Beyond Batteries and Bulbs, Circuits and Conductors: Building Green, Activist-Oriented Student Communities

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Abstract:

In this article we provide an example of how to foster an activist-oriented student community by critically examining green technology. We designed this curriculum unit to teach students about the fundamentals of electricity, green technology, and experimental design. Additionally, we viewed this activity as an opportunity for students to apply their science content knowledge and skills to a societal issue and, in turn, to take an active stance as part of a science community and member of society. This unit extends how elementary electricity content and activities have been traditionally taught to highlight the relationship between science and society.

Keywords: classroom activity | electricity | elementary | social justice | socioscientific issues | education | elementary education

Article:

INTRODUCTION

Today, science is an ever-present aspect of our personal, civic, and political lives. Energy efficiency, health epidemics, and environmental hazards are examples of imposing challenges facing citizens around the globe. These issues demand a scientifically literate citizenry that can use its science knowledge and skills to take action and find solutions (National Research Council 2007). How do we prepare students to gain these competencies? In this article we provide an example of how to foster an activist-oriented student community by critically examining green technology. This activity required fourth-grade students to apply their knowledge of electricity to take a critical stance in regard to the accessibility of green technology within their community. In the state of North Carolina, one of the four major competency goals for science instruction in fourth grade requires that learners build an understanding of magnetism and electricity through observation and investigation.

CRITICALLY EXAMINING GREEN TECHNOLOGY

Students investigated the pros and cons of replacing incandescent lightbulbs with compact fluorescent (CF) lightbulbs and considered to what extent this example of green technology was accessible to members of their class. This project extended a more traditional unit on electricity and magnetism, which was taught using a Full Option Science System (FOSS) kit called Magnetism and Electricity. Magnetism was covered first for approximately 2 weeks, and then electricity was taught for another 2 to 3 weeks. With respect to electricity content,

FOSS expects student to:

- Identify materials that are conductors and insulators.
- Understand and construct simple open, closed, parallel, and series circuits.
- Learn how to make an electromagnet.
- Experience the relationship between the number of turns of wire around an electromagnet core and the strength of the magnetism.
- Use their knowledge of electromagnets to make a telegraph.
- Acquire vocabulary associated with electricity.
- Exercise language, math, and social studies skills in the context of electricity investigations.
- Develop and refine the manipulative skills required for making investigations in electricity.
- Use scientific thinking processes to conduct investigations and build explanations: observing, communicating, comparing, and organizing. (FOSS n.d.)

Traditional activities, such as using wires and a battery to light an incandescent lightbulb and wiring a circuit, were completed by students in the FOSS magnetism and electricity unit. This unit is correlated with *Benchmarks for Science Literacy/Project 2061* (American Association for the Advancement of Science 1993) and the *National Science Education Standards* (National Research Council 1996) (see Table 1).

TABLE 1 FOSS Kit Correlations with Sets of Science Standards/Benchmarks

Benchmarks for Science Literacy/Project 2061	**National Science Education Standards**
Nature of Science	Science as Inquiry
• Results of scientific investigations are seldom exactly the same, but if the differences are large, it is important to try to figure out why. One reason for following directions carefully and for keeping records of one's work is to provide information on what might have caused the differences. • Science is an adventure that people everywhere can take part in, as they have for many centuries. • Doing science involves many different kinds of work and engages men and women of all ages and backgrounds. The Physical Setting • Things that give off light often also give off heat. Heat is produced by mechanical and electrical machines and any time one thing rubs against something else.	• Abilities necessary to do and understand about scientific inquiry Physical Science • Properties of objects and materials • Electricity in circuits can produce light, heat, sound, and magnetic effects. Electrical circuits require a complete loop through which an electrical current can pass. Science and Technology • Abilities of technological designs • Understanding about science and technology Science in Personal and Social Perspectives • Science and technology in local challenges History and Nature of Science • Science as human endeavor

OVERVIEW OF THE CLASSROOM ACTIVITIES IN OUR UNIT EXTENSION

Incandescent bulb dissection was the first activity of the unit extension. The dissection activity was a good bridge between understanding circuits and the structure and function of parts of a lightbulb. We used burned-out household lightbulbs. To prepare the bulbs for dissection, we covered the glass with duct tape, broke the glass with a hammer, and removed the glass—leaving the rest of the bulb intact (please see Safety Concerns regarding preparation of bulbs for dissection). Teachers challenged their students to investigate why the lightbulbs stopped working. Students were asked the questions, “How does an incandescent bulb light, and what causes the lightbulb to stop working”? The dismantled incandescent bulb allows the student to unravel the tungsten filament to better understand the structure of the bulb and the path that electricity travels through the bulb. Once students notice that the tungsten filament is broken ("the wire is broken"), then they can compare and contrast intact lightbulbs with bulbs that have stopped working. Another way to pique students' interests might be to present them with a set of lightbulbs that light and a set of lightbulbs that do not light (or have burned out) and then ask them to look for differences between the two sets.

After students learned that the tungsten filament must be intact for incandescent bulbs to light, they recorded their observations through drawing and labeling diagrams of the incandescent bulb in their science notebooks. They also included a written description of the flow of electricity through the bulb. This activity provided a foundation for students to compare and contrast the incandescent bulb to the CF bulb.

Next, students investigated the similarities and differences between the two types of working lightbulbs (incandescent and CF). Teachers presented their class with a CF bulb, and students shared their experiences with and knowledge about the technology. Most students had either some experience with or knowledge about both bulbs. Some students used both types of bulbs in their homes. Classroom discussions highlighted how the CF bulbs were marketed as green, good for the environment, and more energy efficient than regular or incandescent bulbs, which allowed our teachers to seamlessly transition into the next challenge they presented to students.

Teachers challenged students to design an experiment that would test whether the incandescent bulb or the CF bulb was more energy efficient. Teachers provided students with the following tools: a board wired with two sockets, a CF bulb (equivalent to 60 W), an incandescent bulb (60 W), a ruler, two alcohol thermometers, a stop watch, a cardboard box, and aluminum foil (see Figure 1 for a sample data table used for this activity and Figure 2 for a picture of the apparatus used for the lightbulb comparison activity).

Comparing the Energy Efficiency of Incandescent and Compact Fluorescent Bulbs Predict: Which lightbulb will generate the most heat?		
Time (Minutes)	Temperature °F (Incandescent bulb)	Temperature °F (Compact fluorescent bulb)
0		
3		
6		
9		
12		

FIGURE 1 Sample data table used for lightbulb comparison lab.

FIGURE 2 has been omitted from this formatted document.

In small groups, students brainstormed how they could measure energy efficiency with the tools provided. Students designed investigations that measured the heat output of each bulb as an indication of energy efficiency. They placed the alcohol thermometer at equal distances near the bulbs and recorded the temperature in predetermined time intervals.

For fourth graders, the energy efficiency of lightbulbs can be conceptualized by explaining to them that lightbulb efficiency is measured in terms of the amount of light produced for each unit of electricity used. There are only two products when lightbulbs are plugged in: light or heat. Incandescent lights use 100% of the electricity to produce approximately 10% light and 90% heat. CF lights produce approximately 30% light and 70% heat. Therefore, by measuring heat output from the two comparable light sources over a given period of time, students can make generalizations about the energy efficiency of the two kinds of lightbulbs. Energy is defined as the ability to do work, and the everyday usage of conservation of energy refers to saving any energy source by using it efficiently and not wasting it (Smith 1993). As energy changes from one form to another, much is lost, as a portion of the energy enters a state that can no longer do work. For example, when gasoline is burned in an automobile only a small portion is used to move the car; the remaining energy produced from combustion dissipates into the atmosphere as heat that cannot do useful work (Smith 1993). Energy efficiency and efficient energy use are terms used to describe efforts to reduce the amount of energy required or consumed to provide a particular service or product (California Center for Sustainable Energy 2010; World Energy Council 2011).

While students brainstormed their experimental designs, teachers used questioning to force the students to grapple with the relationship between experimental design and the group's ability to compare and contrast their data. For example, some students realized that the distance from the bulb to the thermometer would influence the temperature reading. In the end, students compared their data and created line graphs on a SMART Board to represent their findings, which supported their prediction that the incandescent bulb would give off more heat compared to the CF bulb. Students concluded that their data supported the claim that the CF bulb was indeed more energy efficient than the incandescent bulb.

As a homework assignment, students completed a home lightbulb survey (see Figure 3) to count the number, type, and wattage of each lightbulb in their homes. The next day, students researched the cost of CF bulbs and calculated the cost to replace each incandescent bulb in their homes with the more energy-efficient bulbs. Students also researched the energy savings associated with CFs (see Figure 4). They discovered that for some of them, it would cost upward of $600 to replace every incandescent bulb in their homes. Teachers then urged students to share these calculations with their families, share the results of their experiment (i.e., that CFs were more energy efficient), and discuss the cost associated with CF bulbs. The rationale for this activity was to prompt students and their families to discuss the feasibility of switching to green technology.

Home Lightbulb Survey

Count the number and type of lightbulbs in your home.

Incandescent____________________

Compact Fluorescent_____________

Ask your parent or other adult for an electric bill and obtain the fee for energy (e.g. $0.07 per kilowatt hour).

Cost per kilowatt hour __________________

FIGURE 3 Sample of lightbulb survey.

The Cost of "Going Green"

Using the newspaper circular advertisements, record the price of each bulb below.

Incandescent_____________ Compact Fluorescent_____________

Calculate the cost to replace each incandescent bulb in your home with compact fluorescent bulbs.

Price of bulb × number of bulbs =_______

Calculate the cost to operate each type of bulb.

Electricity used = hours of use X (wattage of bulb divided by 1000)

Cost = electricity used × electric rate

FIGURE 4 Sample handout used for mathematical comparison of bulbs.

Next, teachers provided the students with recent newspaper articles highlighting legislation around the globe, which called for a ban on the production of incandescent bulbs (see the Resources section for electronic access to articles). Using the data they collected from the previous activities, students discussed the implications of the legislation for individuals in society— especially those who are impacted by poverty. Some students even made the case that banning the incandescent bulbs might cause job losses in industries. The teachers and students weighed the benefits and potential drawbacks of green technology.

For the culminating activity, students were urged to use their science knowledge from these activities to take a stance on the accessibility of CF bulbs. Students took action and wrote persuasive essays to their state governor or created posters that educated the student body on the science and accessibility of green technology. In their letters, students presented the data that they collected and urged the governor to create programs to make CF bulbs more affordable for all individuals.

As we reflect about refining this unit extension, several issues surface. First, we would incorporate a discussion about possible environmental implications from the manufacturing of both incandescent and CF bulbs. We would also incorporate the disposal of and recycling issues associated with both types of bulbs. Finally, when considering the possibility of using new improved LEDs for household lighting, we now have another important variable to include.

ASSESSMENT

We assessed the unit extension by evaluating the letters that students wrote to their state governor. Students were required to use facts about green technology and costs of CF bulbs and incandescent lightbulbs in their letters. We also assessed classroom participation when students were conducting their experiments, collecting and analyzing data from these experiments, and sharing their results with their classmates. We have since considered using a line debate to engage students in a more formal discussion with regards to lightbulb choice when we teach this unit extension again.

CONCLUSION

We designed this unit extension not only to teach students about the fundamentals of electricity, green technology, and experimental design, but also to provide students with an opportunity to take an active stance as part of a science community and a member of society. These activities underscored how science is intertwined with economics, politics, and students' lives. But even more important, students learned to use their science knowledge and skills to take action. Students were enthusiastic and vocal about their interest in this aspect of the electricity unit. This unit extension provides an example of how elementary teachers, in their own classrooms, can step outside the traditional approaches to teaching electricity to encourage an activist-oriented school science community.

SAFETY CONCERNS

It is important for the teacher to carefully prepare the incandescent bulbs for dissection by ensuring that all glass is removed. Although it is possible to see a broken filament without breaking the glass, dismantling the bulb allows students to unravel the tungsten filament to understand the importance of this structure to the circuit. In addition, burned-out bulbs sometimes darken, making it difficult to view the filament. When working with electricity, the teacher can plug and unplug the electrical cord, after lightbulbs have been screwed into the socket, or use a power strip to turn the bulbs on and off. Students can screw and unscrew the bulbs into the sockets; just remind them to do so carefully and to stop at the first sign of resistance. Make sure that the students and teacher are wearing eye protection. The teacher can remind students not to have water near the apparatus. Remind students to watch carefully for electrical cords in the classroom so that they do not trip. Finally, disposal of both incandescent bulbs and CF bulbs should be discussed. Neither kind of bulbs should be placed in household trash. Instead, they should be taken to an acceptable disposal center in your area. Additional information on disposal options can be found on the following United States Environmental Protection Agency Web site, http://www.epa.gov/cfl/.

APPARATUS FOR LIGHTBULB COMPARISON

To replicate the apparatus depicted in Figure 2, line a large cardboard box with aluminum foil—with the shiny side facing in—to reflect all the light back into the box. Place the light fixture in the bottom center of the box. Make a hole in the box lid and insert the thermometer from the outside, sealing the entry with duct tape on both the inside and outside of the box. Inside the box, construct a radiation shield with two sheets of aluminum foil suspended between the light and the thermometer. Leave space above and below the shield so the heated air can rise to the top of the box.

RESOURCES

1. Barrie, J. 2004. Kilowatt ours: A plan to re-energize America, DVD. Nashville, TN: Jeff Barrie. Film length: 38 minutes (60-min version available on the same DVD). Grades: 5–12 (easily modified for younger and older students). Time needed: One class period to several class periods. Curriculum content standards: Science, social studies, math, language arts.
2. Kanter, J. 2009. Europe's ban on old-style bulbs begins. The New York Times, August 31. http://www.nytimes.com/2009/09/01/business/energy-environment/01iht-bulb.html.
3. New York Institute of Special Education. n.d. Compact fluorescent lightbulb fact sheet. http://www.nyise.org/earthday/bulb.html.

4. U.S. Department of Energy. n.d. Energy education and workforce development lesson plans. http://www1.eere.energy.gov/education/lessonplans/default.aspx
5. WorldNetDaily. 2010. Congress bans incandescent bulbs. http://www.wnd.com/?pageId=45156.

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