Ideas and techniques to enhance your science teaching

I remember how exciting it was when the teacher had “stuff” on the front desk: unfamiliar objects and other things out of place in the traditional classroom. Years later, as a new teacher, I learned the importance of building lessons around concepts and that demonstrations are an integral part of concept development in science.

With the current focus on constructivist perspectives, however, science demonstrations have fallen out of favor in some circles. That’s a shame. Demonstrations are easy to do and offer many benefits and unique opportunities in the constructivist classroom. With careful use, demonstrations can be powerful teaching tools.

Figure 1, page 54, describes some effective demonstrations to explore the properties of air with students. They’re Creative
Many demonstrations are created by good teachers rather than purchased from supply houses, and most can be presented with everyday materials. Want students to see the difference between speed and acceleration? Compare the motion of a ball rolling down an inclined ramp (acceleration) with that of a windup toy car (speed or velocity). By measuring distances and the time it takes each of these objects to move through those distances, children can record data and chart the motion of each object. At younger ages, the children might just see that one moves “faster and faster” while the other moves at a steady pace.

Don’t have the funds for 25 kits? Reconfigure an activity for students as a teacher demonstration. For example, a text might call for inquiries using pulleys. Younger students rarely get the relationship between force and distance. Yet a creative teacher can suspend a relatively heavy weight with a “hardware store pulley” and establish the concepts related to force, distance, and work. Children usually find it very difficult to grasp the effect of simple machines in making work easier from typical “mathematical relationships.”

But when the teacher makes it “life size” and uses real objects like a bag of sand, a rope, and that “hardware store pulley,” the teacher has an opportunity to amaze children with the amount of work done with reduced force and increased distance.

The Teacher’s Role
Demonstrations are certainly more teacher-centered than hands-on inquiry. Yet this is a plus, not a drawback—careful lesson planning and questioning techniques give the teacher more control in establishing the problem/concept and in directing and modeling scientific thought. These goals are accomplished in several ways:

• State the concepts in your lesson plan, but do not offer them to students before the demonstration;
• Question students throughout the demonstration (Why do you think...?);
• Elicit predictions and hypotheses and encourage conclusion development. (What do you think will happen if...?);
• Include students in carrying out the demonstration, being part of the procedure, and assisting with material setup; and
• Encourage active observation that includes diagramming, illustration, etc. Students may keep a journal or notebook and should enter “Problem, Materials, Diagrams, Predictions” (before the presentation is carried out), and “Observations, Results, and Conclusions” (after understanding the principle or concept).

Sometimes it’s best for teachers to do demonstrations because of safety issues. For example, handling of live animals may raise safety concerns for children (or the animal). The teacher may choose to show an animal, rather than have children hold or touch it, affording the opportunity to focus on key characteristics.

In other demonstrations, heat, the use of glassware, and complexity of procedure call for teacher performance rather than individualized “hands-on” inquiry. A demonstration is a way to provide the experience while maintaining control of safety and content.

**Aha! Moments**

A wonderful quality of a demonstration (or a series of demonstrations) is that it can be used to clearly present a concept, the fundamental cornerstone of a lesson. When carefully selected, developed, and presented, a demonstration can make many concepts meaningful and authentic.

Abstractions that are often meaningless to students can become concrete ideas after students experience demonstrations. For example, consider the concept that “Air exerts pressure.” You may talk about it; show a film about it; have students read about it, measure it with a barometer, and some learning will certainly result. But, add a demonstration set and ... aha! The abstraction becomes concrete.

In the case of air pressure, to help students to move beyond the notion of “suction” and begin to understand the concept of pressure, I conduct the following demonstration:

• Fill a clear plastic “shoebox” two-thirds full of cold water.
• Then, fill an empty soft drink can with enough water to cover the bottom of the can (about 1 to 2 cm) and heat the can on a hot plate until water vapor can be seen coming from the can.
• Next, using tongs, remove the can from the hot plate, invert the can (the water can pour out into the cold water), and immerse the can’s top in cold water. **THE CAN IMPLODES.**

You won’t have to come up with lead questions. The kids shout their surprise! “Why did that happen?” (Have a few backup cans. This one doesn’t always go as planned.) After, we are able to suggest reasons for this surprising
Properties of Air/Gases

The fact that air is matter is a difficult concept for children to grasp. Because air isn’t visible, we must look for other evidence. The following demonstrations can help children to begin to understand some important properties of air. While the children could do these, they require some care to do them properly; otherwise the results can be misleading.

• The first challenge is to plant the idea that air is “something.” A very simple way to demonstrate this is to show your class an “empty” clear plastic bag. Ask what is in it. Students will probably answer “nothing.” Wave the open end of the bag in the air then close the open end of the bag (the bag should be somewhat expanded). Ask again what is in the bag. Students may respond that air is in the bag. Ask how they know because you don’t see anything. Ask students to provide evidence. Students will say that the bag is bigger or that it is “full.” Students should clarify that they know there is something in the bag because it expands and it resists when pushed. This is an excellent opportunity to work on the process skill of inference because we know something is in the bag but our evidence is indirect.

• In order to expand student understanding that air takes up space, fill a large, transparent container (e.g., an aquarium) with water. Stuff a tissue or piece of paper towel at the bottom of a transparent cup. Ask the students what will happen if you put the cup in the water. Why do they think that? Turn the cup over (being careful not to dislodge the paper) and carefully immerse it in the water. The air should remain in the cup, keeping the paper towel from getting wet. Have the kids notice that water does not enter the cup. Ask what keeps the water out. Lead them to the idea that air takes up space, and water cannot enter the space if air remains in the cup. Remove the cup carefully. Have the students inspect the paper, which should have remained dry. Was their prediction correct?

• After the children understand that air is matter, they can move to understanding other properties of air. One is that air has weight and exerts pressure. This concept can be demonstrated by filling a jar with water and placing a three-by-five card or piece of overhead transparency over the mouth of the jar. The jar may now be inverted, to the amazement of students (and sometimes teachers alike, though I do recommend doing this over a sink.) It is air pressure that “seals” the container. Reinforce the concept development by pressing a plumber’s plunger onto a smooth surface of a desk, or better yet, pressing two plungers together (applying a thin layer of water, oil, or petroleum jelly to the edges of the plungers will help form a good seal). Once the air is squeezed out, the plungers cannot be easily pulled apart. After the students have developed explanations, a diagram with arrows showing air pressing on the outside will help children to understand. You will need to “break the seal” allowing air to enter in order to separate the plungers. (Safety note: Do not let children pull with their full force, as they can lose their grip and fall backward.)
event. (When the air is heated, it expands. As it cools, it contracts. The pressure inside is less than that outside. The pressure of the air outside crushes the can.)

Young children have a difficult time understanding the notion of air pressure. Diagrams with arrows representing pressure help students to visualize in a concrete way that which they may be unable to observe directly. Keep in mind that your students will revisit these scientific principles at higher grades, if the interest is generated early.

Connecting to the Standards
This article addresses the following National Science Education Standards (NRC 1996):

Teaching Standards
Standard A:
Teachers of science plan an inquiry-based science program for their students.
Standard B:
Teachers of science guide and facilitate learning.

Content Standards
Grades K–4
Standard A: Science as Inquiry
• Abilities necessary to do scientific inquiry
• Understandings about scientific inquiry

Selecting Demonstrations
All teachers want children to be interested. For young students, things that challenge existing patterns of thinking generate interest. The discrepancy between what the mind expects and what is observed—events that bring about the “huh?” response—accomplish the goal. However, demonstrations are neither magic tricks nor party tricks. Though they sometimes bear surprising results, mostly their purpose is to make concepts concrete.

To this end, teachers should choose demonstrations for their relation and applicability to scientific principles they are trying to teach. Ask yourself, Is there a connection between what the children observe and the principle? Can a diagram be prepared to help explain the demonstration? Diagrams often help to make concepts concrete. If the demonstration’s explanation can be augmented with a clear diagram, it is likely the demonstration is appropriate for students.

Demonstration Assessment
Skill in demonstration lies partly in understanding the nature of inquiry and embedding the demonstration and its assessment in the inquiry process, via questioning throughout the learning experience. We must remember that kids can easily form misconceptions as well as understandings. As science teachers, it’s important to avoid presenting the concept before the demonstration, though we may certainly ask some leading questions, such as Have you ever felt.....? How do you think that.....? Has anyone ever seen.....?

During or immediately following the demonstrations, we ask the children to state, describe, or explain what they have observed. What happened when.....?, What formed in the .....?, Did any one notice that...?, are questions that can elicit responses that reveal students’ understandings.

Why, what, or how, is the next line of questioning. At this point, students are ready for a statement of the concept or scientific principle explored. What do you think caused the....? How can we explain ....? What might happen if we ....? Why did the ....?

Whether teaching about the properties of air or other topics we cover in science, we can make learning about it attention grabbing, intellectually challenging, concrete, and concept-based with the art of demonstration.

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Resources