A virtual lab supplements an exploration of simple circuits.

By Jefferson Stewart and Daniel Vincent

One of our most successful science activities has always been the "circuit" lab during which students use a dry cell (a D battery), a lightbulb, and copper wire to try to light the bulb. We provide students a chance to play around with the materials and recorded observations, and then we lead a class discussion on what caused the bulb to light. Students are typically able to discover the concept of a circuit through this process. The article "Light Students' Interest in the Nature of Science" (Olson 2003) describes a similar process that uses science content, the processes used by scientists, and the nature of science (i.e., using evidence of properties and reactions to gather clues to form ideas) to help students develop a robust understanding of science concepts. However, we are always on the lookout for new ways for our sixth-grade students to connect to science.
This year, we incorporated an online virtual component to the simple circuit lab investigation. We felt that many students could be motivated by technology. The use and availability of virtual labs has grown considerably over the past several years. Numerous online simulations have provided students a chance to interact with science concepts in ways that offer easy manipulation, showing concepts through causes and effects. Curriculum publishers currently provide virtual components as part of content sets. Using supplemental resources in bundles with textbooks, publishers offer multiple pathways for inquiry learning, including hands-on kit materials, as well as virtual technology tools accompanying traditional textbooks.

We were able to connect to the following Scientific Practices mentioned in A Framework for K–12 Science Education (NRC 2012) while incorporating the technology: Constructing explanations and designing solutions (#6), and obtaining, evaluating, and communicating information (#8). We also were able to address the Core Idea of Energy. Grade 5 endpoint for PS3.A says, “Energy can be moved from place to place by moving objects or through sound, light, or electric current” (p. 122). In this article we describe our experiences incorporating the virtual lab into a simple circuit lesson during an energy unit.

A Virtual Spin to a Traditional Lesson

Tried and True

Rather than substituting the virtual lab portion for the hands-on portion entirely, we decided that a combination of them both was the most beneficial to students. We felt that students developed deeper initial concepts when working with real materials; they seemed to discover the concept of simple circuits in a more holistic and scientific way. There were several things we observed that led us to this conclusion. When working with real materials, students had to really test their ideas; they didn’t get help with any special features the simulation might offer. Students would often exclaim in surprise when wires become hot, or when a configuration finally lit the bulb. This created a climate of discovery in the classroom. Students were also required to record their attempts on paper and make the representation understandable enough to be shared later.

Therefore, we began our exploration phase of the circuit lesson the same way we do with the traditional lab. We separated the students into groups, gave them real materials to share, and gave them their task: to use only a single battery, wire, and lightbulb to find a connection configuration that lights the bulb. This created an environment in which communication was essential for accomplishing the primary goal of lighting the bulb. We provided the students guide sheets that could be used to record circuit configurations, ideas, and observations (see Figure 1).

To encourage student-to-student communication of ideas, we used question prompts like “Does it matter where you touch the bulb to make it light?” and “Is there a way to make the bulb light by only connecting one side of the battery?” This also helped with student assessment, as we were able to hear and see how students developed their ideas during these discussions. We noticed that the students communicated while using real materials. They would ask for help from each other and verbalize achievement. Comments such as “Hold this wire so I can connect the bulb,” “The wire is getting hot!” and “We got it!” were frequent among the groups. Once students were able to light a single bulb they would immediately try new configurations. They would go to the supply area and pick up additional bulbs, wires, and batteries. Most common were comments such as “Look! Three batteries really make the bulb light up!” and “Two bulbs with one battery make them dim.”

Incorporating a Virtual Lab

Students worked with the materials about 45 minutes, and then spent 30 minutes on the virtual portion. This can be done individually or as a class demonstration of the simulation, with the teacher leading a whole-class discussion while using the simulation. There are several simulations available for free online, but we chose one...
that provided the ability to manipulate components of a circuit, in ways similar to using real materials. Fortunately, the simulation we used (see Figure 2) was free and it provided ways to drag and drop virtual materials from a sidebar in the application. This provided an intuitive way to connect the pieces together, which was comparable to connecting the real materials. Following the investigation with materials and virtual lab, a class discussion focused on an explanation of what made the bulb light—the concept of closed circuit.

During the explanation the virtual lab was running, and it was connected through an interactive display. We asked students about open and closed circuits, and students would come to the board and construct example configurations. When students became uncertain about the next step, then the rest of the classroom was able to help guide them. For example, students would raise their hands, and one would be selected. The student would say something like “Could you move the wire to one end of the battery and then place the bulb on the other end?” The student at the interactive display would make the adjustments and if it worked, the class would discuss why. If a solution was not found, then another student could make a suggestion. Students would use configuration examples that they copied down on their lab sheets. We prompted with, “Does anyone have a design that uses three bulbs?” and students with such a configuration would raise their hands and, when a student was selected, would come to the interactive display to construct the circuit. Questions like “What do you think the arrows are representing in the simulation?” are also helpful when explanations of the concept become the focus of the lesson.

Our virtual environment was ideal for explaining the process of how electricity flowed through a circuit. Small dots represented electrons and were visibly moving through the circuit once it was closed. When the circuit was open, the virtual electrons stopped moving. Also, the ease of creating configurations upon an interactive screen avoided the logistical problems of presenting demonstrations with the real materials. Ideally, a unit on electricity would include structure of atoms as building blocks of matter. When a discussion of atoms, current, and electrons is introduced later in the year, students may benefit from an activity like the one described in “The Pennies- as-Electrons Analogy” (Ashmann 2009). Books that may illustrate those concepts into the lesson are listed under Resources.

After students have gone through the class discussion with the teacher-led virtual demonstration, the virtual environment could be used to help
them confirm or solidify the phenomena observed using physical materials. In addition, the virtual lab could be used to define academic, scientific language by explicitly teaching vocabulary when demonstrating the virtual lab to the entire class. To continue the theme of collaboration, assign one computer to two or more students. The task we provided to the students was the same—to use only a single battery, wire, and lightbulb, and find a connection configuration that lights the bulb. Using the same simulation as the teacher-led demonstration, students began work on lighting the virtual bulb again virtually. With this particular simulation, it represents something that is not possible to observe directly in real life—the movement of electrons in the wire. This demonstration of concept could provide more structure to students’ ideas and help reinforce the teacher’s explanation during the demonstration. As with any lesson involving the internet, we took care to stay on predetermined websites, and periodically verified that students were on task.

A teacher with access to a single computer could still give students the opportunity to reinforce in the virtual environment what they learned earlier with the real materials. The simulation can be projected onto an interactive display board and student volunteers could take turns coming to the board and trying new configurations. After the virtual portion is completed, you may want to consider incorporating a summative assessment (see NSTA Connection) into the lesson wrap-up.

A Positive Combination

From our experience, the use of virtual tools does have a place in exploration and concept development, but these simulation tools may not be as useful as a first-hand, multisensory experience. Instead, the virtual tool could be used to augment and reinforce student ideas after they have been authentically developed by the students through use of real materials. This idea is not new. Chen sums it up by stating, "...authentic scientific inquiry or problem solving seldom takes place in perfect conditions. It is the essence of science that, in a scientific investigation, a relationship between variables is identified, while other variables are controlled. Nevertheless, the identification is seldom straightforward due to poor apparatus or difficulties in precisely controlling some factors. Investigators sometimes have to combine the imperfect data with thought experiments to infer the best explanation” (Chen 2010). In other words: Science should be messy! Authentic science needs exploration tools that are challenging to understand, which produce effects that can be sensed by students in many ways, yet are not readily understood. Educational materials which presume causes and effects, in highly organized ways, may not be the best tools for exploration because they are easy to use and easy to explain. Our conclusion is that virtual tools are much more suitable for reinforcing and clarifying concepts; after students have plenty of time to explore with the inscrutable real materials.

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References

Resources