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Building Civic Engagement Capacity

An Introductory Chemistry Example

"Training the next generation of citizens" was the collective vision that gave birth to many institutions

WHAT ARE THE EXPECTATIONS for me, as a chemistry professor at a public, research-intensive university, to "do a good job" within the teaching component of my faculty line? Am I doing a good job if my students satisfactorily master chemical principles and problem-solving techniques according to the department's overall curriculum plan? That's a start. And it would be dandy if I could weave some of my current research into the course, right? Maybe I could even get some students to consider a major in chemistry! Striving to meet such criteria, I would certainly not be indicted by my colleagues for neglect of duties. But everything I've listed so far is a parochial list of outcomes to which I can aspire, unnecessarily confined to department-level visions.

With a slight paradigm shift, not only can I better meet the department's needs, but I can also address the university's corporate responsibility to make education socially relevant. Relevancy is important in seeking funding for our institutions. If we expect the public to continue investing in science and higher education, it is more critical than ever that students connect the content of our courses to its role in public issues. In fact, "training the next generation of citizens" was the collective vision that gave birth to many institutions. University mission statements still reflect this sentiment[1]. If we champion civic engagement in our teaching, focusing it through the lens of our disciplinary specialties, we help our institutions uphold this public trust. We develop the capacity in our students to become active in their postgraduate communities and careers.

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Relevance

The pedagogic modification needed to simultaneously meet departmental and campus-wide agendas is at the heart of the SENCER initiative (Science Education for New Civic Engagements and Responsibilities), launched by AAC&U and underwritten by the National Science Foundation (NSF). NSF supports programs which use complex, unsolved public issues to frame a course—HIV-AIDS, genetic engineering, toxic substances in the environment, and sustainable energy supplies/lifestyles to name a few. It brings immediacy to the science concepts needed and the available tools taught within a course. The idea is to get students to ask questions such as: "Which air pollutants in our community pose the most serious health threat?" and "Who releases them?" or "How can we work as a community to get the biggest health gain for the time and money we invest?" The course content stands squarely between the questions and the answers. Students must navigate the course content if they are to reach some resolution to such questions.

While stimulating civic engagement among students is a lofty goal, the rub, you say, is, "How do you add more to your already overstuffed course without taking away some content?" This

University of Montana

is a pivotal question, especially if you are a "civic engagement pioneer" within your academic unit and you teach an introductory course in a multi-semester sequence. Colleagues expect students coming into their course sequels to have already mastered an agreed-upon set of topics. This article briefly outlines some strategies that I have successfully implemented to infuse elements of civic engagement into my large, first-semester chemistry course (enrollment usually about 450), without sacrificing traditional content. The selection of appropriate illustrative examples and recurrent themes in my lectures sets the stage for civic engagement. Then, an extra-credit mechanism entices students to sample at least some civic activity outside the classroom.

Civic engagement in the classroom

For the past eight years I have retooled my introductory CHEM 151 course at the University of Montana so that students must increasingly connect the course content and themselves to the world outside of the lecture hall. I layer civic engagement into as many facets of my course as I can: (1) incorporating public issues into my sample problems; (2) offering extra credit for calculations that extend the lecture material into local problems; (3) inviting the students to participate in policy hearings; (4) encouraging students to volunteer for relevant community-service projects.

I view every sample problem I work, every application I relate, as yet another opportunity to engage the students and help them appreciate why this particular course is a prerequisite for their majors. I take advantage of public issues that are most likely to capture the specific interests of my student audience. CHEM 151 is the first semester of a one-year, non-major's survey of general, organic, and biochemistry. The course is for students in disciplines that require grounding in chemical principles and an understanding of biochemical processes, e.g., forestry, wildlife biology, pre-nursing, physical therapy, medical technology, exercise physiology, sports medicine. Given these demographics, I instantly garner their attention by connecting the concepts I am teaching to topics such as toxic chemical releases and their health impacts, conservation biology, water quality and fishery impacts, sustainable timber harvests, prescribed burns as a forest management tool, diabetes (prominent among our Native American students), and performance-enhancing drugs. I often try to keep a lightness to the class atmosphere as well. Here are a few illustrative examples:

- Conversion between metric and English units: If a slug uses 0.10 mL of mucus to travel 1.0 meter, how many miles per gallon does the slug get? (Answer: 24 mpg.)
- Heating and cooling curves: If a bird needs 5 grams of water each day, how much energy does it save by finding open water in the winter instead of eating snow? (Open water: 190 cal to warm to body temperature; snow: 615 cal to warm to body temperature, or 3.3 times more energy.)
- Nuclear chemistry: Sticks encased in mineral deposits just north of Yellowstone National Park were carbon dated to establish how long metal-laden waters have been flowing into the Lamar Valley. If the C-14 count in the mineral-bound sticks is 45 percent that of living sticks of the same species, how long ago were the sticks cemented in place? (Answer: 6,500 years ago.)

Making room for civic engagement

Once I capture the students' interest through relevant sample problems, I shamelessly use extra credit as a civic engagement hook to cajole them into donating out-of-class time toward exploring topics further. Extra credit is built into the weighted-average formula I use to compute the overall course average. The formula, which is deceptively simple, has three terms, each of which serves a different role:

quizzes (25%) + hour exams (50%) + final exam (25%)

term 1 term 2 term 3

The overall course grade is based on a 600 point system: 150 points for the quiz term, 300 points for the hour exam term, and 150 points for the final exam term. The interaction among the three terms or components is what allows me to subtly exert influence on the class in different ways. Regular attendance in class is forced by the quiz term. The ultimate accountability for overall course content is contained in the final exam term. But the middle term, the one for hour exams, lets me draw them into giving outside time to the course.

While exams serve their traditional role in evaluating student mastery of course concepts and problem-solving skills, the exam portion of the formula is where I tabulate extra credit for out-of-class civic engagement activities. Since I

keep the best three of four one-hour exams, 300 points is the maximum score for the hour exam term. Throughout the semester I offer a wide variety of supplemental engagement activities for students to earn points that can be directly added on to their hour exam point total. Through this extra credit, there is a redemption mechanism for a subpar performance, so I feel no compunction to relax the rigor of my exams. (But I usually strive for an average of 75 percent so as not to trounce any positive attitudes that may be developing toward the physical sciences among a generally insecure population.)

Some exam extra credit is simply an optional assignment through which the day's lesson is applied to a community issue. For example, when I teach chemical stoichiometry, the mass relationships among substances in a chemical reaction, my lecture illustration quantifies the local pulp mill's carbon dioxide releases. At its conclusion, I point out that the mill's CO_2 emissions are biomass derived. For extra credit, I have the students compute how many pounds of fossil fuel CO_2 are emitted from the collective driving of motor vehicles in our city. To do this, I supply them with the latest traffic-count statistics. (As a community, Missoulian's drive 1.3 million miles a day just within our small, mountain-bound city and release more than 1 million pounds of fossil fuel CO_2 per day.)

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My favorite extra credit takes students out into the community to advocate for policy: attending public hearings, writing letters to the editor or elected officials, testifying at public hearings, or participating in volunteer mentoring—math/science tutoring in after-school programs (Flagship Project) or in-school programs (McKinney Tutors) for children of latch-key families, homeless families, or families whose battered mothers seek refuge.

Why am I, a chemist, interested in public policy? I want to ensure there are voices, comfortable with science, whenever community discussions occur. I work toward this goal in making my students scientifically competent civic agents. Isn't a hallmark of our democratic heritage the notion that decisions grow out of a community dialogue? Shouldn't we be training our students about how decisions get made? There is some extra effort (i.e., time) that must be invested to get a complete buy-in by the students. Unless they see through their own participation that the out-of-class activities are worth the ef-

Smith at local K-12

University of Montana

fort, they will be less than enthusiastic. It is also important to personally witness some of their "extra-credit" altruism. This was often painless for me, as many of the county- and state-level policy hearings offered as extra-credit options were heard by policy boards on which I hold a seat. If they testified, I was there to take their comments.

With mentoring, in particular, strong bonds often arise between my student tutors and their young charges. Some donate more than thirty hours over the course of the semester. Many continue to volunteer in the following semester when there is no built-in extra-credit motive; they simply cannot imagine abandoning their protégés. For instance, Matt Phifer, a sophomore Spanish major who took CHEM 151, in an extra-credit report wrote:

> I have been participating in the McKinney tutoring program for about 7 weeks now and have seen improvement in Julian [the student]. Julian seems to favor science over his other subjects. He has a basic understanding of the other subjects, but seems interested more in my chemistry class than his own homework. It has been a great experience this semester, and I am looking forward to continuing the tutoring next semester.

The fact that Matt had to digest the CHEM 151 course material for Julian validates in my mind that the tutoring activity is germane to course goals and that it promotes deeper learning for my student volunteers.

Extra credit is awarded at the rate of three points per hour for out-of-class activities. Given the weighting factors in the overall course formula, six points (or two hours of community activities) are required to raise the course average by 1 percent. Students are hooked into pursuing extra credit on three counts. First, there are those who do the extra credit to build up a cushion as insurance against a stumble later in the semester or as a mechanism for coasting, once the desired grade level seems assured. Second, students do extra credit after a bad exam result. Finally, the remainder of the class gets drawn into the "extra-credit chase" after they see their classmates accumulating points. I prominently post weekly spreadsheets that include an "EEC" column that tracks "exam extra-credit" points

where the positive impact is only too apparent.

Participation

How much do students take advantage of the exam extra-credit course feature? During fall 2002, 375 of 412 students participated in some form of extra credit and averaged 9.6 points apiece. In fall 2003, with increased effort to engage students, 381 of 410 students averaged 12.2 points of extra credit. Most students earned points via a combination of lecture extension exercises and community involvement. Most invested about three hours outside of class in off-campus activities. Thus, the class was responsible for contributing almost 1,150 hours of community involvement—a gift to the city leveraged by a required chemistry course.

Occasionally, a student gets wise to my weighted average formula and tries to "blow me out of the water" with extra credit. I don't panic. I smile and then exempt them from the final exam. Without exception these are very engaged students who would have gotten an A without extra-credit options. So they get their A, and I get to let them savor the taste of "good citizenship."

Do the students feel exploited? Not in my experience. Cathy Crane, a post-baccalaureate student returning for a second degree in exercise physiology, shared her opinion of the civic-action options in an unsolicited email:

> I also really enjoy the way you use extra credit. It encourages people to pull their heads out of the sand, out of their books, out of televisions, and out of their "You-know-whats" in order to do something productive. Very inspirational. Thanks again.

Summing up

The prescriptive plan I have just summarized for my introductory chemistry course is but one example of how to build civic capacity into a course. There are many other models for this kind of approach at institutions around the country. Surfing the Web using "civic engagement" as the subject reveals dozens of papers, presentations, and workshops that describe curricular reforms or pedagogic innovations that draw students into exploring current, real-world issues. The National Science Foundation has articulated the importance of civic engagement, so that most administrators will be receptive to one's initiating some personal efforts in this direction. Judith A. Ramaley, assistant director at the NSF Education and Human Resources Directorate, said, "The major challenge facing contemporary higher education is to enhance its relevance and connectedness to the issues and problems faced by the broader society, as these problems are defined by community members and not by academics independently of the views of others."

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If we want to prompt our students to become civically engaged, what better place than at the beginning of their college careers, in introductory courses, before they know any better? Ideally, they will exit the course with the expectation that this is the way all college courses work. And what better place to deliver the experience than in large, required, undergraduate survey courses? It is efficient and ensures that a high percentage of students get a taste of civic engagement. It draws favorable attention to one's department from both the administration and the community. Lastly, a little civic outreach by a sizable number of students adds up to a great benefit for our local communities. We do well to inculcate the perception that higher education is a good thing to have in the neighborhood. □

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NOTE

1 As a case in point, here is an excerpt from the mission statement of my home institution, the University of Montana-Missoula: "Through its graduates, the University also seeks to educate competent and humane professionals and informed, ethical, and engaged citizens of local and global communities." (www.umt.edu/president/UMMS2.htm)