How to find students’ inner geek

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How to Find Students' Inner Geek

Our family has two special pets, Shine and Shimmer. Place them under black light, and they will glow green. They are transgenic nude mice, which means that they have no fur but possess genetic material from another species: in this case, green fluorescent protein from jellyfish.

When my daughter's kindergarten class had "pet week" last March, I brought Shine and Shimmer to the class. Our slightly smelly, very unusual rodents fascinated the kids. They listened to everything I had to say and then drowned me with questions: "What if my cat ate Shine? Would she glow?" "Is it right to put jellyfish stuff in Shimmer?" "Does it hurt them?" and "Could you put bird DNA things in your mouse and make him fly?"

Two weeks later I took Shimmer and Shine to a sixth-grade class, where I had been invited to talk about chemistry as part of a "career day." Half of the students reminded me of the kindergartners — they were wildly excited and interested. However, a sizable portion of the sixth graders were so practiced at hiding their interest that I couldn't tell whether they would rather hear about the mice or eat spinach. What had happened to all their noisy, exuberant thirst for answers? Was it still there? And, if it was, could we reach deep inside them and bring it back out?

By the time they reach college, students have matured. They no longer jump up and down so that they can be the first to ask the teacher their questions. Most of the students in introductory science classes are no longer fascinated by science; they are taking the courses only to fulfill some requirement.

As a chemistry professor at a liberal-arts college, I believe it is my job to find the youthful awe in my students and draw it out so that they will be intrigued once again by science and nature, so that they want to learn about equilibria, pH, and redox reactions. I have to go fishing inside their brains, to find, hook, and reel in their scientific spirit.

Fortunately, in the fertile fishing ground of my selective college, most of the students I teach have not yet deeply suppressed their inner science geek. I can hook almost all of them if I use the lures available to professors everywhere: enthusiasm, a smorgasbord of teaching techniques, demonstrations, and real-life examples.

But every year I see some fish swimming through my courses that I would dearly like to catch, students from underrepresented groups or students with great potential who don't seem to hunger for science. To reach the scientist within those students, I resort to my extra-super-duper bait: undergraduate research.
The Council on Undergraduate Research defines undergraduate research as "an inquiry or investigation conducted by an undergraduate that makes an original intellectual or creative contribution to the discipline." Requiring that the research contribute to the discipline implies that the work be disseminated through established means, like peer-reviewed journals, and that others in the discipline value the findings.

But to work as superbait, undergraduate research has to be made attractive to teenagers who often have completely different social, cultural, and scientific backgrounds from those of their "nerdy" professors. In addition, many studies have shown that students from underrepresented groups and first-generation college students are reluctant to talk to their professors and do not feel entitled to their time.

Liberal-arts colleges are fortunate enough to be able to offer relatively small introductory courses, taught by research professors. I teach a general chemistry class and laboratory, and I know all my students on a first-name basis. Small class sizes give me the luxury of seeking out the students who are uncomfortable with science or academe, and drawing them into research by inviting them to help me with my experiments.

Although liberal-arts colleges enroll only 8 percent of all four-year-college students, from 1991 to 1995 their graduates received more than 17 percent of all the Ph.D.'s awarded in science. Clearly liberal-arts colleges are much better than research universities at finding the smaller fish, those students who are not doing well in class but have great potential to develop into scientists on their way to graduate school. The big fish will get caught no matter where they are, but their smaller peers benefit more from personalized research experiences, small classes, and specialized support services — characteristics commonly associated with small, liberal-arts colleges.

Undergraduates have to spend at least two summers doing research in college to reach the break-even point, at which their contributions to the research outweigh their demands on the professor. Professors at liberal-arts colleges generally don't have graduate or postdoctoral students, nor do they have time to train new students each summer. Therefore we have an incentive to hook students early and keep them interested in doing research. That can be done in many ways:

I have changed how I think and talk about my research, especially when I am trying to lure undergraduates into it. For example, once I would have told students who were interested in doing research with me that they would be undertaking a computational analysis of nonplanar deformations of factor F430 in methyl coenzyme-M reductase. That's just what my students have been doing for the past three years — but I hooked them into doing it by saying that we'll be using computers "to study cow farts." The students will also be learning about glowing genes and cancer.

Students need role models. I often brag about "fish" I have caught in the past, and whenever possible I bring those students to class so my current students can see what opportunities are available to them, and what they can accomplish.

The first exposure to scientific research can be intimidating. I try to make the lab a friendly place, and I spend a lot of one-on-one time with my research students, not all of it in the lab. In the last two months I have invited the students to my house for dinner so they can meet Shine and Shimmer, and we have
gone to the beach and some local sports events.

Research has shown that it takes one and a half to two years to establish a mentoring relationship in a university setting. In my experience, the liberal-arts setting, and especially a one-on-one research relationship, speeds up that process and is very effective at breaking down barriers between professors and students.

- Professional meetings are an important part of the research training of our students, so I have gone out of my way to find funds to send my students to chemistry conferences. At least once a year I take them to national meetings of the American Chemical Society, where they present posters about their research. I also send them to local meetings. Most of the trips are paid by my grants, with a supplement from the college. Not only are the students exposed to lots of new science, but they also have fun hanging out as a group.

Those are some of the ways I try to catch the scientist within my students. I suspect that most science professors at other liberal-arts colleges are using similar bait.

That might be changing, however, because some faculty members at liberal-arts colleges are adopting a big-university research model to become more productive researchers, a change that their administrators believe will help improve the colleges' rankings. Those professors are no longer using their own rods and reels but are hiring postdocs and technicians to do most of the research, placing a layer between themselves and undergraduates. As a result, they are reducing their ability to become effective mentors.

Perhaps it is time that liberal-arts colleges add fishing to research, teaching, and service as criteria for tenure and promotion.

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By Marc Zimmer, Professor of chemistry at Connecticut College.

Marc Zimmer is author of Glowing Genes: A Revolution in Biotechnology (Prometheus Books, 2005).

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