PreK-5

The FRUGAL Science Teacher

STRATEGIES AND ACTIVITIES

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Preface

by Linda Froschauer

frugal *(froo'gal) adj. Practicing or marked by economy, as in the expenditure of money or the use of material resources. See synonym at* sparing. *2. Costing little; inexpensive.*

—The American Heritage Dictionary

Frugality practically defines how we as teachers approach provisioning our classrooms. (I half expected to see a picture of a science teacher next to the entry!) We cleverly create learning opportunities with limited resources and have amazing aptitudes for stretching shrinking funds and doing more with limited resources. Still, we find ourselves augmenting school and district funds with our own dollars, digging into our own pockets to purchase equipment and other essentials. A quick web search suggests that K–12 teachers spend between $475 and $1,500—per year—on classroom materials. And we do this willingly because we know it makes a difference in our students' learning.

In an issue of *Science Scope* devoted to limited classroom resources, editor Inez Liftig expressed concern about giving tacit approval to the expectations that teachers should spend their own money to outfit their classrooms: "I wanted to be very sure that we did not send the wrong message about whether or not science teachers should spend their own money to support instruction. . . . Parents and school districts should not expect teachers to pay for equipment and supplies from personal funds, and we should not have to choose between doing them at all" (Liftig 2007, p. 6). I share her concern, but my intent here is not to lecture or opine. Rather, I hope this volume provides a valuable reference at a time when we all need to be resourceful.

To collect all of the articles, books, websites, and organizations that can help you save money is an impossible feat. Not only is there a tremendous quantity of available resources, but the information also changes rapidly and is best pursued through internet searches. Therefore, you will not see lists of websites, grants, and "free" opportunities in this book. Rather, you will find a collection of inspiring articles and book chapters that will provide you and your students with valuable, standards-based learning opportunities that can also serve as springboards to additional investigations. The authors detail untapped resources for materials, reimagined uses for items you already have at home or school, inexpensive workarounds to costly classroom projects, and creative activities that require only free or inexpensive materials.

In addition, many articles and chapters include suggestions for further reading that may expand on the ideas discussed, apply a similar learning tool in a different way, or revise a particular activity for use with different grade ranges. These additional resources are available through the NSTA Science Store (*www.nsta.org/store*), for free or little cost.

A WORD ABOUT ORGANIZATION

This book comprises five categories, or overarching strategies, for thinking about how to conduct science investigations without spending a great deal of money—either your own funds or those acquired through your district budget.

Student-Created Constructions

When students build their own equipment or create their own models, they have a greater connection to the overall experience, thus enhancing learning. An amazing number of investigations can be developed with a single piece of paper, throwaway items, or dollar-store finds. You already may be familiar with more traditional student constructions, such as paper airplanes, and the lessons they convey. Think how much more students could learn from building roller coasters or paper towers.

Teacher-Created Constructions and Repurposed Materials

Science teachers are great savers of materials. We check out sale bins in stores and rinse out used containers. We collect soda bottles, aluminum cans, shoe boxes, scraps of wood, odd lots of rubber bands, old CDs . . . anything that may possibly be useful in our classrooms. This section suggests ways to put those materials to good use in two general categories: repurposing materials that we have collected and building equipment for student use from free or inexpensive components.

Teaching Strategies That Maximize the Science Budget

There are many ways to reorganize our instructional approaches that enable quality learning to occur at reduced cost. The articles in this section provide suggestions on how to engage students through a variety of strategies. Although the strategies are explained within the context of a specific content area, they can serve as creative inspiration as you consider how to adjust lessons in *any* content area. Creating project materials, playing games, drawing cartoons, developing class newsletters, using learning stations, and tapping into current events all require minimal financial investments but provide enriched experiences for students. Many of these ideas also integrate other subject areas to provide broader curriculum impact.

Instructional Lessons That Maximize the Science Budget

The fourth section offers a collection of life science, Earth science, and physical science and chemistry investigations. They are specific to a given content area but utilize materials that may stimulate ideas for innovative activities with any subject matter. You can use them as they are or modify them to fit your curriculum. Several articles highlight the use of outdoor spaces around your school site that are ideal for scientific investigations.

Funds and Materials

Even after implementing the ideas in this book, you may still have classroom needs that prove too costly to be fulfilled through your budget (or pocket). This section presents suggestions for how to acquire those additional funds.

ADDITIONAL RESOURCES FROM NSTA

In this volume, I have culled some of the most useful NSTA print resources for maximizing your classroom dollars. However, NSTA also provides a variety of free electronic resources that are available for members and nonmembers alike to improve both teaching and learning.

e-Publications

Individual articles from *Science and Children*, *Science Scope*, and *The Science Teacher*, as well as chapters from NSTA Press books, are available in electronic format from NSTA's online Science Store (*www.nsta.org/store*). Many of these—at least two articles per journal issue and one chapter per book—are free to everyone. (The balance of articles is free to NSTA members and available for a small fee to nonmembers.)

Teachers and administrators can also keep up with what's happening in the world of science education by signing up for free weekly and monthly e-mail newsletters (*http://www.nsta.org/publications/enewsletters.aspx*). *NSTA Express* delivers the latest news and information about science education, including legislative updates, weekly. Every month *Science Class* offers teachers theme-based content in the grade band of their choosing—elementary, middle level, or high school. News articles, journal articles from the NSTA archives, and appropriate book content support each theme. *Scientific Principals*, also monthly, provides a science toolbox full of new ideas and practical applications for elementary school principals.

Learning Center

Anyone—teachers, student teachers, principals, or parents—can open a free account at the NSTA Learning Center, a repository of electronic materials to help enhance both content and pedagogical knowledge. By

creating a personal library, users can easily access, sort, and even share a variety of resources:

Science Objects are two-hour online, interactive, inquiry-based content modules that help teachers better understand the science content they teach. New objects are continually added, but the wide-ranging list of topics includes forces and motion, the universe, the solar system, energy, coral ecosystems, plate tectonics, the rock cycle, the ocean's effect on weather and climate, and science safety.

SciGuides are online resources that help teachers integrate the web into their classroom instruction. Each guide consists of approximately 100 standards-aligned, web-accessible resources, accompanying lesson plans, teacher vignettes that describe the lessons, and more. Although most SciGuides must be purchased, there is always one available at no charge.

SciPacks combine the content of three to five Science Objects with access to a content expert, a pedagogical component to help teachers understand common student misconceptions, and the chance to pass a final assessment and receive a certificate. Yearlong SciPack subscriptions must also be purchased, but one SciPack is always available for free.

Anyone may participate in a live, 90-minute web seminar for no-cost professional development experiences. Participants interact with renowned experts, NSTA Press authors, scientists, engineers, and other education specialists. Seminar archives are also available on the NSTA website and can be accessed at any time.

Particularly popular web seminars are also offered in smaller pieces as podcasts that can be downloaded and listened to on the go. These 2- to 60-minute portable segments include mini-tutorials on specific content and ideas for classroom activities.

Grants and Awards

NSTA cosponsors the prestigious Toyota Tapestry Grants for Teachers (*www.nsta.org/pd/tapestry*), offering funds to K–12 science teachers for innovative projects that enhance science education in the school or school district. Fifty large grants and at least 20 mini-grants—totaling $550,000—are awarded each year. NSTA also supports nearly 20 other teacher award programs, many of which recognize and fund outstanding classroom programs (*www.nsta.org/about/awards.aspx*).

You may not save hundreds of dollars a year by following the recommendations found in this book. You will, however, find creative ways to keep expenses down and stretch your funds while building student understanding. . . . And perhaps you will be inspired to invent your own low-cost constructions, develop even more inexpensive student activities, find additional uses for everyday items, or uncover a wealth of new resources for obtaining classroom materials.

Reference

Liftig, I. 2007. Never cut corners on safety. *Science Scope* 30 (6): 6–7.

Chapter 6

Materials Repurposed

Find a Wealth of Free Resources at Your Local Recycling Center

by Orvil L. White and J. Scott Townsend

Few teachers find themselves with the support to purchase all the materials they ideally need to supply their classrooms. Buying one or two simple, ready-made items can put a serious strain on anyone's budget. However, materials for science in the classroom need not be prefabricated or expensive. By looking at the function and purpose of any piece of equipment, a creative teacher can find a suitable replacement for many premade science materials, sometimes from the most unlikely places. This is not to say we advocate the potentially hazardous practice known in some circles as "Dumpster diving," but with proper caution and common sense—like partnering with your county's local recycling center—you can find some terrific, serviceable materials among what others have deemed "trash."

Our local recycling center offered a community outreach program called "Materials for the Arts," in which public and homeschool teachers in the county had access to a wealth of materials salvaged from or donated to the recycling center. The center dedicated two rooms at the facility to the program, which stored objects such as clean, sanitized containers of all sizes, including plastic and glass bottles, coffee cans, potato chip cans, baby food jars, and cereal boxes and oatmeal containers; as well as cardboard tubes, carpet squares, compact discs, plastic trays, corkboard, bubble wrap, and other things. All of the materials were required to be completely cleaned with, depending on the material, either antibacterial soap or Lysol spray, before being accepted for donation. Use salvaged materials only if they have been thoroughly sanitized.

CAUTION

If there is no such program in your area, you might consider starting one at your school. Local recycling centers are often looking for outreach opportunities. When we conducted a presentation at our state science teachers' conference a few years ago, several outreach personnel from various state recycling centers approached us for ideas about how they could perform the same outreach services to teachers and the community.

Sometimes we visited the recycling center with specific material needs in mind. Other times, though, we simply explored the rooms to see what ideas were sparked by the materials at hand. Of course, not every item at the recycling center can be repurposed into a useful tool for the science classroom, but here we share a few of our favorites.

TIMER

Teachers can make a classroom timer from two plastic drink bottles with caps and an old 35mm film canister with the bottom removed. Glue the bottle tops

together inside the film canister with the tops touching. Trim off the excess canister with kitchen shears, and using an electric drill with a 3/16 bit, drill a small hole through both caps. Place approximately 800 g (for a five-minute timer) of sand, salt, or sugar into one bottle and screw the cap in place. Next, invert the second bottle and screw it into its cap. Test it out and adjust the amount of material as necessary for the time desired. This timer can now be used in a variety of ways, including as a guided-inquiry activity model for students to create other timers of various durations. The timer itself can be used to time speakers, give "time remaining" for a quiz or other assessment, and allow students to better understand the ways in which time has been historically measured.

Using different models of timers, students can investigate questions such as the following: Is there a difference in using sand, sugar, or salt? How does the size (diameter) of the hole in the caps affect the rate at which the materials flow? How does the particle size affect the time it takes for the grains to go through the opening? If using a material other than sand, does the flow rate change over time, and if so, is it faster or slower? Upper elementary or middle school students could also create a graph to show the relationship between mass (in grams) of granular material versus the amount of time it takes for the material to completely travel through the container. This would ultimately allow students to predict how much material they would need to insert for resulting amounts of time in the timer.

SEDIMENT TUBES

Any plastic tube or bottle can be used to show the sedimentation of materials through a water column. We used plastic tubes made from a fluorescent lightbulb cover, a plastic sheath you can buy to cover the bulb, which we cut to size using kitchen shears. The covers are available at most home center outlets. Pour sand or soil into the bottle and fill with water. Know the source of the soil to avoid contaminants. Make sure children wash hands thoroughly after handling soil. Shake and allow the material to settle. The students can observe the soil settling into layers based on the density of the materials contained in the soil.

The sediment tube allows students to model and observe the process of deposition of materials in the natural environment. This process is the prelude to the formation of sedimentary rocks in the Earth's crust. The process of deposition of materials can be used to show how, over geologic time, rocks with differing colors of strata are formed. Students can also use this method to separate different soils into parts according to grain size and, by measuring the thickness of the layers, calculate percentage of each part—thereby adding a link to mathematics standards. Also, sediment contamination of streams and rivers is an issue in environmental science that can be better visualized and understood once the students can see how soil breaks down and is deposited when mixed with moving water.

Figure 1

Air circulation demonstration setup

PHOTOGRAPHS COURTESY OF THE AUTHORS

DEMONSTRATING CIRCULATION

Recycled materials can also be repurposed for a teacher demonstration exploring air circulation behavior. Remove the bottoms of two 2 L plastic bottles and connect them with a plastic tube, actually a fluorescent lightbulb cover that was cut to size with kitchen shears. Place a small candle under one bottle and hold a lighted stick of incense over the other (see Figure 1). Do this as a teacher demonstration only. Use a tea candle and keep matches out of reach of children. The heated air should rise from the top of the bottle and produce a low-pressure area, drawing the air from the higher-pressure area of the other bottle. This will cause the smoke from the incense to flow down, flow across, and rise with the heated air out of the top, demonstrating the process of air flow in weather systems.

The demonstration models the movement of air in the environment. Air that has been warmed rises, and cold or cooler air moves in to take the place of the warm air. When used as part of a unit on weather, this demonstration enables students to see a process that is generally unobservable and helps explain the shifting wind patterns they can feel. It is useful in exploring sea, land, mountain, and valley breezes, as well as the displacement of warm air when a cold front moves across the landscape. Additionally, this is a good model

of how other fluids react when heated. Ocean currents and the movement in a pot of boiling water are other concepts linked to thermal circulation.

GRADUATED CYLINDER AND SCOOPS

You can make a graduated cylinder by measuring a known volume of water into an old plastic bottle, with the label and bottom removed, and marking the measurement with a permanent marker. A clear 1 L water bottle works best for larger volumes, and any smaller straight-sided bottle will work with lesser amounts.

Cutting the bottom of a 1 L bottle will create a scoop that is easy both to use and to pour material from. Scoops can also be made from old salad-dressing bottles cut along the bottom and side. The caps should be glued in place to prevent accidental spills.

FUNNEL AND CUP

A simple funnel can be made by cutting the top off a 2 L bottle and inverting it so the small opening is at the bottom. Aside from their usual use, funnels can be used as part of an inquiry challenging students to design the "most effective" water filtration device. Give students a choice of materials (e.g., coffee filters, paper towels, sand, activated charcoal, shelf liner [the puffy, nonslip type], gravel, cotton balls, sponges, and so on) to design a three-layered water filter within the plastic funnel to remove a small scoop of potting soil from a water sample. Follow all safety rules when working with soil. Know the source of the soil to avoid contaminants and wash hands thoroughly with soap and water after working with soil. The goal for the student groups is to design a filtration system that will result in "clear" water being produced in a timely manner. This activity can be used as a stand-alone inquiry or as part of a larger unit on soils/Earth materials, water quality, or mixtures and solutions and the separation of their component parts.

MYSTERY BOXES

Mystery boxes are a favorite tool for teachers to introduce the meaning of observation and inference and various aspects of the nature of science. Often they are made by purchasing small cardboard boxes from the local jewelry store and placing common classroom or household items in them so students can shake and listen as they try to conclude what is hidden inside. Our local recycling center had a large supply of small cardboard boxes that had once contained hand soap—voila! We found an ample supply of free mystery boxes! Mystery boxes work well as beginning-of-the-year activities. Using the box, students should first make observations—things they hear or feel. Then they can make an inference—based on the observations, what do you think the object is? Is there any way to know for sure without opening the box? How is this like what a scientist does? This process can help students begin to understand something of the nature of science and what it means to be a scientist.

HOVERCRAFT

Our local recycling center always carries a steady supply of CDs and closable water-bottle tops of different varieties—these materials can be used to make inexpensive hovercrafts. Teachers should build the hovercrafts before presenting them to students for exploration. Using a hot glue gun, teachers glue the base of a water-bottle top that has been cleaned with rubbing alcohol to the center of an old CD (we use the type of spout that pulls up to open and pushes down to close because balloons fit easily over these spouts). When the glue is dry, it is ready for use.

Figure 2

A hovercraft

To operate the hovercraft, students place an inflated balloon over the closed water-bottle top. When the student pulls up on the bottle top, air from the balloon begins rushing out, causing the craft to move.

We've used these models to introduce such concepts as Newton's laws of motion, friction, and force. For example, before the top is pulled up (and opened), we have the students try pushing their devices across the tables. They note how far each device travels without the air rushing through the top and under the CD. We then have the students pull open the top and try the same process. They quickly observe how much farther the device travels when a force—in this case a push—is applied. We then give the students the option to add washers or other weights to see what happens to the distance the hovercraft travels when the same

Connecting to the Standards

This article relates to 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.

Standard D:
Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science.

amount of force (once again a push) is applied. This exploration leads easily to discussion about Newton's laws of motion.

To extend learning beyond exploration with the simple hovercraft, we often challenge students to find ways to make the hovercraft travel without the students pushing it, or we challenge the students to design a hovercraft that will travel farthest when set in front of a fan in the hallway.

These are just a few of the recyclable items we have adapted for use in our classrooms. We encourage our fellow teachers to visit their local recycling centers to see what types of reusable science teaching treasures they may find. After all, the only thing better than an effective science teaching tool is a FREE science teaching tool!

Reference

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

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