GRADUATE RESEARCH PROGRAMS ENRICH UNDERGRADUATE EDUCATION

J. E. Leach
University Distinguished Professor of Plant Pathology
Kansas State University

Few of us would disagree that graduate education and research are inseparable, that is, high quality graduate education is built upon creative and productive research programs. What may not seem so obvious, especially to non-academics, are the tremendous contributions that graduate research and education programs make to undergraduate education. More frequently, we hear assumptions to the contrary, that is, graduate research and education negatively impact or distract from undergraduate education. For example, some suggest that associations between graduate students and undergraduates occur only when graduate students serve as teaching assistants in undergraduate classes, or that excellent researchers are mediocre teachers because they are too busy scrambling for research dollars. Here, I would like to provide examples that demonstrate how undergraduate education programs are enriched by graduate programs.

The Benefits of Research Experiences for Undergraduates

Our goal in graduate education is to provide the philosophical, theoretical, and technical bases that are needed to develop strategies, to solve problems, and to enhance our knowledge base. In other words, we strive to educate our students in the process and excitement of discovery. Graduate education provides students with skills in the scientific method, including hypothesis development and the technical and analytical skills needed to test that hypothesis. Graduate students are taught to collaborate to achieve research goals at many levels, i.e., the one-to-one interactions with their major professors or their advisory committee members, with other scholars in their department or research group, or with researchers at other institutions who are tackling the same research question.

How do graduate research and education impact undergraduate education? In first-rate research universities, graduate students constitute one part of the continuum in education offered to undergraduates. As part of their training to teach, graduate students not only serve as teaching assistants, but they also learn valuable skills by supervising undergraduate research projects. For example, at any given time in my

own laboratory, between three and five undergraduate students are involved in research at different levels, each supervised by a graduate student or postdoctoral fellow. These research experiences last for various lengths of time. For example, we frequently host undergraduates from the 1890's universities in the United States or from a university in France to perform summer research projects. Other students may be involved in one or more research projects throughout their undergraduate program. One undergraduate worked directly with a postdoctoral fellow to clone rice genes encoding an enzyme thought to be involved in targeted secretion of plant defense compounds. She started as a freshman and worked on the project throughout her undergraduate career. During the course of her project, she mastered many basic and advanced techniques required for molecular biology, and, by the end of her stay, she was training new lab members in these techniques. This well-trained and motivated student has just started a Ph.D. program at Oregon State University in Plant Molecular Biology.

Many of the undergraduate students start in the lab as dishwashers but soon become interested in what's happening around them and ask to do research projects. The funding for the projects is usually from external grants, but some students have had their own fellowship funds. For example, one of my undergraduate students was a Goldwater Scholar and another a Howard Hughes Scholar. Depending on the interests/skills of a student, projects vary from stand-alone to those in which the undergraduate assists a graduate student with his or her research project. Several projects have been so successful that the students have presented their work in the form of a paper or poster at a regional or national meeting or have earned co-authorship on a publication in a peer-reviewed, national journal.

Considering who the undergraduate student works with or interacts with in the laboratory, the training often goes beyond acquiring research skills; these students learn collaborative skills. Interactions between graduate students from other countries and "Kansas kids," who may have never been out of the state benefit both the undergraduate native and the graduate student. It is thrilling to watch prejudices melt and admiration build as research interactions progress. We have a responsibility to prepare our graduate and undergraduate students to function in a global economy; what better way than to build international friendships and collaborations early in their careers?

Spillovers from Research Technologies: Innovative Teaching Tools

Research programs can impact undergraduate education in other ways. Undergraduates are exposed to state-of-the-art equipment and technologies through classes as well as research experiences. Access to

such equipment and technologies can inspire researchers to develop innovative teaching technologies that impact both graduate and undergraduate students. For example, we recently experimented with the Internet 2 as a means for interactive, high quality teaching. In the fall 1999 semester, two colleagues and I collaborated to teach Molecular Plant-Microbe Interactions on three campuses (University of Nebraska, Oregon State, and Kansas State University) simultaneously. To deliver this graduate-level course, we used new interactive technologies made possible by the high-speed, high-capacity Internet 2. The Internet 2 can send more than 2.4 billion bits of information per second, a much faster rate than many phone modems that operate at 56,000 bits per second. The huge capacity of the Internet 2 makes it an ideal medium for sending high-quality video.

For many years, my colleagues and I have been concerned that in our shrinking and often small-sized classes, our students were missing out on the kinds of exciting exchanges that shaped our own graduate careers. Using the Internet 2 as our medium, our dream was to link our classes at the three universities into one high quality, fully interactive, real-time class. Each classroom contained microphones, cameras, and video monitors. For example, my classroom at Kansas State University had three monitors, two showing the University of Nebraska - Lincoln and Oregon State University classrooms, and one displaying the visual aides I was using. Initially, both students and professors were shy of the cameras, but it was amazing how quickly we adapted to talking to our colleagues on the television screens as if they were in the same room.

Our goal was to expose the students to the different expertise and philosophies of the three instructors while at the same time "meeting" and interacting with their future colleagues at the other universities. The class was a lecture/discussion format, with the three professors sharing responsibilities for presenting lectures and leading discussions. To help stimulate discussions, my colleagues and I were present during each lecture or discussion. A common website was developed to provide a venue for posting notices, handouts, and reading lists as well as for group threaded discussions.

From the very beginning, the instructors agreed that class discussion sessions were critical to the students' learning experience, so having real-time discussion capabilities with no delays or gaps in conversations was given the highest priority—and this component was the most taxing to our technology systems. The broadcast video engineers and the computer and network specialists worked for six months before the start of the class and were literally testing, experimenting, and writing software throughout the semester to achieve the high quality we demanded. This was a true collaboration between the engineers,

computer specialists, and instructors. And it worked. It was amazing how the technology became transparent during the heat of a discussion. After one particularly stimulating discussion in which the students from all three campuses participated freely, one engineer commented “we have landed.”

Although the course was not without its bugs, in general, the students and instructors agreed that the experiment was worth the effort, and that the technology offers great possibilities for teaching in the future. How we use that technology to provide high quality learning experiences for our graduate and undergraduate students or to advance our research fields is limited only by our imaginations.

Summary

The intertwining of graduate and undergraduate education and research programs benefits and enriches the learning experience for students at both levels. Graduate students learn to teach and advise, they learn from teaching, and together, the graduate and undergraduate students learn the excitement and process of research. Faculty research and teaching efforts also benefit from the continuum of training. Research productivity increases from their groups, and the energy of the interactions charges new ideas that can benefit both research and teaching. For example, development and testing of a novel teaching approach involving the Internet 2 for highly interactive discussion classes resulted from exposure to state-of-the-art research tools.