Learning Through Stories

High school chemistry students at Unionville High School in Kennett Square, Pennsylvania, embrace the tenets of "writing to learn" pedagogy in their class. For example, while studying gas laws, students created children's books about the properties of gases, geared toward ages 8–12, to display their understanding of the science content (see Figure 1 for a set of directions given to students for their book-writing project and Figure 2 for a rubric that helped with evaluating their work). Their books spanned genres and styles and were rich in content and creativity.

The high school students were eager to share their books and their science knowledge with elementary students, so a partnership was set up between the high school and a local elementary school. Using their science stories as the central focus, the high school students and their teacher created a half-day science program for fourth- and fifth-grade elementary students. The program's theme was "Air Is Something." In addition to highlighting the high school students' own books, the program also included a series of laboratory activities, demonstrations, discussion, and writing activities.

The "story" of this partnership is one of learning and excitement for both the high school and elementary students.

FIGURE 1

Directions on writing a book that teaches children about gases.

Objective

To design a children's book (geared toward ages 8–12) about the properties and behavior of gases. Your job is to show your understanding of the chemistry of gases through the creation of a children's book. The book should be informative, complete, scientifically correct, original, and entertaining. Your children's book may be either fiction or nonfiction. You may write it as a story or as an informational book.

Directions

1. Design children's book using:
   a. Words: Your book must teach/inform children about gases.
   b. Pictures or Diagrams: You may use original drawings or clipart.

2. Your book must include the following:
   a. A scientifically accurate explanation of the properties and behavior of gases.
      i. Include a molecular picture of gases and a description of their properties.
      ii. Include a description of the effects of temperature, pressure, and volume on the properties of gases.
      iii. Include a real-world example of gases and their unique properties.
   b. Include a child friendly explanation of the science topic.
      i. You must present the science information in words that a child could understand.
      ii. Your book must be well organized and easy to understand.
   c. Your book must look like a real book. For example, it should open like a book, have a cover, and include page numbers.
   d. Make sure your book is original. Be creative! Have fun with the project.

Reading circles

After quick introductions, the half-day science program began in the elementary school's gymnasium. Small circles of elementary students filled the gym floor. High school students served as facilitators for each of these reading circles. The high school students read their books, pausing to elaborate on the science ideas described in the books and to ask and answer questions. The high school students were proud of their books and eager to share them with an authentic audience of children and the elementary students were awed by the "cool" high school students.

Laboratory activity

Following the reading circles, students were led to a series of 10 small tables set up along the perimeter of the gym. At each table a high school student directed the students in completing a hands-on investigation. Each lab activity investigated an important aspect of the properties of gases, yet was safe and simple to complete. [**Editor's note:** Activity proposals were reviewed for safety by the teacher before approval.] The elementary students rotated through the 10 lab stations. At each station, elementary students listened to the high school student's explanation of the procedure before recording a prediction of what they believed would happen. The elementary students then performed the experiment, recording

their observations and comparing it to their predictions. The students were engrossed in the experiments and the gymnasium often erupted in "WOWs" as students completed each fast-paced experiment. When all students had finished the 10 experiments, everyone assembled in the center of the gym and the high school students led a discussion about their experimental findings. Sample stations are described in Figure 3.

Demonstrations

Following the hands-on laboratory activities, the high school students performed a science show they choreographed for the elementary students. The show consisted of a series of demonstrations about air. The students' choices of demonstrations were based on available resources and suitability for the elementary student audience. The high school students were allowed to research and choose suitable demonstrations with the teachers' guidance. This

FIGURE 2

Rubric for evaluating the children's books.

Scientifically accurate
Clear, concise, well-organized description of the science topic. You must show your understanding of the property and behavior of gases by clearly describing the process in your children's book. (15 points)

Complete
You must include a molecular picture of gases and a description of their properties. Also include a description of the effects of temperature, pressure, and volume on the properties of gases and a real-world example of gases and their unique properties. (15 points)

Age appropriate
Your explanation of the topic must be appropriate for an 8–12 year-old child. (10 points)

Creative
Your book must be appealing and engaging to a child. (5 points)

Well constructed/neat
Take pride in your work! (5 points)

TOTAL
(50 POINTS) ____________

FIGURE 3

Sample Stations.

Safety note: Make sure to follow proper safety precautions required for each of these demonstrations.

CAUTION

Station #1
1. Blow up two balloons and tie their ends.
2. Use tape to attach one balloon to each end of a meterstick.
3. Place the meterstick on the fulcrum to create a balance scale and adjust it until each side is balanced.
4. Carefully put a small hole in one of the balloons.
5. What happens to your balance scale? Explain.

Station #2
1. Place a funnel into an empty soda bottle.
2. Use clay to create a seal between the soda bottle and the funnel.
3. Pour water into the funnel. What happens? Explain.

Station #3
1. Place a beaker half full of water on a hot plate and boil.
2. Carefully hold a toy pinwheel over the steam of the boiling water. What happens to the pinwheel? Explain.

Station #4
1. Place about 20–25 mL of water in a clean, empty aluminum soft-drink can.
2. Place the can on a hot plate until the water rapidly boils and you see steam coming from the opening.
3. Use tongs to quickly remove the can from the heat and immediately invert it into a container of ice-cold water. What happens? Explain.

Station #5
1. Find the "cartesian diver" inside the bottle and carefully observe how much air is in the diver.
2. Squeeze the outside of the bottle.
3. Record your observations of the "diver" and the volume of air inside the "diver."

Station #6
1. Place a stopper on the end of an empty plastic bottle.
2. Make sure the stopper is pointing toward the ground and quickly squeeze the bottle as hard as you can. What happens? Explain.

process allowed the high school students to gain a fuller sense of ownership over the performance. Where possible and safe to do so, elementary students were chosen from the audience to participate as assistants or test subjects for the demonstrations. Examples of demonstrations include the use of a vacuum chamber, dry ice, liquid nitrogen, and helium- and carbon dioxide–filled balloons.

Writing task

The program ended with a challenge to the elementary students to share what they learned about air with a friend. To do this, students were encouraged to write to a friend about their experience. Their correspondence could be in the form of a letter, card, or postcard that they wrote and designed. Just as the high school students shared their books with them, the elementary students were to pass on this information to other children.

This cooperation between the high school and the elementary school proved to be a great learning experience for both levels of students. Every student ended the program excited and motivated. Reading and writing paired with action and investigation was truly a recipe for successful science learning!

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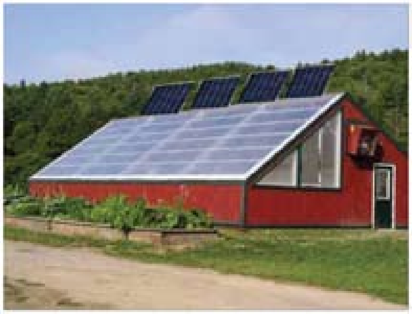
Asking Authentic Questions with Tangible Consequences

As a physics teacher, it seems irresponsible to teach energy without asking students hard, relevant questions such as, "What will we do when oil becomes prohibitively expensive?" Therefore, in the fall of 2005, I asked my physics students to identify some energy-related problems in our community that we could solve. During brainstorming sessions, students in my senior-level physics course generated a huge list of suggestions. Even though students came up with excellent ideas, the suggestions were a bit too complicated and expensive. Eventually, with help from other faculty, we came up with a suitable project: Students would research options for a renewable onsite power source for the new water pump we would soon buy for our school's greenhouse. My students were immediately excited about this project and we went right to work.



PHOTOS COURTESY OF THE AUTHOR

Student-generated image of solar panels on the school's greenhouse.

Exploring different options

The greenhouse at our high school was completed in 2004 and biology students began using it in the fall of 2005 to produce salad greens for the school lunch program. Compost is collected from the cafeteria and trucked to Vermont Compost Company, which in turn provides a cheaper rate for soil to grow more plants in the greenhouse.

In keeping with the sustainable ideals of our school and community, we were committed to providing the electricity for the pump from a renewable, localized system. The first step for our project would involve conducting a feasibility study regarding our onsite electric generation options. Students were perfectly capable of doing the research and they proposed many potential sources—wind, solar, hydro, and even bicycle generators.

The feasibility study became the culminating project for a unit on energy and power. Students, working alone or in pairs, chose one possible power source to research. The final activity of the project was to present the research to the class with a recommendation to the school to pursue the option or not. The presentation had to include energy and power calculations (linking this project to traditional science standards), as well as documented evidence that students had contacted an expert in the community regarding their research topic. After all, if the school was really going to invest in one of these options we needed expert advice. The students squirmed at the thought of calling an adult they didn't know, but I assured them that it was a skill they would use throughout their lives.

As students began to contact experts, we found ourselves flooded with support from the community. For example, the president from Solar Works Inc. (a local photovoltaic company) came to our classroom to discuss the benefits and challenges of solar panels. Other groups that helped inform our students' presentations included Windstream Power LLC, Northern Power Systems Inc., and Central Vermont Solar and Wind.

After four weeks, students gave their presentations, all of which were top quality. The authenticity of the question provided a refreshing motivation to the students. Over

the course of two class periods, students presented their research to the school's principal, head custodian, a handful of science teachers, and the service learning coordinator. After an extensive discussion, the students recommended:

- Acquiring as many solar panels as we could fund to be connected to our local power grid, using an inverter and fail-safe system;
- Building bicycle generators; and
- Continuing to explore hydropower in the coming year.

Securing funding

Solar Works Inc., provided a cost estimate for a 2KW photovoltaic system, and agreed to work alongside students during the installation process once funding had been secured. During summer 2006, we held a two-week summer school session that was entirely dedicated to building bicycle generators. I cotaught this course with a shop instructor who taught students how to weld, and we had a professional electrician from Common Ground Audio help us with the electrical connections.

By the end of the summer session we had five operational bicycle generators. A photograph in the local newspaper announced a public reception to show off the generators, which was attended by many members of the community, as well as parents and school staff.

A student powers a stereo system by pedaling!

Through one of the contacts made by my students, a member of the Montpelier Energy Team (MET) heard about the energy project. The MET is a group of local experts that advise the city government about energy decisions and climate change. He invited a group of students to present their results at one of their meetings. The students were delighted and surprised that someone outside of our school system would be interested in their work. After the presentation, the MET promised to help us realize our goals and has since helped us find funding.

Knowles Science Teaching Foundation also asked for my students and me to present our project at their summer fellows' meeting. And recently, we received a grant to purchase the solar panels from the Sustainable Future Fund with the Vermont Community Foundation for $2000. Although we are still looking for additional funding, receiving this grant was very exciting for us.

The whole experience has taught us that there are people in the community that are more than happy to be involved in classroom efforts. More importantly, it helped me understand that when I started asking my students real questions, with unknown but significant answers, I needed the expertise of the community to support the learning in my physics class.

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