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Teaching the Value of Science

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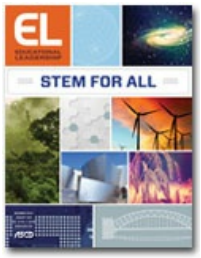
Students will more readily engage in science when they see its relevance—to them. Here are four value-enhancing approaches to teaching science content.



A hush fell over the trigonometry class, heads swiveled around, and my classmates stared at me (Lee), dumbfounded. A few told me later they couldn't believe I'd had the nerve to ask the teacher, with some exasperation, to explain the purpose of the function he was teaching. But I simply couldn't imagine the purpose of the abstract and tedious work we were expected to do, and I wasn't interested in doing a set of problems just for the sake of doing them. Luckily, I had an experienced teacher who provided several concrete examples that illustrated how very useful the function was in the real world. The reassurance that this was actually useful satisfied me, so I did the problems without complaint. All these years later, I still remember the respect I gained for both him and the value of trigonometry.

The fact is, most adolescents perceive little or no value in what they're expected to learn in school and, as a result, they report being bored and disconnected. Educators recognize that students who value what they're learning are more motivated and engaged in class, yet judging from the many teachers we've observed as researchers and talked with during professional development sessions, most don't know how to promote that essential motivational ingredient. In fact, many teachers describe motivation as a fairly stable trait of their students, like eye color or body type.

Thankfully, motivation isn't a trait. Rather, it's a *state*—and states are far easier to change than traits. A central purpose of our work is to empower educators to enhance their students' motivation to learn. Fostering value is one of the best ways they can accomplish this.

The Science Slump

Student engagement tends to decline as students move through middle and high school—and nowhere does it drop more dramatically than in science. The evidence and examples we draw on come from research that we and others have conducted in middle and high school science classrooms (Hulleman & Harackiewicz, 2009; Schmidt, Shumow, & Durik, 2011; Shumow & Schmidt, 2014). However, the concepts and strategies we discuss are relevant for educators across content areas and grade levels.

The fact that few adolescent students in the United States value science has long-term consequences. Jobs require more scientific knowledge and skill than ever before, and that trend is predicted to continue. Students with high scientific literacy will have better career options than those without.

But career readiness isn't the only reason to understand and value science. Many everyday decisions are informed by scientific literacy and by one's ability to think about and analyze situations using evidence. Concerns about the environment, the food supply, health, and energy rank high among the major issues facing communities and society. As such, scientific literacy plays a central role in preparing citizens, a fundamental purpose of secondary education.

Through our own and others' studies, we've learned a lot about why and under what conditions students value their science learning. With funding from the National Science Foundation, we observed approximately 400 science classes in diverse schools and collected in-the-moment reports from students about what they were thinking and feeling during the classes we observed. As a result, we were

able to tie what was happening in the classrooms to students' motivational states and engagement.

Why It Matters

Several teachers we observed were amazingly adept at regularly promoting the value of science, both through explicit statements about why the day's content was important in life and through seemingly off-hand comments that weren't about specific course content at all.

For example, Donna, a 7th grade science teacher, asked one of her students to "explain what speed means." The student replied, "Speed is d/t—and I don't really care about speed. It's just a term we have to memorize for science. It's not really all that important to think about speed in life." To this, Donna responded,

> You play an instrument, right? Does it matter what speed you play the song? Can you play it as fast or slow as you want, and will it still sound good? Or how about getting to class on time? Do you need to be worried about speed? These two examples aren't just about science. Speed is everywhere. You use it all the time.

During this same class period, Donna learned that a student was absent from class because of an orthodontics appointment. She jokingly commented, "Don't orthodontists know that they're taking students out of science class and that science is kind of important? After all, they had to do well in science to become orthodontists!" Donna's comments were rather ordinary, but they emphasized how all aspects of students' lives related to science. Not coincidentally, Donna's students reported the highest science interest levels of all the students whose teachers and classrooms we studied.

By and large, however, teachers like Donna have been rare in our studies. We more often observed missed opportunities for teachers to promote the value of science. In some cases, teachers felt pressured to get through enormous amounts of content and believed they didn't have time to make those connections. The inevitable consequence, however, is that many students disengage from science.

Four Kinds of Value

Research and common sense tell us that when we see value in an activity, we're more likely to engage in it. The good news for educators is that value can take many different forms. Individuals don't have to perceive the same value in a given activity to be motivated to engage in it.

For example, one of us (Jen) is a runner. She runs primarily because she derives great enjoyment and peace from it. In contrast, a friend of hers drags herself out to run even though she finds running unpleasant; she believes that anyone who's truly fit *must* be a good runner. The two women see different value in running, but both types of value motivate them to put on their running shoes each day and ultimately make them better runners.

The same principle holds true for academics. Students don't have to all see the same value in what they're learning. Here are four different ways your students can come to value science—and four different approaches you can take to promote student engagement.

Finding It Interesting: Intrinsic Value

Not surprisingly, students who are interested in a topic are more engaged when studying it.

Some students are interested in a particular kind of music, whereas others are interested in a given sport or game. Individual interests often begin during childhood and are sustained over a lifetime. For example, E. O. Wilson, the father of sociobiology and a renowned biologist, was deeply interested in ants as a child and eventually became recognized as the world's leading myrmecologist (a zoologist specializing in ants).

Teachers who know about their students' interests can draw on those interests when teaching concepts, whether it's connecting a unit on respiration or evolution to someone's interest in fishing or relating content about acids, bases, and chemical reactions to someone's interest in cooking. Teachers can learn about their students' interests through checklists or open-ended survey questions administered early in the school year or by communicating with parents.

Interest development often begins with *situational interest* in which curiosity or wonder is aroused. Many scientists and college science majors point to a high school teacher who sparked their initial interest in science by generating situational interest.

Science teachers can do this by offering *novelty*; many amazing images and demonstrations are available to generate interest in a phenomenon. Showing dramatic video of specific weather events will certainly spark more interest in students than simply having them read textbook definitions. Yet in the numerous lessons we observed during a middle school unit on weather, we rarely saw any videos of the phenomena that students were studying.

Personalizing and dramatizing the importance of concepts through *storytelling* also foster situational interest by appealing to students' emotions. One of the outstanding teachers we know brings the concept of homeostasis to life for her students by telling about a time she fainted in class (see www.youtube.com/watch?feature=player_detailpage&v=fx6arX83bz4).

Perhaps the most effective and underused method is for teachers to *express their own enthusiasm* for the topic. In our research, we rarely observed teachers being passionate about their subject and, instead,

frequently rated teachers' level of enthusiasm as "matter of fact." Our ratings match the recent Gallup poll finding (2014) that the vast majority of teachers report being disengaged in their work.

Now, just because an academic activity is fun doesn't mean that it's necessarily interesting or engaging to students. For example, several chemistry teachers we observed chose to do a lab in which students each made their own ice cream. Unfortunately, the teachers didn't highlight the connections between making the ice cream and the chemistry concepts, vocabulary, or reasoning the students were supposed to be learning. Instead of learning about solutions, states of matter, phase transition, colligative properties, freezing point depression, and crystals, the students simply appeared to enjoy eating the ice cream they made, and they rated the activity as enjoyable but of low value.

Finding It Useful: Utility Value

Students might value their academic work because they perceive it as useful in meeting a short- or long-term goal. A physics student might find that a particular principle helps him or her hit a baseball more effectively. Students may see science as useful for solving a variety of broader problems—from reducing energy costs; to preventing accidents; to promoting good health; to improving air, soil, and water quality.

Students might also value science because it has meaning and purpose beyond their own self-interest. Adolescents are starting to turn their attention to the broader world and their place in it and are often concerned about social justice, moral ideals, and the well-being of others. They're more likely to persist in learning if they believe that what they're learning might matter in preventing or solving social or environmental problems.

For example, we observed a teacher whose students learned physical science through studying the soil from the prairie that surrounded the school, nurturing worm farms in class, growing crops with the compost from the worms, and using solar power from panels on the school roof. Using the Internet, his students shared their knowledge and expertise about high-intensity food production with a high school class in the Middle East (see http://greducation.blogspot.com/2014_02_01_archive.html). The students' realization that they could use what they were learning to help feed hungry people at home and abroad had a profound effect on their sense of autonomy and on their understanding that science has value. In the end, it increased their motivation to learn.

Some research suggests that helping students appreciate the utility value of science content might be particularly effective at promoting engagement among students who lack confidence in their science ability (Hulleman, Godes, Hendricks, & Harackiewicz, 2010; Hulleman & Harackiewicz, 2009). When students feel they're struggling at something, they tend to lose interest in it—that is, "I'm not good at math, so I'm not interested in math." Providing opportunities for students to appreciate why this challenging content is worth knowing can help them maintain their commitment to learning.

A good deal of science content is abstract, and students are unlikely to automatically connect those concepts to their experiences, goals, and the outside world without some guidance from adults. The evidence we collected in classrooms demonstrated that the more teachers talked about how science content applied to the world outside the classroom, the more their students were able to make these types of value connections *on their own*—and the more interested they were in their science education.

Finding It Connects to a Sense of Self: Attainment Value

Before you run out and tirelessly laud the utility of science, there's one caveat here. It's counterproductive to emphasize the utility of science for reaching goals that are inconsistent with students' strongly held identity beliefs. For example, if a female student believes that working in a science field isn't part of the female gender role and her teacher exclusively highlights the value of the course content for those going into careers in the field, this student may grow increasingly uninterested in science. The teacher would need to either emphasize a value more in line with the student's identity beliefs or work on broadening the student's notions about who goes into science careers.

On the other hand, an aspiring paramedic who comes from a family with a long line of military service as medics might have a self-perception of being responsible, cool under pressure, and service-minded. This student is more likely to see success in high school biology as central to fulfilling an identity than is a student who aspires to be a writer, musician, or banker.

Ideas that students have about particular socio-demographic groups can also facilitate or undermine attainment value. Recently, a high school teacher in one of our professional development workshops shared that one of his black students said that his science class was worthless to him because "I'm black. We don't do science." This is a stark reminder of how important it is to expose students to role models with whom they can identify—through stories, posters, films, or guest speakers—and take steps to combat the damaging effects of stereotypes.

Teachers can foster attainment value in several different ways. First, understanding how students perceive themselves enables teachers to help students relate to the content they teach. Asking students to identify their hobbies and career interests on surveys can help teachers identify students' self-perceptions. Second, because adolescents are still formulating their identities, teachers can offer them opportunities to explore various aspects of science through inquiry-based labs, service projects related to science, and career exploration assignments.

Finally, we've observed a handful of teachers who've created a class identity and sense of belonging that they've tied to class work. They use words like "we" and "our class." For example, in reference to an upcoming student mentoring project, the teacher said, "We'll be teaching 5th graders about invasive species. Each one of you plays an important role in making this succeed. The 5th graders depend on your

knowledge, preparation, and good example."

Finding Its Relative Worth: Cost Value

Like savvy shoppers, students often weigh the relative costs of their options. Before engaging in learning, participation, and achievement, they may think about what they'll have to "pay" for it and what they'll gain in return. Video games, part-time jobs, other classes, and socializing may compete with studying for students' time and effort.

If students perceive that their science content has little value, they may calculate that the cost of engaging in it is simply too high. However, if a teacher consistently highlights the value of science in terms of students' interests, goals, self-perceptions, and daily life, it's often enough to sway this cost analysis in favor of science.

A Worthwhile Investment

When students hold the belief, flawed though it may be, that academics have little value, it's no wonder they're disengaged from school. Fortunately, teachers have tremendous power to influence those beliefs. Investing the effort to implement the strategies we've suggested here is well worth the cost. Helping students find value in their learning activities is likely to result in increased student engagement, interest, and performance both in and out of school.

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Poets say science takes away from the beauty of the stars—mere globs of gas atoms. I too can see the stars on a desert night, and feel them. But do I see less or more? The vastness of the heavens stretches my imagination—stuck on this carousel my little eye can catch one-million-year-old light. A vast pattern—of which I am a part. … What is the pattern, or the meaning, or the why? It does not do harm to the mystery to know a little about it.

—Richard P. Feynman From *The Feynman Lectures on Physics*

Strategies to Foster Value

- Identify and capitalize on students' attitudes and self-perceptions, and find ways to discover their interests, goals, beliefs, and concerns.
- Express enthusiasm and wonder for topics of study.
- Create interest during instruction through novelty and surprise.
- Include students in creating meaning.
- Draw connections between the content and its practical applications.
- Use familiar examples. When defining inertia, you might say, "You know how people and things in the car keep moving forward when you slam on the brakes?"
- Make learning emotionally compelling through telling stories.
- Make content relevant to students' families, communities, and cultures.
- Convey the purpose of what and how students are learning. In addition to knowing how the concepts they're learning matter, students also need to understand how inquiry and study skills will benefit them in the future.

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