm, 20.1 cm
Brand C: 10.0 cm, 15.4 cm, 21.6 cm, 12.9 cm

### Example 3: pH of Substances (grades 5–10)

The following are pH values of common household substances taken by three different teams using pH probes. Safety precautions in repeating this experiment include hooded ventilation, chemical-splash safety goggles, gloves, and apron. Do not use bleach, ammonia, or strong acids.

Lemon juice 2.4, 2.0, 2.2; Baking soda (1 Tbsp) in water (1 cup) 8.4, 8.3, 8.7; Orange juice 3.5, 4.0, 3.4; Battery acid 1.0, 0.7, 0.5; Apples 3.0, 3.2, 3.5; Tomatoes 4.5, 4.2, 4.0; Bottled water 6.7, 7.0, 7.2; Milk of magnesia 10.5, 10.3, 10.6; Liquid hand soap 9.0, 10.0, 9.5; Vinegar 2.2, 2.9, 3.0; Household bleach 12.5, 12.5, 12.7; Milk 6.6, 6.5, 6.4; Household ammonia 11.5, 11.0, 11.5; Lye 13.0, 13.5, 13.4; and Sodium hydroxide 14.0, 14.0, 13.9; Anti-freeze 10.1, 10.9, 9.7; Windex 9.9. 10.2, 9.5; Liquid detergent 10.5, 10.0, 10.3; and Cola 3.0, 2.5, 3.2

**Example 4: Automobile Land Speed Records (grades 5–10)**

In the first recorded automobile race in 1898, Count Gaston de Chasseloup-Laubat of Paris, France, drove 1 kilometer in 57 seconds for an average speed of 39.2 miles per hour (mph) or 63.1 kilometers per hour (kph). In 1904, Henry Ford drove his Ford Arrow across frozen Lake St. Clair, MI, at an average speed of 91.4 mph. Now, the North American Eagle is trying to break a land speed record of 800 mph. The Federation International de L'Automobile (FIA), the world's governing body for motor sport and land speed records, recorded the following land speed records. (Retrieved on August 29, 2008, from http://www.landspeed.com/classroom/classlsrbasics.html)

| Speed (mph) | Driver | Car | Engine | Date |
|---|---|---|---|---|
| 407.447 | Craig Breedlove | Spirit of America | GE J47 | 8/5/63 |
| 413.199 | Tom Green | Wingfoot Express | WE J46 | 10/2/64 |
| 434.22 | Art Arfons | Green Monster | GE J79 | 10/5/64 |
| 468.719 | Craig Breedlove | Spirit of America | GE J79 | 10/13/64 |
| 526.277 | Craig Breedlove | Spirit of America | GE J79 | 10/15/65 |
| 536.712 | Art Arfons | Green Monster | GE J79 | 10/27/65 |
| 555.127 | Craig Breedlove | Spirit of America, Sonic 1 | GE J79 | 11/2/65 |
| 576.553 | Art Arfons | Green Monster | GE J79 | 11/7/65 |
| 600.601 | Craig Breedlove | Spirit of America, Sonic 1 | GE J79 | 11/15/65 |
| 622.407 | Gary Gabelich | Blue Flame | Rocket | 10/23/70 |
| 633.468 | Richard Noble | Thrust 2 | RR RG 146 | 10/4/83 |
| 763.035 | Andy Green | Thrust SSC | RR Spey | 10/15/97 |

## Handout 16: Guidelines for Making a Bar Graph

Bar graphs are ideal for showing information that reflect quantities or the frequency of things, such as kinds of pets, number of children, or people's favorite brands. Bar graphs are frequently used to display data in science and are the first graphs that students learn to create. Follow the steps below to create bar graphs based on data in a data table.

Which detergent makes the best bubbles?

| Detergent Brand | Size of Bubbles (cm) | | | | Average Size of Bubbles (cm) |
|---|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | Trial 4 | |
| A | 44.0 | 38.9 | 30.8 | 29.4 | 35.8 |
| B | 25.6 | 30.2 | 23.3 | 20.1 | 24.8 |
| C | 10.0 | 15.4 | 21.6 | 12.9 | 15.0 |

### Step 1: Identify the variables

Independent variable (purposefully changed by the experimenter): *Detergent brand*
Dependent variable (changes with the independent variable and is measured):
*Size of bubbles*

### Step 2: Determine the variable range

Subtract the lowest data value from the highest data value for the dependant variable.
Range of average bubbles: *35.8 cm - 15.0 cm = 25.8 cm*

### Step 3: Determine the scale of the graph

Determine the numerical value for each grid unit that best fits the range of each variable.
Number of lines on graph: 36 (*y* axis)

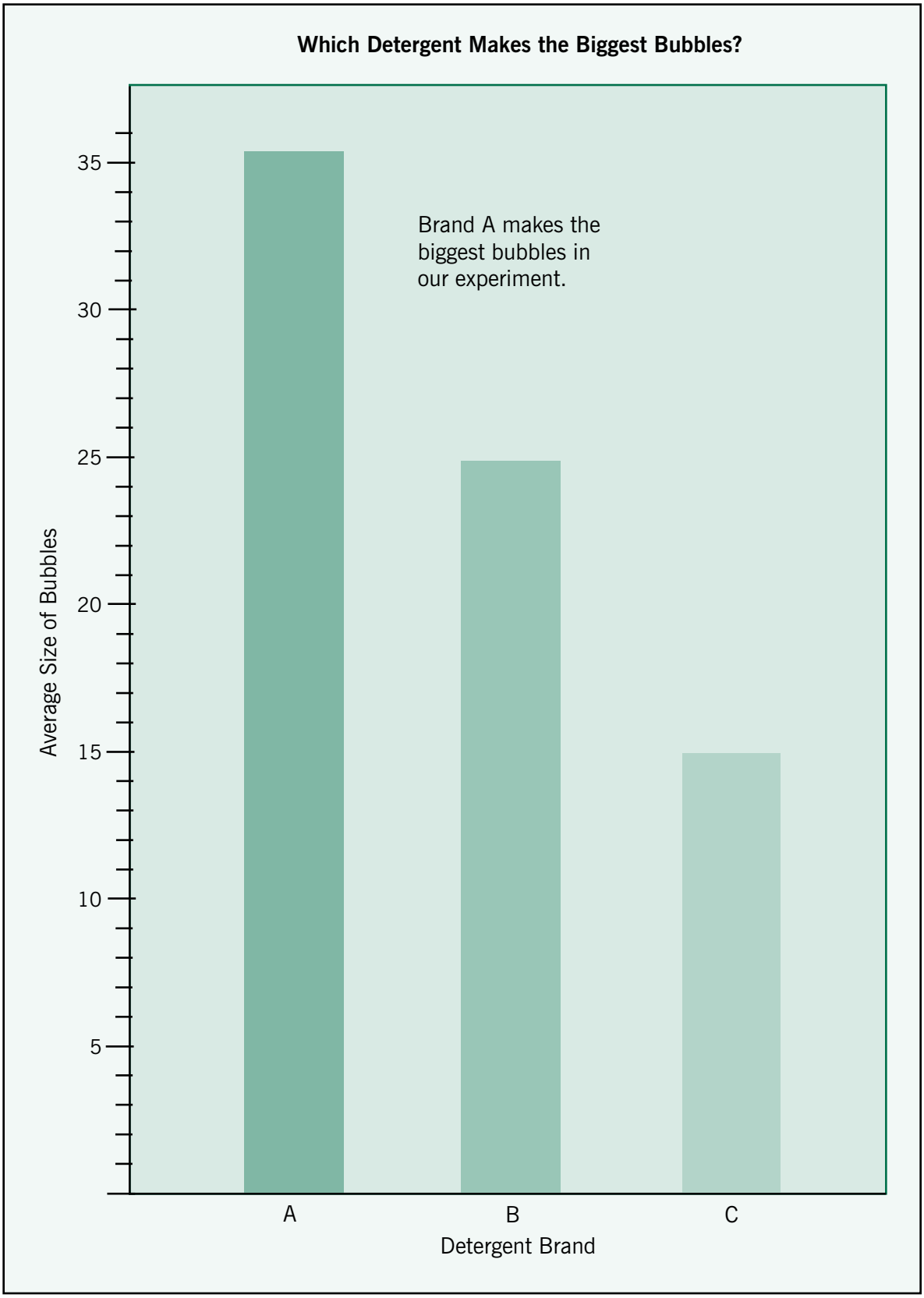
$$\frac{\text{Range}}{\text{\# of lines}} \qquad \frac{25.8 \text{ cm}}{36 \text{ lines}} = .72 \text{ cm/line } \textit{(round to 1 cm/line)}$$

Number of bars on graph: (*x* axis)
3 brands: evenly spaced

### Step 4: Number and label the *y* axis, label the *x* axis, and title the graph

### Step 5: Determine the data points and create the bar graph

*(A: 35.8 cm, B: 24.8 cm, C: 15.0 cm)*


Which Detergent Makes the Biggest Bubbles?
Brand A makes the biggest bubbles in our experiment.
Average Size of Bubbles
35
30
25
20
15
10
5
A
B
C
Detergent Brand

## Handout 17: Checklist for a Bar Graph

| Criteria | Self | | Tutor | |
|---|---|---|---|---|
| | Yes | No | Yes | No |
| Is there a title? | | | | |
| Are axes drawn so that the allotted space is well used? | | | | |
| Are the independent variable(s) spaced evenly on the horizontal axis? | | | | |
| Is the dependent variable axis subdivided with equal intervals? | | | | |
| Are the axes named with the correct variables? | | | | |
| Are units in parentheses ( ) after the variable, if applicable? | | | | |
| Is the type of graph appropriate for the data? | | | | |
| Are data plotted correctly? | | | | |
| Are colors, textures, or other features used to make the graph easier to read? | | | | |
| Is a key used if applicable? | | | | |

# Reflection

## Preparation

- How well did the lesson planning help you prepare for this activity?
- What can you do to feel more prepared?

## Academic Enrichment

- How did this lesson support other academic content areas like math or literacy?
- What changes could you make to strengthen academic enrichment while still keeping the activity fun?

## Classroom Management

- What strategies did you use to make the lesson go smoothly?
- What changes would you make if you taught the lesson again?

## Expansion

- How can this activity be improved to include concepts from other content areas?
- What resources or connections can be made to the larger community to provide support for this activity?

# Lesson 4

## Learning to Make Line Graphs

*Note:* This is the last lesson in a series. Complete the first lesson, "Interpreting Data From Birdfeeders," the second lesson, "Learning to Make Data Tables," and the third lesson, "Learning to Make Bar Graphs," before starting this one. You may also want to review "Learning to Make Bar Graphs" if you think it would help students understand line graphs.

This lesson is one example of how you can implement the practice of *Tutoring to Enhance Science Skills*. In this activity, students take the results, or data, from different experiments and learn to make line graphs.

**Grade Level(s):**

5–10

**Duration:**

Two 45-minute sessions

**Student Goals:**

- Analyze data from a data table
- Construct a line graph to represent data
- Understand line graphs and interpret data using line graphs

## Imagine This!

The afterschool student and tutor admire the student's poster. At the top of the poster, a data table shows automobile land speed records. Below the data table, a colorful bar graph and line graph illustrate data from the table. "I was always so embarrassed when I was the only one in a group who could not make a bar graph or line graph," the student says. "Now, look what I can do. This tutoring has really helped. Thanks!" The tutor and student have finished their last session in basic science skills—learning to make line graphs. Now the student is ready to apply her skills and achieve academic success.

## What You Need

- ❒ Notebook paper
- ❒ Pencil
- ❒ Clear ruler
- ❒ Graphing paper (1 x 1 cm preferred)
- ❒ Handout 18: Sample Data for a Line Graph
- ❒ Handout 19: Guidelines for Making a Line Graph
- ❒ Handout 20: Checklist for a Line Graph

## Getting Ready

- Connect with the day-school teacher to review students' needs.
- Review the lesson, handouts, and Tips for Tutoring Students in Science.
- Copy all of the handouts for this lesson. If you are working with more than one student, make copies as needed.

## Safety Considerations

There are no safety precautions for this lesson. However, if simple experiments are conducted in expanding this lesson, follow appropriate safety precautions such as using goggles or safety spectacles.

## What to Do

- **Engage** students by asking them what they already know about bar graphs, or asking them to show you a sample of any bar graphs they have made. Select one data set and ask students how they might represent the results in a line graph. Note what students understand and where they need to modify their thinking.
- **Explore** bar graphs.
  - Review Handout 19: Guidelines for Making Line Graphs. Ask students to create a line graph from sample data you provide.
  - As students work, review any vocabulary associated with data representations. Watch for typical errors and help students learn to identify them, check their work, and correct errors independently.
- **Explain** the results. Ask students to explain how they organized the data in their line graphs. Review students' line graphs using the line graph checklist (Handout 20). If you think that sufficient progress has been made, ask students to continue using other sample data sets to create additional line graphs.
- **Extend** learning as time allows. Ask students for ideas or use day-school science lessons or the Internet to collect additional data for more line graphs.
- **Evaluate.** Look for the following outcomes:
  - Student participation and engagement
  - Answers that reflect an understanding of how data can be organized in a line graph (use the line graph checklist)
  - Understanding of *x* axis, *y* axis, and variables
  - Understanding of how to interpret data from a line graph

## Handout 18: Sample Data for a Line Graph

### Sample Data for a Line Graph

Use these data to create data tables and line graphs following Handout 19: Guidelines for Making a Line Graph and Handout 20: Checklist for a Line Graph. If you have already created data tables, use your completed data tables to make line graphs.

### Example 1: Automobile Land Speed Records (grades 5–10)

In the first recorded automobile race in 1898, Count Gaston de Chasseloup-Laubat of Paris, France, drove 1 kilometer in 57 seconds for an average speed of 39.2 miles per hour (mph) or 63.1 kilometers per hour (kph). In 1904, Henry Ford drove his Ford Arrow across frozen Lake St. Clair, MI, at an average speed of 91.4 mph. Now, the North American Eagle is trying to break a land speed record of 800 mph. The Federation International de L'Automobile (FIA), the world's governing body for motor sport and land speed records, recorded the following land speed records. (Retrieved on August 29, 2008, from www.landspeed.com/classroom/classlsrbasics.html)

| Speed (mph) | Driver | Car | Engine | Date |
|---|---|---|---|---|
| 407.447 | Craig Breedlove | Spirit of America | GE J47 | 8/5/63 |
| 413.199 | Tom Green | Wingfoot Express | WE J46 | 10/2/64 |
| 434.22 | Art Arfons | Green Monster | GE J79 | 10/5/64 |
| 468.719 | Craig Breedlove | Spirit of America | GE J79 | 10/13/64 |
| 526.277 | Craig Breedlove | Spirit of America | GE J79 | 10/15/65 |
| 536.712 | Art Arfons | Green Monster | GE J79 | 10/27/65 |
| 555.127 | Craig Breedlove | Spirit of America, Sonic 1 | GE J79 | 11/2/65 |
| 576.553 | Art Arfons | Green Monster | GE J79 | 11/7/65 |
| 600.601 | Craig Breedlove | Spirit of America, Sonic 1 | GE J79 | 11/15/65 |
| 622.407 | Gary Gabelich | Blue Flame | Rocket | 10/23/70 |
| 633.468 | Richard Noble | Thrust 2 | RR RG 146 | 10/4/83 |
| 763.035 | Andy Green | Thrust SSC | RR Spey | 10/15/97 |

**Example 2: Electromagnets: Increasing Coils (grades 3–5)**

The following data were collected using an electromagnet with a 1.5 volt battery, a switch, a piece of #20 insulated wire, and a nail. Three trials were run. Safety precautions in repeating this experiment include using safety goggles or safety spectacles and avoiding short circuits.

| Number of Coils | Number of Paperclips |
|---|---|
| 5 | 3, 5, 4 |
| 10 | 7, 8, 6 |
| 15 | 11, 10, 12 |
| 20 | 15, 13, 14 |

**Example 3: Electromagnets: Increasing Batteries (grades 3–5)**

The following data were collected using an electromagnet created with 1.5 volt batteries in series, a switch, a piece of #20 insulated wire, and a nail. Three trials were run with 10 coils. Safety precautions in repeating this experiment include using safety goggles or safety spectacles and avoiding short circuits.

| Number of Batteries | Number of Paperclips |
|---|---|
| 1 | 5, 4, 5 |
| 2 | 12, 10, 9 |
| 3 | 17, 15, 14 |
| 4 | 19, 23, 20 |

## Handout 18: Sample Data for a Line Graph, continued

### Example 4: Inclined Plane (grades 8–10)

The following data were collected using a photogate to measure the time that it takes for a ball to roll down an inclined plane. The angle of the plane was increased by using blocks (5 cm each) to increase the height of the plane from the floor. Four trials were run at each height. The same ball was released from the same starting point and was allowed to roll exactly 100 cm down the ramp. Create a data table, plot the data using a line graph, and draw the best-fit line or curve.

| Height of Inclined Plane | Time |
|---|---|
| 5 | 2.02, 2.10, 2.05, 2.00 |
| 10 | 1.85, 1.82, 1.67, 1.82 |
| 20 | 1.22, 1.29, 1.18, 1.25 |
| 30 | 1.00, 1.05, 1.07, 1.03 |

### Example 5: Distance and Time (grades 8–10)

The following data were collected using a car with a water clock set to release a drop in a unit of time and a meter stick. The car rolled down an inclined plane. Three trials were run. Create a data table with an average distance column and an average velocity column, create an average distance-time graph, and draw the best-fit line or curve. Estimate the car's distance traveled and velocity at six drops of water. Describe the motion of the car. Is it going at a constant speed, accelerating, or decelerating? How do you know?

| Time (drops of water) | Distance (cm) |
|---|---|
| 1 | 10,11,9 |
| 2 | 29, 31, 30 |
| 3 | 59, 58, 61 |
| 4 | 102, 100, 98 |
| 5 | 122, 125, 127 |

## Handout 19: Guidelines for Making a Line Graph

The effect on increasing coils on the number of paperclips an electromagnet picks up.

| Number of Coils | Number of Paperclips | | | Average Number of Paperclips |
|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | |
| 5 | 3 | 5 | 4 | 4 |
| 10 | 7 | 8 | 6 | 7 |
| 15 | 11 | 10 | 12 | 11 |
| 20 | 15 | 13 | 14 | 14 |

**Step 1: Identify the variables**

Independent Variable (purposefully changed by the experimenter): *Number of coils*
Dependent Variable (changes with the independent variable and is measured): *Number of paperclips*

**Step 2: Determine the variable range**

Subtract the lowest data value from the highest data value for each variable.
Range of paperclips: *14-4 = 10*
Range of coils: *20-5 = 15*

**Step 3: Determine the scale of the graph**

Determine the numerical value for each grid unit that best fits the range of each variable.
Number of lines on graph: 36 (*y* axis)

$$\frac{\text{Range}}{\text{\# of lines}} \quad \frac{\text{10 paperclips}}{\text{36 lines}} = .28 \text{ paperclips/line } \textit{(round to .5 paperclips/line)}$$

Number of lines on graph: 25 (*x* axis)

$$\frac{\text{Range}}{\text{\# of lines}} \quad \frac{\text{15 coils}}{\text{25 lines}} = .6 \text{ coils/line } \textit{(round to 1 coil/line)}$$

**Step 4: Number and label each axis and title the graph**

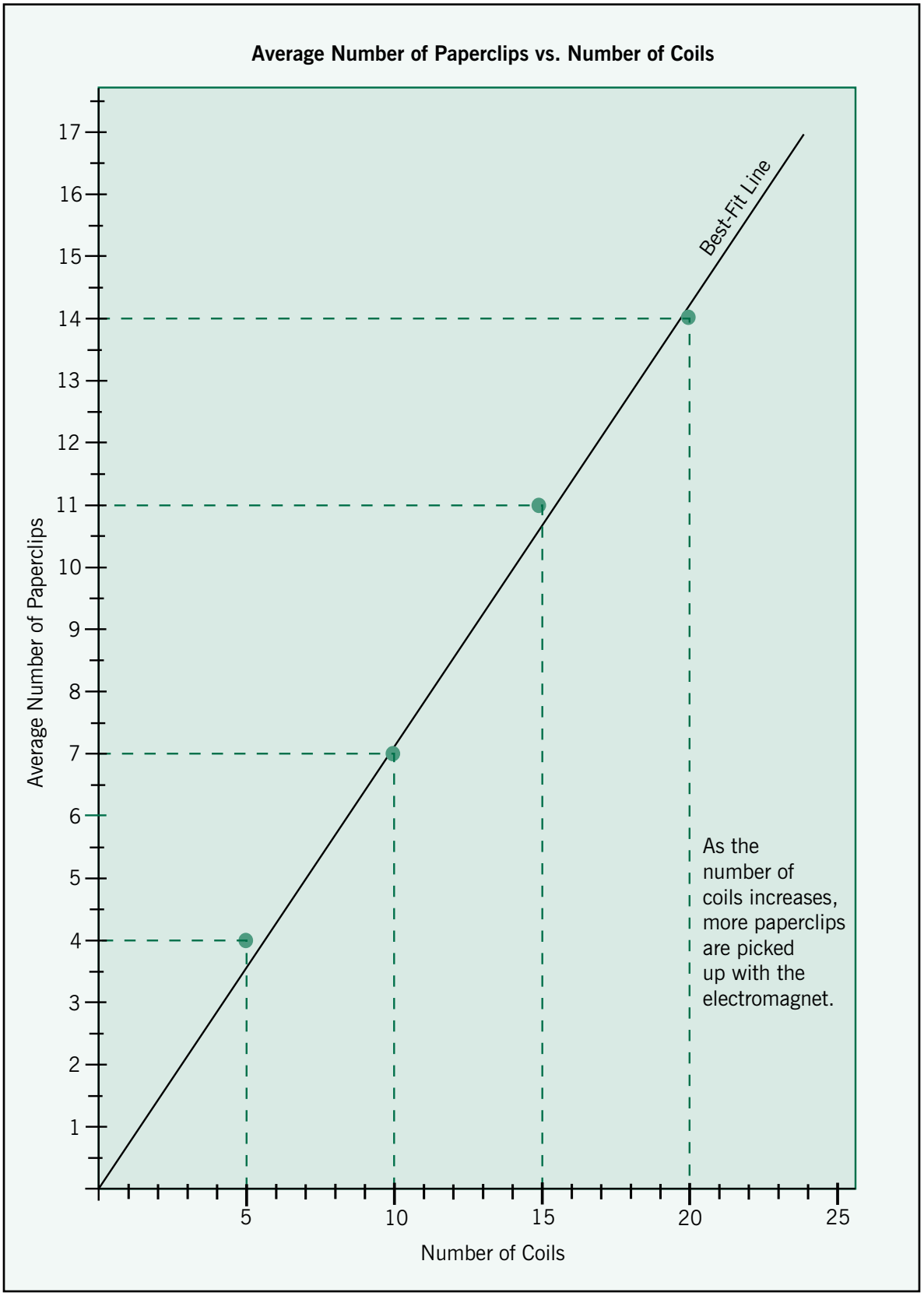
**Step 5: Determine the data points and plot on the graph**

*(5, 4) (10, 7) (15, 11) (20, 14)*

**Step 6: Draw the graph**

Draw a curve or a line that best fits the data points. Do not connect the dots.

**Handout 19: Guidelines for Making a Line Graph, continued**



## Handout 20: Checklist for a Line Graph

| Criteria | Self | | Tutor | |
|---|---|---|---|---|
| | Yes | No | Yes | No |
| Is there a title? Is there a name and a date? Is the source noted? | | | | |
| Are axes drawn so that the allotted space is well used? | | | | |
| Is the independent variable scale appropriate for the data and the space allotted? | | | | |
| Is the independent variable axis subdivided into equal intervals? | | | | |
| Is the dependent variable scale appropriate for the data and the space allotted? | | | | |
| Is the dependent variable axis subdivided into equal intervals? | | | | |
| Are the axes named with the correct variables? | | | | |
| Are units in parentheses ( ) after the variables? | | | | |
| Are data plotted correctly? | | | | |
| Are data points visible on graph—dark circle or other symbol? | | | | |
| Is the type of graph appropriate for the data? | | | | |
| Is the best-fit line or best-fit curve drawn? | | | | |
| Are data connected with lines to show appropriate trends? | | | | |
| Are colors, textures, or other features used to make the graph easier to read? | | | | |
| Is a key used if applicable? | | | | |

# Reflection

## Preparation

- How well did the lesson planning help you prepare for this activity?
- What can you do to feel more prepared?

## Academic Enrichment

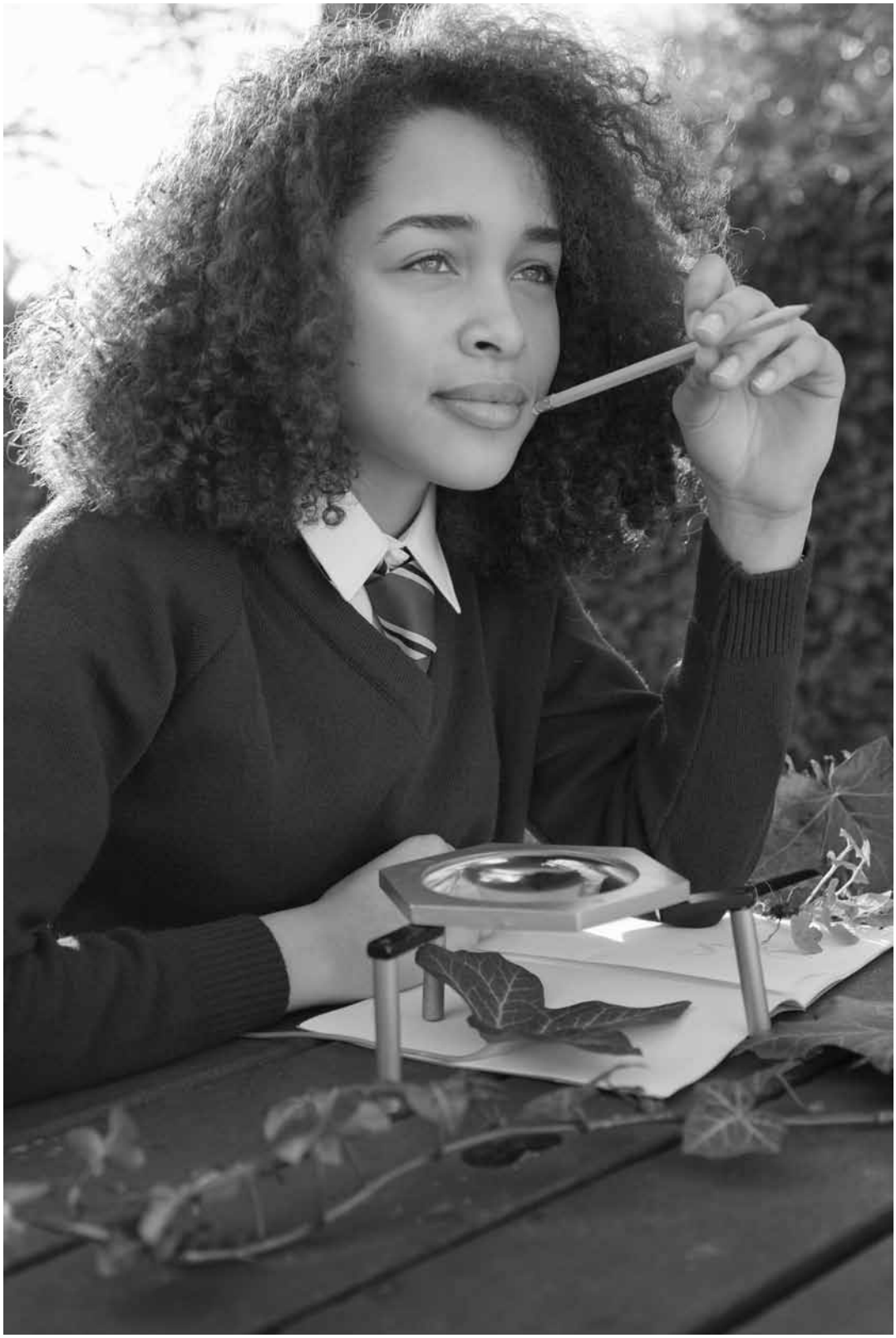
- How did this lesson support other academic content areas like math or literacy?
- What changes could you make to strengthen academic enrichment while still keeping the activity fun?

## Classroom Management

- What strategies did you use to make the lesson go smoothly?
- What changes would you make if you taught the lesson again?

## Expansion

- How can this activity be improved to include concepts from other content areas?
- What resources or connections can be made to the larger community to provide support for this activity?



## Principles of Quality Afterschool Science Programs

The most effective afterschool science programs incorporate the following eight principles:

- They are for all students.
- They are intentional and standards-based.
- They are active, interesting, and relevant to students.
- They reflect current research and practices.
- They are age-level appropriate.
- They integrate skills from different subjects.
- They incorporate staff training in science teaching.
- They are based on ongoing assessment of student needs and progress.

### Getting Started: Implementation Considerations

Before you begin any practice, consider your program, the background of your staff, and how you can enhance the science content knowledge and teaching strategies of your staff.

### Considerations for Programming

The best afterschool science programs provide instructors with professional-development learning experiences to better understand and teach science through inquiry. Professional development is available through regional and national afterschool training events. Consider online courses or inviting master teachers from a local high school, university, or community college to mentor afterschool instructors as they implement science programs.

Science kits contain materials easily found in most local stores. Note that many need to be resupplied after each use. Allocate time and money for maintaining supplies and equipment. Consider asking one teacher to be in charge of restocking.

### Considerations for Curriculum

Always begin by connecting with the day-school teacher to learn more about specific grade-level skills and standards in science. Every state has science standards that day-school teachers and afterschool staff should be familiar with.

For more information on each state's science standards, see the state standards at www.sedl .org/afterschool/toolkits/science/tk_state_standards.html. Day-school teachers can also help in selecting age-appropriate materials and books.

## Considerations for the Afterschool Environment

Research shows that children excel when they are in a safe and respectful environment that honors the culture, race, and ability of all students. Visual displays, texts, and other materials should represent the children in the class and portray men and women from a variety of cultures in science careers.

Safety is always a consideration for any science program, and afterschool science is no exception. Students should always have adequate adult supervision—a good rule of thumb is one adult for every 5–10 children. When working on projects outside of the school, pair up students and always have them within your sight. Remind students to wash their hands before their fingers end up in their mouths or eyes and to always use eye protection. Safety goggles or spectacles are available from any science materials vendor. Most importantly, anticipate the worst that could happen and plan for it. Have a first-aid kit available and follow center guidelines for emergencies. For more information on safety, look for safety reference books from the National Science Teachers Association at www.nsta.org/store/.

## Storage and Materials Management

Consider your storage needs. Large, clear, plastic storage boxes with contents clearly labeled and an up-to-date inventory can help organize equipment for all afterschool staff to use. Carts are also useful in transporting science materials. Trays and baskets are useful in organizing all materials needed by a set of students. Instructors can make students responsible for collecting and returning supplies. One way to organize students is to assign them to cooperative groups and assign rotating roles such as materials gatherer, chief investigator, recorder, and timekeeper and safety inspector. All students should have the opportunity to experience each of these roles over time. The roles are described below.

- Materials Gatherer: Responsible for obtaining and returning materials to a central location.
- Chief Investigator: Responsible for leading and conducting the investigation, manipulating the equipment, or assigning others to do so.
- Recorder: Responsible for creating or completing data charts and sharing the information with everyone in the group.
- Timekeeper and Safety Inspector: Responsible for keeping track of the time and making sure everyone is using time wisely so that investigations can be completed in the time allowed. This person may also be responsible for helping to ensure that the group wears goggles and adheres to the safety instructions given by the instructor.

Finally, have fun! The afterschool environment lends itself to discovery through hands-on activities that extend science learning. Make the most of the afterschool hours and the resources available to you.

## The 5Es

The 5E Instructional Model provides a format for lessons that builds on what students already know. The 5Es sequence the learning experience so that the learners construct their understanding of a concept across time. Each phase of the learning sequence can be described using five words that begin with E: *engage*, *explore*, *explain*, *extend*, and *evaluate*.

| Learning Phase | Students' Roles | Teachers' Roles |
|---|---|---|
| **Engage** | Students are introduced to the concept. Students make connections to prior knowledge and what is to be studied. Student thinking is clarified. Students become mentally engaged in the new learning experience. | Teachers ask questions of students and engage them in the guided-inquiry lessons. They use strategies such as KWL charts that make connections between the past and present learning experience. Teachers set a level of anticipation. |
| **Explore** | Students explore or experiment at this point. They engage in observations, use science tools and materials (manipulatives), collect data, and record data. | Teachers set up the investigation and guide students in inquiry by asking probing questions to clarify understanding. |
| **Explain** | Students verbalize their understandings from the "explore" phase, look for patterns in their data, and describe what they observed. This can be done in small or whole groups. | Teachers ask probing questions that encourage students to look for patterns or irregularities in their data. |
| **Extend** | Students expand their learning, practice skills and behavior, and make connections or applications to related concepts and in the world around them. | Teachers provide learning opportunities for students to apply their knowledge and to gain a deeper understanding. Activities can include reading articles and books, writing, designing other experiments, and exploring related topics on the Internet. |
| **Evaluate** | Students answer questions, pose questions, and illustrate their knowledge (understandings) and skill (abilities). | Teachers diagnose student understanding through an ongoing process. Assessment can be both formative (ongoing and dynamic) and summative (end-of-lesson final test or product). |

The 5E Instructional Model was developed by the Biological Sciences Curriculum Study.

# Background Resources for Activities

## Practice 1: Investigating Science Through Inquiry

### Books

Allen, P. (1985). *Who sank the boat?* New York: Putnam.

Barber, J. (2001). *Bubble-ology teacher's guide*. Great Explorations in Math and Science (GEMS). Berkeley, CA: University of California, Berkeley, Lawrence Hall of Science.

Barber, J., & Willard, C. (1992). *Bubble festival teacher's guide*. Great Explorations in Math and Science (GEMS). Berkeley, CA: University of California, Berkeley, Lawrence Hall of Science.

Cothron, J. H., Giese, R. N., & Rezba, R. J. (2000). *Students and research* (3rd ed.). Dubuque, IA: Kendall/Hunt Publishing Co.

Trumbauer, L. (1997). *Sink or float?* New York: Newbridge Communications, Inc.

### Web Sites

The Art and Science of Bubbles
www.sdahq.org/new1198/kids/

CyberBee
www.cyberbee.com/

Exploratorium Bubbles
www.exploratorium.edu/ronh/
www.exploratorium.edu/snacks/

Online Bubble-ology Video for Teachers (Lawrence Hall of Science)
www.lawrencehallofscience.org/

Sink or Float Online Animation Game (Kerb Company)
www.kerb.co.uk/Showcase/elearning

## Practice 2: Exploring Science Through Projects and Problems

### Books

Galdone, P. (1981). *The three billy goats Gruff*. New York: Claron Books.

### Web Sites

Case Studies in Science (The National Center for Case Study Teaching in Science, State University of New York in Buffalo)
http://ublib.buffalo.edu/libraries/projects/cases/ubcase.htm

Citizen Science Programs (Cornell University School of Ornithology)
www.birds.cornell.edu/

Frogwatch USA
www.nwf.org/frogwatchUSA/

Global Learning and Observation to Benefit the Environment (GLOBE)
www.globe.gov/

The Jason Project
www.jason.org

## Practice 3: Integrating Science Across the Curriculum

### Books

Barton, M. L., & Jordan, D. (2001). *Teaching reading in science*. Denver, CO: McREL.

Bentley, D. (1999). *The icky sticky frog*. Santa Monica, CA: Piggy Toes Press.

Berger, M. (1995). *The restless Earth*. Delran, NJ: Newbridge Educational Publishing.

Cole, J., & Degen, B. (1987). *The magic school bus inside the Earth*. New York: Scholastic Press.

Honig, B., Diamond, L., & Gutlohn, G. (2000). *CORE's teaching reading sourcebook*. Novato, CA: Arena Press.

### Web Sites

Carolina Biological
www2.carolina.com

FEMA for Kids
www.fema.gov/kids

Natural Sounds
www.naturesound.com

Plate Tectonics—The Cause of Earthquakes
www.seismo.unr.edu/ftp/pub/louie/class/100/plate=tectonics.html

Ring of Fire Map
http://vulcan.wr.usgs.gov/Glossary/

Savage Earth
www.thirteen.org/savageearth/animations/

Windows to the Universe (University of Michigan)
www.windows.ucar.edu

World and Other Maps
www.eduplace.com/ss/ssmaps/

## Practice 4: Engaging Families and Communities

### Books

Barber, J. (2001). *Bubble-ology teacher's guide*. Great Explorations in Math and Science (GEMS). Berkeley, CA: University of California, Berkeley, Lawrence Hall of Science.

Barber, J., & C. Willard. (1992). *Bubble festival teacher's guide*. Great Explorations in Math and Science (GEMS). Berkeley, CA: University of California, Berkeley, Lawrence Hall of Science.

Cothron, J. H., Giese, R. N., & Rezba, R. J. (2000). *Students and research* (3rd ed.). Dubuque, IA: Kendall/Hunt Publishing Co.

Hopkins, L. B. (1994). *April, bubbles, chocolate: An ABC of poetry*. New York: Simon and Schuster.

Zubrowski, B. (1979). *Bubbles: A children's museum activity book*. Boston: Little, Brown.

### Web Sites

The Art and Science of Bubbles
www.sdahq.org/new1198/kids/

Bay Area Creek Restoration Project
www.ecologycenter.org/

San Francisco Bay Area Creek Restoration
www.bapd.org

Santa Clara Valley Water District: Adopt-A-Creek
www.valleywater.org/Water/

Seattle Creek Restoration
www.ci.seattle.wa.us/util/About_SPU/

## Practice 5: Tutoring to Enhance Science Skills

### Web Sites

Audubon Society, Birds of North America
www.nature.net/birds/

The Birds of North America (Cornell Lab of Ornithology and the American Ornithologists' Union)
http://bna.birds.cornell.edu/BNA/
www.birds.cornell.edu/LabPrograms

Create a Graph (National Center for Educational Statistics)
http://nces.ed.gov/nceskids/graphing/

Getting the Picture: Communicating Data Visually (Annenberg/CPB Learner.org)
www.learner.org/interactives/dailymath/getpicture.html

Graphing Resources (North Carolina State University, LabWrite Resources)
www.ncsu.edu/labwrite/res/gh/gh-linegraph.html

Graphing with Excel for High School Students (North Carolina State University, LabWrite Resources)
www.ncsu.edu/labwrite/res/gt/gt-menu.html

Science NetLinks: What Is a Graph? (American Association for the Advancement of Science)
www.sciencenetlinks.com/Lessons.cfm?DocID=37

Teaching Kids About Birds
www.wildbirds.com/IdentifyBirds/KidsBirds/tabid/675/Default.aspx

## Acknowledgments

This resource was developed with the support of the U.S. Department of Education as part of the National Partnership for Quality Afterschool Learning project. It was designed to support 21st Century Community Learning Center instructors who wish to create quality learner-centered environments for their afterschool programs.

The content of the Afterschool Training Toolkit is based on more than 4 years of research and observations at 53 afterschool programs with evaluation data suggesting an impact on student learning. The content also draws from a review of relevant research studies and the experience and wisdom that each of the developers brought to the project. The collective experience of the developers includes afterschool programming, professional development, educational research, program development, program management, and direct instructional experience with students.

The developers believe that these practices and materials will help afterschool leaders and educators create high-quality programs that will motivate, engage, and inspire students' learning and participation.

We extend our appreciation to our site schools and thank the parents of the children in these classrooms for allowing us to showcase their children at work in the toolkit videos.

U.S. DEPARTMENT OF EDUCATION

Technical Assistance and Professional Development for
21st Century Community Learning Centers


**This guide to the Afterschool Training Toolkit was created with the support of the U.S. Department of Education for the use of 21st Century Community Learning Centers. Used with the online Afterschool Training Toolkit, this guide will give you the resources you need to build fun, innovative, and academically enriching activities that not only engage students but also extend their knowledge in new ways and increase academic achievement.**

SERVE Center
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