How One Teacher, Two Students with Visual Impairments, and a Three-year R & D Project Could Change How All Students Learn Science

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Abstract

You probably recognize this standard definition of a comet: "a relatively small extraterrestrial body consisting of a frozen mass that travels around the sun in a highly elliptical orbit." Add an accompanying photograph or diagram, and students "get" what a comet is, right? Science textbook publishers expect students to understand science concepts by describing them using content-specific vocabulary, but for some students, that's a huge roadblock. A student who is blind or who has a visual impairment likely has never seen a comet, either in a night sky or in a photograph, and even when a teacher provides an additional colorful description about "fire balls" and "tails," it doesn't always help. How, then, do students with visual impairments learn scientific concepts? And, what can a science teacher do to ensure all students, including those with visual impairments, are learning? Seeking answers to these questions, two entities—McREL, an education research and development organization, and Edinboro University of Pennsylvania—partnered on a three-year collaboration to design, develop, and test resources for general education science teachers and teachers of students with visual impairments in grades 6–12. The result was a 3-part framework, *Visualizing Science with Adapted Curriculum Enhancements* (ACE). With a direction set, the developers recruited science teachers of students with visual impairments to participate in the study. Most teacher participants had no prior knowledge of how to address the needs of their students with visual impairments, but during the process, everyone learned. What follows is the story of a high school chemistry teacher who jumped into this project blindfolded, literally.

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Seeking answers to these questions, two entities—McREL, an education research and development organization, and Edinboro University of Pennsylvania—partnered on a three-year collaboration to design, develop, and test resources for general education science teachers and teachers of students with visual impairments in grades 6–12. The result was a 3-part framework, *Visualizing Science with Adapted Curriculum Enhancements* (ACE). By creating tools to help these students, they believed they could help all students. Thus, the framework components focused on these three aspects:

1. Understanding the Spectrum of Visual Impairment and Universal Design for Learning (UDL)
2. Assessing the Needs of Your Student with Visual Impairment
3. Enhancing Your Students Understanding of a Specific Science Concept

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Journeying into the center of an R & D project

Pam Liccardi describes her excitement about participating in the ACE Project: “I had two students who are visually impaired—one who was totally blind; another who had low vision, and I knew nothing about visual impairments. Except for a general familiarity with the concepts behind Universal Design, everything related to the ACE project was brand new to me.”

To determine students’ prior knowledge, progress, and mastery, she first had to become familiar with the spectrum of visual impairments. In the science classroom, most learners use observation and visual perceptions of models as their primary learning conduit but students who are visually impaired primarily explore models tactilely. Here are some questions that Pam had to answer and that you can use before beginning to work with a student who is visually impaired:

- Is your student classified as blind or as low vision (see sidebar for definitions)
- What *specific* visual impairment does your student have?
- How does your student cope with the visual impairment?
- Which optical aids have helped your student in the classroom in the past?
- What physical and educational environments are best for your student? (Bogner et al., 2009)

Sidebar 1:

Determining the kind of visual impairment your student has

Students who are visually impaired are more frequently being assigned to traditional classrooms. Rather than focus on perceived limitations, it is more important to **determine your student's capabilities.** Once you have identified them, you can provide appropriate assistive technologies, those devices or processes that assist a person with a disability to do something that otherwise would be difficult or impossible to accomplish. There are many kinds of visual impairment which are generally classified as follows:

"Partially sighted" indicates some type of visual problem has resulted in a need for special education.

"Low vision" generally refers to a severe visual impairment, not necessarily limited to distance vision. Low vision applies to all individuals with sight who are unable to read the newspaper at a normal viewing distance, even with the aid of eyeglasses or contact lenses.

"Legally blind" indicates that a person has less than 20/200 vision in the better eye or a very limited field of vision (20 degrees at its widest point)

Source: Retrieved from http://www.ace-education.org/learning/index.asp

Seeing through my students' eyes

"The single most important thing I learned was to find out where my students were along the spectrum of visual impairment," says Pam. "To help us do this, the developers immersed us in the experience of being visually impaired by having us enter an unfamiliar room, blindfolded, and with a cane. Later, to give us a sense of the different types of impairments, we wore goggles that hindered our vision in ways appropriate to the impairment being illustrated. Finally, we had to conduct a science experiment while wearing the goggles. These experiences were simultaneously frustrating and interesting."

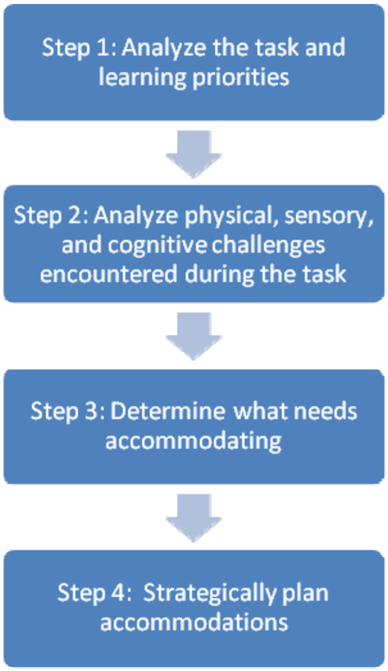
Pam describes her feelings about being blindfolded and the new learning she took away from the experience: "The first time I was blindfolded and had a task to accomplish, I seemed to lose track of time. When I thought I had only been engaged at a task for one or two minutes, I'd later learned that I had been at it for 10 minutes or more. This realization was something I could immediately take into the classroom. When I was wearing the goggles, my ability was completely changed; some things I just could not do; some things I could do with modifications. Having experienced how much more difficult a seemingly simple task is for someone with a visual impairment gave me real insight into something I could immediately change once back in the classroom."

The amount of time a teacher allows for a task in the classroom may feel very different for someone with a visual impairment or other learning disability. Any teacher who can put his or herself in a student's shoes is going to be better at adapting the learning task and the learning environment for that student. Figure 1 depicts four steps for accommodating students with disabilities, but all science teachers should ask these questions before teaching a science unit or lesson:

- What does the task require and what are the most important concepts the student should learn?

- What might challenge a student's physical, cognitive, or sensory abilities, whether or not the student has an identified disability?
- What specific portion(s) of the lab or activity will need to be adjusted so all learners, including those with disabilities, can meet the learning outcomes?
- What accommodations should I make?

Figure 1. The four-step accommodation model for science activities and labs



Reprinted from Bogner et al., Visualizing Science with Adapted Curriculum Enhancements (ACE) Resource Manual (2009).

Surveys and questionnaires: Tools of discovery

The second part of the project focused on helping teachers learn about their students in order to assess their needs. For example, how a student pictures what a comet might look like depends on his or her visual history (e.g., blind from birth, blind later in life, partial vision). Knowing the visual history, adaptations that have worked in the past, and student and parent goals helps a teacher determine the best support to provide. The ACE developers created several tools for communicating with parents, teachers, and support personnel (e.g., a parent survey, former teacher survey, and student questionnaire) to help teachers learn about relevant aspects of students' backgrounds and come prepared to work with their student.

Pam shares which tools she found most helpful: "I used the parent survey (see Figure 2) during the summer. It helped me to hear what the parents thought about their child's learning background, what they thought they already knew, and what they thought their child's goals were. Equally helpful, if not more so, was the student questionnaire. By sitting down with the student, I learned the student's preferences, such as Braille instead of audio. Quite honestly, going in, I didn't imagine some of the things I ultimately discovered."

Figure 2: Sample questions for use in parent survey

I. Background and Mobility
1. Explain your child's visual impairment; include an explanation of his/her functional vision, if any. 2. When was your child's visual impairment diagnosed? Child's Age _______Year _______ 3. What are you child's general interests, and what does your child really like to do? 4. How long has your child been in general education classrooms? ________ years 5. Is there a teacher or aide who comes to your mind who you believe has sound insight into working with your child? If possible, could I contact him/her for more information?
II. Independence and Support
1. What tasks does your child do at home? (e.g., making the bed, taking out trash) 2. Does your child travel in the neighborhood or community by himself or herself? 3. When your child enters a new room, how does he or she learn about the room?

4. Has your child participated in any specialized science camps or programs outside of the school system? Give dates and details, if possible.

5. How much experience has your child had in the kitchen? (lab science skills and kitchen skills are similar)

III. Learning Preferences

1. Did your child enjoy audio or tactile toys?

2. Does your child have difficulties with social interactions and making friends?

3. Given a choice, would your child choose to work *in a group* or *alone*?

4. What type of setting does your child prefer to study in?

5. How much opportunity has your child had to create things (e.g., art projects)?

Source: Bogner, D., et al. (2009). *Visualizing Science with Adapted Curriculum Enhancements (ACE) Resource Manual.* Denver, CO: McREL and Edinboro, PA: Edinboro University.

Ken Quinn, a social studies teacher and ACE reviewer who has been blind from birth, emphasizes that teachers not only must get to know their student with visual impairment, but they also must learn about parents' permissiveness: "My parents treated me as if I had sight. I rode a two-wheel bike; participated in creating meals (i.e., measuring, cooking, dealing with the stove), and I was more independent in the classroom setting as a result," says Quinn. "But other students might experience the 'fairy godmother syndrome,' where they say, 'I want a sandwich,' and it magically appears."

Sidebar 2: For step-by-step instructions on creating Braille Graphics and for other resources to use with students who are visually impaired, visit the "Educators Resources" page of the ACE website—Adapted Curriculum Enhancement NASA Science Inquiry Materials for the Visually Impaired—at http://www.ace-education.org/index.asp.

Creating materials and mastering instructional techniques

The second component of the ACE Framework focused on two critical strategies for making science more accessible to all students: (1) tactile graphics (TG) and (2) visualization techniques. Pam was familiar with visualization and had used it effectively with all of her students, but she had not created TGs.

“The developers asked us to create tactile graphics with written descriptions, and sometimes with 3-D models, that we thought would enhance students’ learning. This turned out to be challenging, but I learned to keep three things in mind when creating them: (1) simplify, (2) focus on the most important aspect of the graphic to portray the essential content, and (3) describe every single step. The beauty of paying attention to these three things is that it helps all students because you’re really focused on creating the most useful resource you can possibly create,” says Pam.

Pam designed a TG at the beginning of the intervention and again at the end so that the developers could assess changes in her capacity to design effective TGs. She observes, “One of my fellow teachers in the project remarked on her tendency to try to replicate the textbook picture. We all learned that our idea of a great looking TG wasn’t quite right; to be effective, a TG has to be about the science concept behind it. The developers reminded us not to try to recreate the little parts of the picture or make it pretty because that is where many TGs fail—they look good to the visual eye, but they don’t mean anything when they are felt by the student.”

Once students work with a TG, you know whether it’s effective. Quinn, who has worked on tactile graphics usability since 1999, confirms the divide between good and poor TGs: “One of our participants made a plate tectonics diagram, and as reviewer, I thought it really conveyed the concept of the plates moving apart.” The TG had several layers and the more layers you folded out, the further the plates moved away from each other. Although not identical to a tactile graphic, a model is a great way for all of your students to learn. Consider making an ice cream comet model in class following the guidance in Figure 3.

Figure 3: Teacher's guide for creating ice cream comet models

Teacher Preparation

What does it mean to describe a comet as a dirty snowball? It means that scientist think comets are a mixture of frozen water, dry ice, and other sandy/rocky materials left over from the early formation of our solar system. In this activity, students develop a comet model that they can eat. Students also trade "comets" and pretend to be an instrument on the Deep Impact Spacecraft called a spectrometer. It analyzes the structure and composition of comets by using nine different filters. Students will use their five senses as spectrometers to decide what is in the ice cream.

Materials needed per group (2–4 students):

Note: Since students will be eating their snowballs, plan this activity for a location other than the lab, and survey your class ahead of time for any food allergies (milk, peanuts) students might have. Remember to choose foods that will not dissolve while the ice cream sets.

Gather the following:

- One sandwich size resealable plastic bag
- One 1-gallon size resealable plastic
- Small cups for eating ice cream (one for each person and one extra cup for feeling the ice cream)
- Plastic spoons (one per person)
- Pairs of kitchen mitts (comet gets cold!)
- Ice (enough to fill a gallon size bag ½ full per team)
- Chunky black/brown cookies, crushed candies, gummy bears, coconut flakes, and peanuts
- 80mL whole milk
- Sugar
- Vanilla extract
- 40mL evaporated milk
- Salt
- Can opener
- Something to crush cookies and other additives
- Food preparation gloves

Student Procedures

Note: Before mixing their comets, students should ***wash their hands*** *or put on food gloves.*

Step 1:

One student holds a sandwich size bag while the other places the following ingredients in the bag:

- 40 mL evaporated milk (or cream)
- 80 mL whole milk
- 5 level teaspoons of sugar
- Less than 1 mL vanilla

Step 2:
Think of ingredients you might add to the ice cream to represent dust (e.g., black/brown cookies in fine and large chunks), rocks (peanuts), or carbon dioxide (coconut flakes). **Be sure to keep a list of what you put into your comet.** Place all the elements into the bag, gently squeeze any extra air out of the bag, and seal it. **Check to make sure it does not leak** (Turn it upside down).

Step 3:
Place the sandwich bag into the bottom of the gallon bag. Put in about 10 heaping spoonfuls of salt.

Step 4:
Fill the gallon bag (containing sandwich bag with comet ingredients) 1/2 full of ice.

Step 5:
Note: Students should start this part of the experiment with bare hands so they can feel the temperature change. Make sure rubber gloves, mitts, cloth towels or some thick fabric is available to hold the bag because it will get extremely cold.

Close the larger bag tightly to remove as much air as possible. **Check for leaks**. Observe what takes place as the ice cream comet forms. Record what you discover as you watch this change take place.
Gently shake and roll the bag while keeping it in constant motion for approximately 6 – 10 minutes or until half the ice has turned to water. Gently feel the sandwich bag through the ice-water mixture. When the milk/sugar mixture in the sandwich bag has hardened into soft ice cream, open the gallon bag and remove the sandwich bag containing the ice cream.

Step 6:
Trade your comet with another team so the ingredients are a mystery to them.

Step 7:
When your team receives a mystery comet, be sure to rinse the outside of the sandwich bag with **very cold, fresh water** before opening it so that no salt flavor is transferred to the ice cream. Divide the ice cream comet by spooning some into the cups provided. **Make one extra cup and put it aside. Don't eat this one!**

Pretend your eyes, hands, nose, ears, and taste buds are spectrometers taking data from the "comet." Gather and record the following "data" on your data sheet. *Note: If no one on the team has eyesight, ask a classmate with vision to obtain your data.*

- Take the extra cup you laid aside and feel the contents with your fingers. Describe what you feel on the data sheet.
- Smell the ice cream for additional information. Record your "odor observations" on the data sheet.
- Listen for any sounds that might be coming from the comet material. Record your findings on the data sheet.
- Taste the ice cream and record any final information about its ingredients on the data sheet.

Step 8:
Compare your results with the team who made the ice cream you tasted and record the following on your data sheet:

- List the elements you identified correctly.
- List the elements you missed and explain why you think your "spectrometers" missed them.
- Compare what you observed in Step 5 with other teams. List anything that was different from what you observed on your data sheet.

Source: http://www.ace-education.org/educ_resource/activ_overview/tg_ice_cream.pdf

Learning lessons along the way

Here are some things the developers learned along the way that all teachers, regardless of their discipline, should know and apply in their classrooms:

- **It is important for educators to know where a student is on a spectrum (e.g., visual, learning).** Like all teachers, those participating in the ACE project simply needed to know where to begin. In this case, that meant increasing their understanding about the spectrum of visual impairments, and the project provided manuals with terms and background information for them to use.

- **One size does not fit all.** Again, as with all teachers who have students with unique challenges, participants in the study needed to learn how to alleviate barriers to learning.

- **When it comes to tactile graphics, in particular, there is a difference between "feeling good" and "looking good."** Teachers in the study needed to learn how to construct specialized resources as well as learning about more general resources that are available.

Reflecting on his experience as a reviewer, Ken Quinn wished something like ACE was available for him when he was growing up but is glad it is helping others now. "The benefit can just expand from here—science, mathematics, or history teachers can take what we did and put it into their field," he says. And that's really the point. Many students are tactile learners, not just a few who have a visual impairment. All the developers, researchers, and participants began this project committed to the idea that whatever tools they developed for one student would help all students.

References

Donna Bogner and others, *Visualizing Science with Adapted Curriculum Enhancements (ACE) Resource Manual.* Denver, CO: McREL and Edinboro, PA: Edinboro University, 2009.

About the Author

At Mid-continent Research for Education and Learning (McREL), Vicki Urquhart fulfills a variety of roles in writing, editing, and producing research-based publications and new products. Also an experienced presenter, she conducts workshops around the country. Vicki has more than 20 years of experience as an educator, having taught at the secondary and postsecondary levels and is coauthor of *Teaching Writing in the Content Areas* and *Remove Limits to Learning With Systematic Vocabulary Instruction.* She also is author of *Using Writing in Mathematics to Deepen Student Learning* and several articles on education issues for magazines and journals such as *Phi Delta Kappan, Principal Leadership*, and the *Journal of Staff Development*, among others. In 2007, Vicki served on the planning committee that developed the 2011 NAEP Writing Framework. Her newest book, Tea*ching Reading in the Content Areas, 3rd ed.,* was released in May.