The Dangerous Intersection Project... and Other Scientific Inquiries

Projects and case studies give students reasons to care about science.

Kathleen Conn

As students move up through the grades, the science curriculum they experience often visits and revisits the same topics. Year after year, students learn about gravity. Elementary school teachers drop objects; middle school teachers drop more objects; and high school teachers begin all over again, this time dropping objects while explaining equations. How many students develop a true understanding of gravity—its importance in the constellation of fundamental natural forces and its unique, mysterious nature? How many students learn to care?

Too often, when we ask teachers why they teach a given topic, they can only reply, "It's part of the curriculum" or "It's in the standards." No wonder students greet each new topic with the pervasive question, "Do we have to know this for the test?"

Science teachers cannot afford to waste their students' time with meaningless repetition. Although not every student will become a working scientist, all students will need to make informed decisions as citizens about crucial science issues: environmental issues, energy issues, spending issues, and ethical issues. That's why we must transform traditional science teaching into meaningful science learning in every grade—by nurturing students' need to know.

Citizens Working for Intersection Safety

If students need to know some given information to be able to accomplish something of importance to them, they learn without seeming to be taught. Science instruction based on problem-solving activities and case studies can motivate students to seek out science information and take ownership of their own learning.

After taking a summer workshop called Engineering Problem Solving in the High School Classroom at Dartmouth College's Thayer School of Engineering, I began to incorporate problem solving in my secondary-level physics classes. Traditional first-semester topics included the kinematics and dynamics of simple objects, such as rolling balls and carts. Thinking about carts reminded me that many of my students were new drivers, and cars were
a hot topic of conversation among them. After reflecting on this, I asked my students to write down the name of an intersection on their way to school that they were afraid to drive through. Perhaps they feared making a left-hand turn there, or the green light signal turned red too quickly, or traffic backed up because of merging lanes. I told the students that we would use the information later, after they had learned some basic information about the physics of motion.

A few weeks into the course, I told the students about a new, nonprofit "think tank" called CWIS—Citizens Working for Intersection Safety—that sought designs for improving dangerous intersections in the local area. Although most of the students immediately realized that I had invented this group, they bought into the idea. They signed a contract to work in teams for CWIS, redesigning the dangerous intersections that they had identified and constructing models or schematics for the improvements that they suggested.

Each contract detailed the kinds of physics equations that students needed to use in their calculations and included a schedule for submitting preliminary plans for the new intersections and presenting final proposals to the CWIS Review Board. The work schedule indicated that students needed to record "billable hours" spent on the project and also outlined the forms that specific parts of the project should take.

As the teams began their work, formerly lifeless kinematics equations became tools necessary to predict how long a car would take to go through an intersection, how fast a car would accelerate down a specific hill, and the safe turning radius for an exit ramp. Students videotaped cars stacked up in left-hand turn lanes, constructed scale models of intersections, timed traffic light sequences, and amassed a large body of information about their community. When the Review Board—composed of teachers, administrators, and community members—assembled to critique student presentations, dress clothes and professional demeanor prevailed among the presenters. No memorization of facts to pass a test was in evidence here. Students learned kinematics equations because they needed to know how to use them to propose improvements in the dangerous intersections they drove through every day.

Science Lessons Based on Problem Solving
To implement the project or case-study strategy, teachers must first choose a scenario on the basis of the learning objectives for a given curriculum unit. The problem-solving scenario must spring from these genuine student learning objectives.

Next, students state the problem that their team proposes to solve. Students must formulate a specific problem statement, so that they know exactly where the team is heading. Students often find this process difficult because they are accustomed to passively receiving instructions from a teacher. Students can continually revise the problem statement throughout the project's duration.

Then, students brainstorm a list of possible solutions to the problem. The team scores each solution on a number scale (1–3 or 1–5, as determined by the team), according to how well it satisfies each of five independent specifications: Will the proposed solution be effective, economically feasible, safe, legal, and aesthetically acceptable to the community? After
generating a total score for each proposed solution, the team ranks the proposed solutions from highest score to lowest score. Looking at the results, the team members decide whether the highest-ranked solution is acceptable or whether they need to refine their problem statement or specifications. The process becomes a loop as the team considers alternative solutions in light of the refined specifications.

When all members of the team are satisfied with their problem statement and proposed solution, they begin to work out the details according to the guidelines established by the teacher.

Teachers can apply this basic problem-solving framework to engage students with a variety of curriculum content in different classes. For example, in a physical science class one year, I invented a "rumor" that a major real estate developer was looking for designs that he could use to build innovative amusement park rides on a local parcel of land. Students had to construct models of the rides they invented and use physics equations to calculate acceleration and momentum at different points in the ride, as well as starting and stopping distances, to ensure riders' safety.

One group of 9th grade boys collected six scuffed but intact football helmets and mounted them on a circular, rotating platform to represent the cars of an amusement park ride. They determined a safe but exhilarating rotational speed for the ride and then calculated the centripetal acceleration of each "car" using equations for force and velocity at the appropriate radius, making sure the ride would not generate excessive "g" forces. The students designed seats and drew schematics for restraining bars, using ergonomic considerations to determine the minimum height and weight for potential riders.

In a chemistry class, I wanted to find a way to stimulate students' interest in the details of organic structure. I told students about a chemical company looking for patentable molecules that would "make the world a better place." Teams of students picked five elements from an element grab bag. Each team was allowed to use an unlimited number of carbon, hydrogen, and oxygen atoms, bonded correctly, and at least three of their grab-bag elements. Their task: to invent a novel organic polymer that would accomplish a worthwhile goal for humanity.

Some of the polymers that students invented would not necessarily have won humanitarian awards. For example, one team claimed that its polymer could be molded into a self-cleaning blue toilet seat using cobalt for color and radium to emit bactericidal alpha particles. Another team came up with the idea of a "Light-Sensitive Crowd Control Device," which emitted hydrogen sulfide when light activated a chain of electron-transferring selenium atoms bonded to a linear hydrocarbon. A third team proposed a detergent-like "Reactor Cleaner" to help engineers flush the inside chambers of nuclear reactors. Pretty heady stuff for 9th graders!

In every case, students became deeply engaged in the science content in the curriculum. Students researched elements and learned how to use single, double, and triple chemical bonds because they wanted to accomplish a task that they had a personal stake in. Not one student asked, "Will this be on the test?"

A slightly different variation on this problem-solving strategy is the case-study approach. Many
biology topics—for example, in genetics or epidemiology—have problems especially suited to this approach. In the case-study model, in contrast to the project model, the teacher usually knows the outcome in advance. The issue may have been resolved in a court case or may have been in the national or international news before the students were even born. The students, however, can struggle with the problem anew, propose and answer "what if" questions, and learn biochemistry, molecular biology, ecology, and critical thinking skills along the way. The creativity of the teacher in describing motivational scenarios or case studies is the only limitation to what students can tackle.¹

For example, an interesting court decision for high school biology students to explore is Moore v. The Regents of the University of California, a 1990 ruling by the California Supreme Court. Moore, a leukemia patient, sued his doctors and medical treatment facility after they used part of his spleen to set up a cultured cell line for the production of cancer-fighting lymphokines. The court declined to find that Moore "owned" his own cells and tissues after surgical removal—although the court did admonish the doctors for not fully disclosing their financial interests in Moore's cells and tissues at the beginning of treatment. This ruling raised important policy issues and led to wide-ranging reforms in what constitutes informed consent and how to conduct biomedical research. Studying this case offers opportunities for students to reflect on ethical questions while learning about diseases and their treatment.

**Bringing the Science Curriculum to Life**

These teaching strategies motivate students to learn curriculum content both because the students themselves define the problem and because the problem requires them to become experts in the subject. The real world is both the stimulus for the project or case study and the motivation that guarantees true student learning.

When teachers use the curriculum to examine real-world problems, the curriculum comes to life and becomes rich in meaning. Students use such technology tools as the Internet, spreadsheets, video, digitized images, data collection devices, graphing software, and presentation software to get a job done. Teachers do not have to be experts in the details of the proposed solutions; they become experts in the structure of the problem-solving loop and guides for students traveling through the loop.

With problems and case studies tailored to students' different ability levels, and student problem-solving teams selected to maximize productive collaboration, differentiated instruction emerges naturally. Peer-to-peer communication skills mature. The classroom is never a boring place, and topics are never stale. The result: authentic science learning.

**Endnote**

¹ Two texts, *Case Studies in Bioethics* and *Case Studies in Bioethics II*, by Ronnee Yashon, are written for the high school biology teacher and contain excerpts from significant court cases as well as discussion questions. Contact RJ Publications, P.O. Box 354, Medford, MA 02144; (617) 625-6165; [http://home.earthlink.net/~ronneey](http://home.earthlink.net/~ronneey).
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