Leverage

I want students to achieve at levels that surprise them. This process begins, as it does most years, at 9:10 am on a Wednesday morning in early September, where I've not only got the mind-boggling thrill of being the first college instructor ever encountered by a group of 450 new first-year students, but the class I'm teaching is organic chemistry. "Organic chemistry"... two words that can bring a dead stop to the polite chat you are having with that person in the seat next to you on the plane from Detroit to San Francisco. And yet, at 9:10 am on that Wednesday, I have an incredible opportunity to leverage an important thing we know about the transition from high school to college: students expect college to be different from high school.

For students who want to engage organic chemistry, this subject I love, on a broader and deeper level than we do in the large lecture, I have created elective options that any of them can take advantage of throughout the year. One of these, called "Structured Study Groups," is designed to emulate the studio assignments I had when I took drawing classes in college. Students are tasked with creative work and then bring the results to weekly, two-hour session for presentation, peer review and critique – all under the watchful guidance of a junior or senior student leader. Many of these tasks surprise the students: for example, they don't always believe that I mean it when I point out that a big chunk of the syllabus is blank because they are the ones who are going to fill it in. For my students and me, teaching and learning are both community property. Here are a couple of examples of "surprising achievements."

(I) First-year students can write the text of the course. As a scientist, I care about one overriding lesson: when students encounter new information, the first two questions they need to answer are "Do I believe this?" and "Does the evidence warrant the claims?"

Every year, then, since 1994, about 100-120 first-year students taking second semester organic chemistry transform a set of contemporary research articles into teaching materials for each other. We internally publish this 250-page book, and launch its companion web site, a multimedia feast, about 2 weeks before the final exam. This is peer-reviewed, student-generated work on which I base the questions for their final exam. My challenge to them is extreme: as good as the work is (and it is excellent), I base my exam questions only on whatever errors remain in *their* book. Inevitably, the students figure out that they (as a class) need to reserve a classroom to work with one another, as a cooperative community, in order to study for the final; after all, if they find something in *their* book or web site about which they have a question, they know who the authors are! Those two questions I posed dominate the discussion, and these are critical lessons that I hope will last when the details of chemical reactions with esoteric names (such as "Diels-Alder Cycloadditions") have long faded away. I've been delighted to learn that there are at least 20 other organic chemistry professors around the United States who wait for our latest web-text to come on line every year, because these instructors give assignments to their own classes based on the teaching materials created by my students.

(II) First-year students can construct the lab course. On the first day of class, my students are stunned because their laboratory syllabus after the mid-term break is literally blank. Once again, they use the chemical literature to devise simple, yet original, research proposals for what ought to constitute their work during the second half of the term. From about 30 team-written proposals, the class is responsible for reviewing and narrowing the field down to the best set of 4, at which point we order the necessary chemicals and have them ready for when the students return from Spring Break.

My philosophy. As a professor, I favor providing opportunities for open creativity and shared leadership experiences for my students. I see my function as no more or less than one of the legs that gives balance to a stool. Not only do my students take a great deal of responsibility for learning from each other, but this kind of complex teaching also relies on a team of instructors. Each year, much of what I have described above relies on a new team of 4-5 upper-level undergraduate student instructors who excelled in this course when they took it; they showed promise from their high mastery of the material, from their ability to communicate it, and from their group leadership skills. These undergraduates – my co-instructors in this course – lead the weekly, two-hour sessions where the bulk of the student-generated work is created. The graduate instructors in the laboratory sections must also learn what it means to teach differently, as their students begin to call the shots. I see this sort of teaching as a true partnership between my undergraduate and graduate instructors, my students, and me: "teaching groups" for doing complex teaching, as an exact parallel to the "research groups" that we in the sciences use so routinely for doing complex research.

Extending to the department. To my surprise and delight, my departmental colleagues have found this idea of teaming with graduate students and post-doctoral associates an appealing way to get their teaching ideas accomplished, too. Over the last decade, faculty-led teams have become *de rigueur* for instructional development projects in my department. I help to coordinate the work of about 40 Chemistry PhD students and 10 post-doctoral associates who have added a program in educational design, implementation, and assessment to their laboratory research. These individuals are the future faculty, and they begin their independent academic careers with an unprecedented level of preparation and experience.

Extending to the university and the community. The concept of extending the intergenerational research group structure to "teaching groups" is finding broad appeal. I accept many U.S. and international invitations to talk about this program. In 2007, the University of Michigan embraced an overture to institutionalize my work, and I was appointed as the co-Director of the *IDEA Institute* (Instructional Development and Educational Assessment). In IDEA, we are extending the "teaching group" structure we have created in chemistry to the other science and mathematics departments. Improving undergraduate education is not our sole focus; because IDEA is a collaboration with the School of Education, we are implementing the concept at the K-12 level. We team K-12 teachers with first-year undergraduates, who can get K-12 teaching experiences while still enrolled in their basic science classes, and at a time before they would be thinking about joining the teacher education program.

International engagement. International collaboration is the next frontier. I am currently working on projects with colleagues in China, including directing the first truly bilateral undergraduate research exchange in the sciences between our two countries. My collaborators at Peking University are also curious about the "teaching group" idea. They want to understand better how the U.S. system of education inspires high levels of creativity and achievement in students. I am excited by the plan we are putting together. In early 2010, we will begin testing a scheme where teams made up of students from both campuses would collaborate on group assignments, such as the "Do I believe this?" text and web site, by using common virtual workspaces and electronic conferencing. We will also be sharing laboratory proposals generated by students in both countries.

Even five years ago, I could only dream of leveraging my earlier work into such exciting opportunities for student achievement, and to have this range from my colleagues' college classrooms, into high schools, and across the globe. Today, I am privileged to see increasing numbers of students, in all of these settings, who can surprise themselves with what they can do.