The Impact of Research Experience: Enabling Students to Meet Future Challenges

Gwen Davis[1], Jun Jiao[2]

[1]English Department, Portland State University, Portland, Oregon, USA ,
[2]Physics Department, Portland State University, Portland, Oregon, USA

gyd@pdx.edu[1], jiaoj@pdx.edu[2]

Abstract

Traditionally, high school and undergraduate education takes place in a classroom and expects students to extract information from textbooks, PowerPoint presentations, and hour-block lectures. For the science and engineering students, the laboratory sessions are typically designed to test only concepts, rules, and laws rather than to solve real world problems. This methodology does not challenge the students to fully understand or master the knowledge presented to them. Consequently, the students feel less prepared when they enter the real world. To overcome this problem, our experience suggests that actively involving students early in their education in research at a university significantly impacts their choice to pursue higher education and bolsters their career development. In this report, we present a research experience for undergraduates (REU) program that has been successfully operating at Portland State University (PSU) since 2001. In this program, we use electron microscopy and microanalysis techniques as a magnet to attract interested students in an effort to motivate them to pursue advanced degrees and careers in this area. Since the microscopy technique is broadly used by many science and engineering disciplines, including Physics, Chemistry, Biology, Electrical and Computer Engineering, and Mechanical Engineering, many faculty members are involved in this program and serve as REU faculty mentors. Teaching students technical skills and involving them in research of various disciplines greatly enhances their self-confidence and problem solving abilities, ultimately making them better prepared to meet future challenges.

Introduction

The research experience for undergraduates (REU) program at PSU is a multidisciplinary program united under the theme of microscopy and microanalysis techniques. It provides opportunities for undergraduate students—with an emphasis on underrepresented minorities and females—to be involved in research projects with faculty members in various science and engineering departments. This unique program enables students to quickly engage in actual research work.

More than twenty years ago, the National Science Foundation (NSF) in the United States established the REU program in an effort to encourage student participation in the sciences.1 REU programs sought to provide research opportunities that would foster a renewed interest in science and engineering research-related graduate education and career paths. Today, this program is training students to be the researchers of the future, more qualified to enter graduate schools as well as more empowered to begin making significant contributions to the science and engineering fields. This program is uniquely complementary to traditional in-class education because great emphasis is placed on professional development and mentorship—key strategies impacting a student's ability to meet future challenges. The success stories of more than 100 undergraduates and 10 high school students who have participated in PSU's REU program suggest that three core components contribute to the effectiveness of the program: (1) Creating suitable research projects, (2) Recruiting motivated students, and (3) Mentoring the students. Together these components in conjunction with the essential features of the program prepare students to meet the demands of advanced education and a competitive job market.

Program Overview

In general, REU programs are eight to ten weeks long and forty hours a week, fully immersing the student in full-

time work on an independent research project to emulate the demands of the career researcher's schedule. At PSU the summer program launches with a week-long intensive training course with seminars on the application of microscopy and microanalysis taught by the program director, database research taught by PSU's research librarian, and safety training taught by the environmental safety technician. The morning session is reserved for lecture and presentation, while the afternoon is dedicated to hands-on, experiential learning with either the scanning electron microscope or focused ion beam microscope. After training week, the students work in the lab with their mentor for the next seven weeks building confidence and shoring up their skills.

Research Project Design

REU programs must provide students with an accurate research experience; the projects they undertake during their internship need to be current and part of an ongoing research endeavor.2 Students should also be able to achieve results during the short time period and the projects must be appropriate for an undergraduate. Creating such opportunities will educate the next generation of scholars who will be experienced at and capable of participating in a dynamic and competitive global economy, in part because of their extensive training.

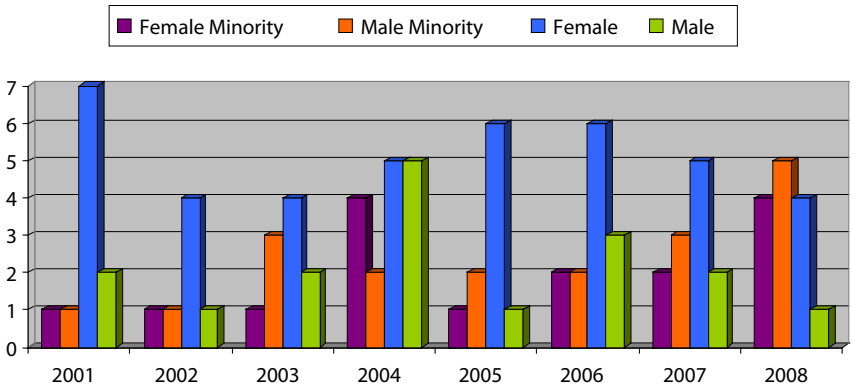
Feedback from past participants confirms that offering appropriate projects promotes both confidence and enthusiasm for the project: "I was constantly busy doing things such as making culture media, preparing samples for analysis, and making databases to keep the lab organized. Also, because my project was heavily dependent on use of the SEM [scanning electron microscope], I was able to put the skills that I learned during training week to good use."3 This type of experiential training complements the didactic techniques employed in the classroom. Including students in research projects allows them to role-play a career in science or engineering as well as encourages high-level problem-solving skills, which are essential for success in the real world: "I also had the opportunity to improve my interpersonal skills …I interacted with not only those people within my faculty mentor's lab…but also people from other labs…Because of this, I gained a new appreciation for how research is done in the lab. I realize now that research projects are often multidisciplinary, which requires that the researcher reach out to a vast variety of resources in order to gain the necessary knowledge."3 These students not only realize that they can accomplish advanced tasks, experiments, and projects, which is a huge confidence builder and motivator, but they also become comfortable in a lab setting. This confidence catalyzes the student to learn more and to seek out additional opportunities that challenge the student to gain further experience.

Recruiting Students

For an REU program to attract a highly motivated pool of applicants, a great deal of recruitment needs to take place. A variety of recruiting tools should be utilized, including mail-out flyers, material distribution at conferences, and web postings.2 In recent years, more and more recruiting is performed via the Internet. An informative, easy-to-navigate website is also imperative to any recruiting effort.2,4 All the necessary instructions, forms, and information about the program should be presented in an organized and visually pleasing manner. Websites also serve to connect former REU participants and keep them updated about the program.2

A key objective for the PSU REU site is the recruitment of underrepresented groups, since they often have the least amount of access to research experiences and labs (Figure 1). Framing a program around the needs of the community, both locally and nationally, in terms of demographic populations focuses recruitment efforts and narrows down the applicant pool to a manageable size. This program has inspired one female participant who is currently at a community college to continue her education at the next level: "If I thought I was motivated to achieve a career in the scientific field before I joined this program, then I am truly dedicated now… I had almost made up my mind that an undergraduate degree would be enough for me, but now I don't think that is the case. I see a future of many more years of education."5

Figure 1 (below) displays the demographic history of the PSU REU program, which focuses on involving female and minority students. Over the years, the program has adapted recruiting methods to target underrepresented students, bolstering the number of minority population applications received:



This sense of urgency—the desire to know more and achieve more—exemplifies why research experience for undergraduates must become the standard in terms of preparing students to take on the immediate challenges of the future. REU students leave empowered to pursue more challenging, high-level opportunities both educationally and professionally. While the typical lecture and lab will always be a necessary step in a student's education, the addition of hands-on, real-world experience completes the picture. Students begin to understand what they are working toward.

Faculty Mentors

Creating hands-on opportunities for students to engage in research is a highly effective way for them to identify the field they are interested in, build the confidence to pursue advanced degrees, and become independent thinkers capable of solving a variety of problems.2 One way this program helps students realize their potential is through mentorship, matching participants with knowledgeable and engaged advisors. The projects created by the faculty mentors are designed to let the participant take control and meant to challenge the participant to problem solve and think independently.

The initial reaction reported by students who have never participated in research is extremely positive: "It was when being led into [my faculty mentor's] lab for the first time that things began to drop into place. We were in a laboratory of a professor who not only intimately understood the concepts of microscopy but actually built his own instruments…it is this hands-on approach that causes concepts to lodge themselves in the mind and to subsequently make one comfortable."6 But this relationship between mentor and mentee is a symbiotic one. A post-doctoral researcher working with an REU participant recognized that involving highly motivated students in the lab accelerates current research efforts: "With the help of an REU student, I can focus on designing the experiment. I can also focus more on writing papers based on our experiment's results. The REU student gains experience about how to use our state-of-the-art equipment, how to organize experimental data, how to do literature research, and how to write technical reports."7 Faculty mentors learn what tools students need to succeed as well as how to address voids in current teaching methods. Educators must adapt their curriculum to better serve the students, training them to meet modern society's needs.

Essential Features of the Program

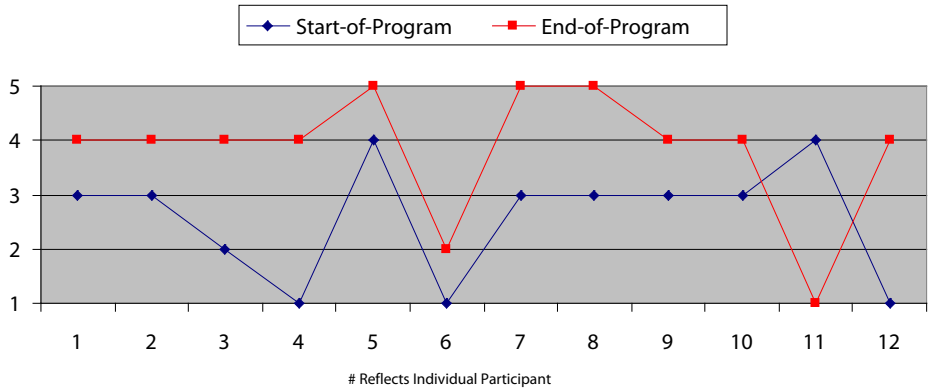
In addition to training week and the following seven weeks spent in the lab, evening ethics seminars offer yet another opportunity for participants to explore science and engineering, but in a very different manner than in the lab. Through scholarly articles, lecture, and group discussion, this two-part series leaves the students with a new awareness, which will hopefully assist the participants in making informed and ethical decisions throughout their education

and career.2

One student addressed how paramount this opportunity was for him: "The framework espoused—that science and all other aspects of society should be inextricable—should be put into practice, considering the ethics of a particular situation should come as naturally to a student of science as mathematics or basic biological taxonomy."6 REU prepares students in as many ways as possible. In school, students are often sheltered from the political issues surrounding science, engineering, or research in general, but introducing them to such issues will lay the foundation for them to make ethically sound decisions in the future.

Another major feature, the end-of-program research symposium culminates eight weeks of intense, graduate level research. The symposium gives participants the opportunity to present their summer research results in front of their peers, faculty, and invited guests. It also allows participants to practice their public speaking and presentation skills. The transformation of the student in terms of confidence level and his or her research knowledge can be measured by the quality of this event and is clearly demonstrated by the presentations.8

Figure 2 (below) reflects the future plans of 2008 PSU REU participants comparatively between the start-of-program questionnaire and the end-of-program questionnaire. This chart clearly demonstrates how motivating experiential learning opportunities are for the student and how it catalyzes their interest in advanced degrees. Interest level on a scale of 1 to 5: (1) Not considering graduate school, (2) Thinking about graduate school, (3) Planning on graduate school, (4) Definitely attending graduate school, (5) Aiming to pursue a Ph.D.



Conclusion

The REU program provides opportunities for students to gain a unique experience. There are plenty of projects that are appropriate for an undergraduate, and professors are eager to involve students in their research. Though necessary, traditional lecture and lab simply cannot accurately emulate an active research experience. The REU program compliments lecture and lab and fills such a void. Designing appropriate research projects, recruiting highly-motivated students who may not have access to advanced research, and partnering undergraduates with faculty mentors prepares students for the demands and challenges of research. Students who are active members of a lab become more engaged, thoughtful, and intelligent—ready to become a part of the next generation of researchers.

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