CUR Focus

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Scaffolding Faculty-Mentored Authentic Research Experiences for First-Year Students

The Challenge that Led to *First Experiences in Research*

As at many U.S. institutions, providing undergraduate research experiences has long been a recognized activity at the University of Pittsburgh for individual faculty members and departments. NSF, Howard Hughes Medical Institute, and other agency-funded research experiences for undergraduates have been offered at the Pittsburgh campus, which enrolls more than 10,000 undergraduates in the School of Arts and Sciences. To assist departments and faculty members in securing funding for and administering summer-research experiences for undergraduates, as well as to support students and faculty members in other academically meaningful activities, the Office of Experiential Learning (OEL) was formed in 2002 (Heely & Grabowski, 2006). OEL supports four sets of activities that mirror faculty work: undergraduate research, undergraduates teaching undergraduates, undergraduate internships, and undergraduate service learning. Undergraduate research is the broadest of these four experiential opportunities.

With OEL established as a strong support mechanism, faculty members with interests in undergraduate research could not only continue existing best practices, but also could now take the time to examine other opportunities to benefit undergraduates with authentic research experiences. We realized that by graduation, the students that our colleagues identified as exemplars had conducted multiple years of research, beginning with their first year on campus. These students found positions in labs by knocking on doors from the moment they arrived on campus. These students typically started with the menial, but necessary, tasks of a research lab, such as washing glassware or making solutions. As they demonstrated reliability and skill, their mentors gradually increased the level of the tasks assigned so that by their junior year, they were the principal researchers for a well-defined component of the problem being investigated in that lab.

We recognized that in general it is hard for a first-year student to find a position, and we wanted more students to enjoy the same success as the "graduation exemplars." We also were aware of literature linking undergraduate research to retention (Nagda, Gregerman, Jonides, von Hippel & Lerner, 1998) and to

alumni-reported satisfaction with their undergraduate research experience (Zydney, Bennett, Shahid & Bauer, 2002; Bauer & Bennett 2003). These factors led us to aspire to engage more students in authentic, faculty-mentored research at the earliest possible moment in their collegiate experience. We recognized that accomplishing this would enable us to realize our dream of making an abundance of experienced undergraduate research assistants available to faculty members across all schools on our campus. As students obtained research experiences earlier in their undergraduate careers, they also could continue such research activities for more terms.

The program conceived was a non-departmental First Experiences in Research (FE-R) "course" centrally located in the office of the associate dean for undergraduate studies. It would target first-year students, recognizing that most of these students would not yet have declared a major. In this FE-R "course," a student would spend 91 to 95 percent of the time working on a portion of a faculty member's research or creative practice, and only seven hours on traditional class activities.

Development

The purpose of the FE-R course is to provide a structured process for first-year students to become involved in cutting-edge faculty research or creative endeavors in the social sciences and humanities, as well as in the natural sciences. In moving from conceptualization to realization, we kept the following points in mind:

- The heart and soul of the FE-R course is student involvement in a faculty-mentored research project or creative endeavor. We want to maximize the time dedicated to research and to minimize time in "supporting activities".

- Using a benchmark of five hours of effort per week per credit hour as the norm for a university-level course, a student would dedicate 75 hours over the term for one credit or 150 hours for a maximum of two credits.

- Students eligible for work-study can elect instead to receive wages for their FE-R efforts.

- FE-R is designed for first-year students with no prior research experience, but a student at any academic level would be allowed to participate.

Professor P.J. Grabowski consulting with her undergraduate biochemistry research team.

Mitchell Thompson, a FE-R student in Spring 2006, collecting data on the chemical reaction mass spectrometer in Professor J.J. Grabowski's lab.

- All FE-R participants, including work-study students, are required to attend seven cohort sessions at which issues, skills, and approaches common to all research or creative endeavors are discussed.

- FE-R does not attempt to make students experts in any specific research activity, but is designed to make them aware of and practiced in generic skills needed to succeed in the research enterprise.

- The capstone event for the course is a poster session, required of all participants.

In summary, we wanted a program in which faculty share their disciplinary expertise with students, students provide definitive help to their mentors on small parts of established projects, and cohort sessions provide the scaffolding to support students in ancillary, but necessary, aspects of the research enterprise. Furthermore, we wanted FE-R to help students and faculty members form successful teams for specific research activities.

Program

Overview: The core of FE-R is composed of two essentials: current faculty research and faculty mentorship of students with no previous research experience. To minimize time demands on faculty members so that they may focus on the important work of mentoring students, OEL assumes the administrative burdens and common skill-building instruction. To ensure that students have the opportunity to engage in research and creative endeavors across the disciplines, projects are included from faculty members in the social sciences and humanities, as well as in natural sciences.

Cohort Sessions: FE-R students meet six times over the term in groups of 20 to 30 students in cohort sessions led by faculty members familiar with undergraduate research. Each 50-minute, bi-weekly cohort session uses active learning techniques to address topics relevant to all research endeavors. The sequence of topics, refined over five years of practice is: (1) keeping research records, (2) reading scholarly and peer-reviewed papers, (3) identifying the research question, (4) how to write an abstract/how to create and critique a poster, (5) peer review of abstracts, and (6) oral presentation of research. The seventh and final cohort session is a poster presentation, the capstone event at which all students present their work to the campus community. Students are not assigned to cohort sessions by discipline, thus allowing first-year students to hear about and discuss research with their peers in all academic areas.

Session topics have evolved over five years of practice to address the demonstrated needs of new researchers. For example, at the first cohort session, students now are introduced to research notebooks and record keeping. Originally, the first session was devoted to advanced techniques for searching the literature . However, we found that as valuable as such skills were for some projects, they were not immediately relevant for the majority. Information-seeking skills are now offered on an as-needed basis by special-collections librarians.

Cohort sessions emphasize the responsibility of researchers to communicate the findings of their work. Therefore, the capstone of FE-R is a poster presentation by each participant. To prepare for the capstone, students learn to keep continuous

and accurate records, which also are used to prepare their posters. Another cohort session is dedicated to learning to read and evaluate peer-reviewed literature, to help students introduce their posters. Oral, written and visual communication skills are introduced at other cohort sessions, which include explicit discussion and practice in writing a presentation abstract, components of quality posters, and oral presentation to the audience at posters. During several cohort sessions, students practice and experience peer review as they evaluate and comment on each others' drafts of abstracts and posters, thus emphasizing learning from the critiquing process (Cho, Schunn & Wilson, 2006; Cho, Schunn & Charney, 2006; Cho & Schunn, 2007).

In previous years during the session on preparing oral presentations to accompany posters, we observed that many first-time researchers found discussing their specific tasks within the context of the big picture of the faculty mentor's research to be a daunting challenge. Therefore, we now include a session to specifically address the overall research question. As part of the "What is the Question?" session, each student prepares an "elevator speech" of no more than two minutes and practices it within a small group. We find that this simple exercise significantly helps students to articulate the larger question into which their tasks fit.

Pre-course activities: The most important ingredient of FE-R is faculty members' willingness to open their research to an inexperienced student. To solicit projects, early in the fall term the associate dean for undergraduate studies invites all faculty members to mentor first-year students during the coming spring term. Interested faculty members submit a one-paragraph project description and indicate the number of students they can mentor. Collected projects (over the five years, 60 percent have been in natural sciences and 20 percent each in the social sciences and humanities) are listed in the order in which they are received and placed on a non-public Web page accessible to student applicants.

Concurrently, FE-R is publicized to first-term, first-year students. The principal marketing is through an Experiential Learning Fair, coordinated by OEL during one week in the fall term and presented as a part of each freshmen seminar. Among other opportunities, FE-R is promoted as the place for first-year students to begin their experiential learning.

OEL collaborates with the English department to provide a Resume Writing Workshop specifically for students who wish

to apply to FE-R. On their resumes, students emphasize their experiences as learners, listing relevant coursework, as well as extracurricular and work experiences as evidence of their responsibility and initiative. Because most applicants are first-term students and have no collegiate GPAs, no grade averages are included on resumes.

After submitting resumes, students are directed to the Web page listing research projects available for the coming spring term. Research projects are listed by title, description, expected tasks, and number of hours per week required. To minimize problems with students who seek projects as a "resume builder," rather than for inherent interest, projects are not identified by faculty, department or school. Students select the three projects in which they are most interested.

With student preferences and resumes in hand, OEL matches students to projects and forwards a limited number of resumes to each faculty member for review. Students are informed of the faculty members affiliated with the projects for which they have applied and make appointments for interviews. Faculty members interview students in person, by phone, or via group interviews and inform OEL of whom they have selected as research assistants. An assignment sheet is created for each student who is matched to a project, to clarify the commitment in terms of project, tasks, number of hours per week, and the compensation in the form of academic credit or work-study wages. The assignment sheet is signed by both the faculty mentor and student researcher.

The Research Experience: The principal commitment of students is to the work they are assigned by their mentors as part of ongoing research projects. Over the past five years, FE-R students have worked on 329 different projects. Examples of projects in, respectively, the humanities, natural sciences and social sciences are the research process in writing a novel, development of biofuels for use in un-modified diesel vehicles, and investigating the assassination of Leon Trotsky. Within the entire set of projects, FE-R students do a myriad of tasks, just a few of which include bibliographic searches, immuno-blotting, searching human genome sequences, document translation, carbonate-shell isolation from sediment cores, affinity-column chromatography, viscosity measurements, and collecting or summarizing survey data. While some students may view their tasks as menial, most understand their assigned tasks as important parts of ongoing, larger projects.

Capstone: The poster presentation is arranged in two 45-minute back-to-back sessions, with half of the students presenting and the other half reviewing posters. Because students do a great job of encouraging their mentors and group members to attend, the poster session is full of energy and lively discussion as students talk about their work. Family members also attend this rare opportunity to be part of their sons' and daughters' learning experience. Students complete an opinion survey about FE-R at the end of the poster presentation. On these surveys, students have identified the poster presentation as a very meaningful capstone event. The responses have led us to extend the length of the poster presentation, because students enjoy this opportunity to display their learning.

Outcomes

As FE-R took shape, we articulated three goals, one for the students, one for the faculty, and one for the university. With five years of experience in offering FE-R, we are in a position to examine the impact the program has had on these stated goals.
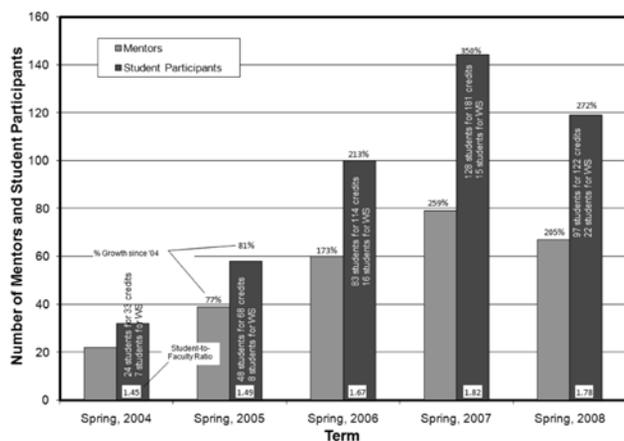
Figure 1: FE-R Mentor and Student Participation. (WS = work study.)

Professor David Pratt and FE-R student Ilana Stol, Spring 2007.

The first goal is to augment a student's academic experience through the participation in and presentation of a cutting-edge research project within a professional environment. Through participation in FE-R, a total of 453 students have been introduced to university-level research or creative endeavors, of which 57.6 percent were first-year and 29.4 percent were sophomore students. While FE-R has grown considerably over five years (Figure 1), the number of first-year students has remained constant at 57 ± 2 over the last four years. Interestingly, over that period, 71.5 percent of participants have been women. In contrast, the general student population in Arts and Sciences over that same period was 55 percent women. There appears to be no bias in the matching process as the applicant pool was 75 percent female in 2008, which closely matches the 73 percent proportion of female participants that year. We also note that during the five years FE-R has operated, 85 percent of the student participants selected "strongly agree" or "agree" on the end-of-term survey in response to the statement, "I recommend that next year's first-year students participate in the FE-R program".

One student who was interviewed three years after participating in FE-R said, "It was a good activity. At the time we were all in classes that were very large. So [in FE-R] you got the exposure to faculty that you actually interacted with on a weekly basis if not more and got to know the other students who were involved with it too." Another student also interviewed three years after her participation said, "My mentor was very helpful. She showed me a lot, not just about the project, but about research in general, which was good."

The second goal is to provide a benefit to faculty by cultivating a cadre of talented and trained research assistants. Mentors are necessary for FE-R to succeed. Faculty members get no concrete, identifiable benefit from mentoring a FE-R student. They do not receive pay raises. They do not receive more lab space or lighter teaching loads. In short, faculty members

become mentors because they believe it is what professors do and that it is beneficial to students. Anecdotally we know that students who participated in FE-R have carried out additional research experiences. One early participant continued for an additional 9 terms (including two summers) of research with his original mentor and, having graduated in spring 2008, is headed to graduate studies at one of the country's elite universities. Another student worked with one of the authors of this article in spring 2005 and returned for both terms of his junior and senior years to work on a different project, on which he made substantial progress and for which a manuscript is in preparation. He is now headed to medical school. Other students who were mentored by one of the authors continue to do research with a different mentor in another school on campus, citing their FE-R experience as an aid in helping them secure these opportunities. While admittedly biased in our views, we do believe we are having the desired effect and can cite the decline in mentors/projects in 2008 as one supporting piece of data. A number of mentors from previous years have informed us that they could not mentor new students in 2008 because their former FE-R students were continuing to work with them.

The third goal is to benefit the university by increasing the number of first-year students involved in an authentic, faculty-mentored, research experience. The success in meeting this goal can be documented only partially. As Figure 1 shows, during the course of the five years, we have increased FE-R participants by 300 percent over the first year the program was offered. However, since there is no other comprehensive data available about the number of students doing research in any one term on campus, we cannot document an absolute increase in the number of first-year students doing research. Anecdotally, we know that a number of mentors who stated that they never had mentored a first-year student now are participating in FE-R.

However, a measurable outcome and one we did anticipate based on prior work (Gregerman, 1999; Woodside, Wong, Wiest, 1999), is enhanced retention of students who participated in faculty-mentored research. Table 1 summarizes the retention rate for first-year and sophomore participants. Retention of students who participated in FE-R was higher than the university rate of 89 to 90 percent over the period from 2004 to 2007 (University of Pittsburgh Common Data Set). For the purposes of this study, retention rate is defined as the percent-

age of students who took FE-R in the spring term who were also enrolled at the University of Pittsburgh the following fall term. Over the five years of the FE-R program, 261 first-year and 133 sophomore students have participated. The 2008 retention data is preliminary (reflecting students registered for fall 2008 as of June 2008). Whereas the data in Table 1 clearly indicate a positive correlation between retention and FE-R participation, we have no independent data to identify the program as the cause of enhanced retention.

Table 1. Retention Rates for FE-R Participants and the University-at-Large

Cohort	2004	2005	2006	2007	2008	Cumulative
First-year	94%	98%	98%	95%	96%	97%
Sophomore	--	100%	96%	98%	91%	95%
University*	89%	90%	89%	90%	Not available	Not available

* Rentention rate for first-year students for the university at large (University of Pittsburgh Common Data Set). Comparable data for the university-at-large for sophomores is not available.

Conclusions

We have described an adoptable model for introducing numbers of younger students to traditional faculty-mentored research or creative endeavors. The program, coordinated by a central office, not only matches individual students to personalized research experiences, but also exposes all FE-R participants to research projects in many different disciplines. Students with interests in the humanities apply an empirical lens to their creative endeavors, and natural science students discover that research and creative endeavors also take place in the humanities and social sciences. During the matching process, faculty research receives the attention of a wider student audience than ever before.

Several challenges remain that we hope to overcome in order to make FE-R all that it should be. The most daunting challenge is that of finding enough faculty research projects in order to place as many students as possible. Currently we are accommodating about 50 percent of the student applicants and ideally we would like to accommodate 80 percent or more. Our experiences have taught us that we must employ multiple means to reach all corners of campus in our search for projects and mentors, and that we must start early in the fall in order to have a sizable number of projects on hand for the application process. To date, we have concentrated on recruiting faculty members, but we are increasing recruitment of graduate stu-

dents and post-doctoral students as well. A brief mentoring workshop is planned for late fall term, for first-time mentors (Pfund, Pribbenow, Branchaw, Lauffer & Handelsman, 2006).

Another challenge familiar to most readers is that of limited resources to assess and evaluate new programs like FE-R. We would like to know what research experiences participants enjoy after their FE-R year, and how the number and intensity of these experiences compare to those in which non-FE-R students participate. Alas, tracking and querying past participants is a time-intensive task to which we have not yet been able to dedicate our limited resources. Similarly, we want to know how FE-R participants compare to a control group of students who bid on projects but were not matched, both in terms of retention and participation in undergraduate research. Now that we have metrics for five years of the program (data not shown) we can ask questions about participation. For example, why did 2.5 times more female students than male students participate?

Mentoring any student, whether it is an undergraduate or post-doctoral student, requires resources from the mentor, especially in terms of time. One of the challenges we see is lack of concrete recognition of this time commitment. Currently, mentoring undergraduates is considered by the university as a "service" that faculty members provide, while faculty members see it as a discrete and time-intensive aspect of their teaching. Could the university recognize mentoring students earning x number of credit hours in authentic research or creative endeavor as equivalent to delivering a three-credit, term-long course? Meeting these and other challenges will help the well-regarded FE-R to further enhance the undergraduate experience.

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Jacob A. Brindley is a sophomore (Fall 2008) at the University of Pittsburgh and is planning to major in economics and statistics. As a FE-R student in his freshman year, he worked on an assessment of the first four years of the FE-R project and was mentored by J.J. Grabowski and M.E. Heely. During his sophomore year he will be a resident assistant and the coordinator of the week-long Experiential Learning Fair 2008. He is a mentor for incoming freshmen.

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