AC 2009-447: GRADUATE STUDENT EXPERIENCES AND MENTOR BENEFITS OF THE PREPARING FUTURE FACULTY PROGRAM IN ENGINEERING

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Graduate Student Experiences and Mentor Benefits of the Preparing Future Faculty Program in Engineering

Abstract

The University of Cincinnati (UC) College of Engineering offers a college-wide Preparing Future Faculty (PFF) program to address the need for more qualified faculty in engineering programs and to improve the overall educational environment. The UC PFF program consists of three one-hour courses and a mentored teaching component. The first course, in the Winter Quarter, provides information on basic effective teaching techniques for engineering, including Kolb learning styles, and how to organize a course. In addition, cultural differences and diversity are discussed in the context of science and engineering classes. The advanced teaching class in Spring Quarter emphasizes advanced pedagogical techniques including Bloom's taxonomy, concept maps, project and team management for developing leadership skills, teaching evaluations, proposal writing, and mentoring and being mentored. ABET engineering criteria a-k are applied to syllabus development, and students hold a mock NSF review panel based on a proposed project in engineering education. The final course, in Autumn Quarter, explores the academic job search process and the range of academic careers available. Panel discussions with new faculty, hiring committees from teaching-oriented and research-oriented universities, and recently tenured faculty provide up-to-date information.

This paper focuses on the experience of a PFF student participant during the 2006-2007 academic year, as well as the experiences of and benefits to his PFF program coordinator and academic research mentor. Overall, participating in the program helped the student to prepare for an academic career. Having two faculty mentors in the PFF program activities provided invaluable opportunities and feedback. The mentored teaching activities applied the concepts learned in the PFF courses. The individualized mentored teaching experience included teaching undergraduate and graduate courses, giving talks at research seminars, and mentoring senior projects and REU (Research Experience for Undergraduates) students in the Department of Electrical and Computer Engineering at UC. Various methods of active learning, motivating students, problem-based active laboratory learning, and peer tutoring were explored and applied to mentor students. The paper also includes feedback from the PFF program coordinator and the academic research mentor.

I. Introduction

Preparing Future Faculty (PFF) is a national initiative to better prepare Ph.D., M.S., and postdoctoral students to pursue careers in academia as the next generation of college and university professors.[1] The PFF program was started in 1993 and is now established at 45 doctoral institutions and 300 partner schools.[1] The program is designed to improve the graduate educational experience and to address the need for more qualified and trained faculty at various academic institutions. UC was one of the original doctoral institutions and an active participant with a university-wide PFF program since 1993.[2,3] The UC PFF in Engineering program

consists of three one-hour courses and a mentored teaching requirement (schematically indicated in Figure 1).[4] The specific aims of each course are as follows:

20-EECE-952. Effective Classroom Teaching, offered in the Winter Quarter, provides information on fundamental effective teaching techniques, including Kolb learning styles, and how to organize a course, how to prepare a syllabus and assessment, to deliver course material, grade, deal with student concerns and problems, motivate students, encourage active learning, and continue to improve as a teacher.[5,6] In addition, cultural differences and diversity are discussed in the context of science and engineering classes.

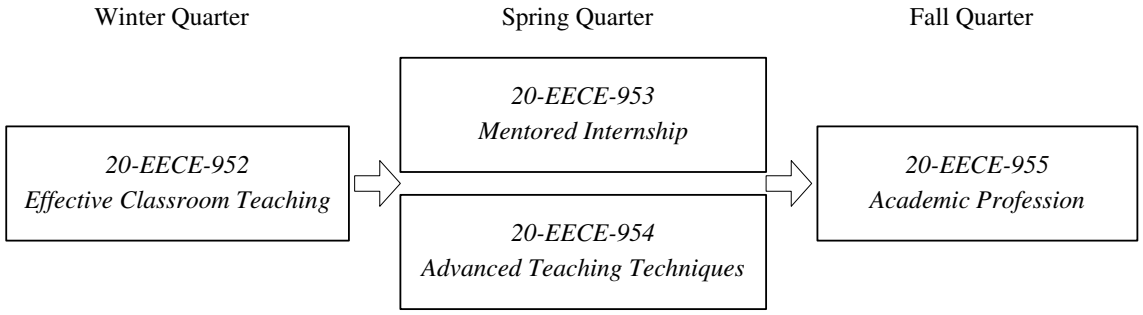

Figure 1. Preparing Future Faculty in Engineering courses at the University of Cincinnati.[4]

20-EECE-953. The Mentored Internship, includes mentored teaching activities and application of the concepts learned in the PFF courses. These can include teaching lower/upper-level undergraduate and graduate classes, giving a talk in a research seminar at the UC cluster, introducing engineering to high school students in the UC summer experience program, supervising undergraduate students for senior projects, and mentoring junior graduate students for research projects. Based on the contract in Figure 2, activities are determined individually with the assigned teaching mentor. Each student must complete a minimum of 10 hours of mentored activities. A broad range of teaching opportunities is provided, and the mentored internship may be completed over one or several quarters, depending on the research commitments of the individual student.

20-EECE-954. Advanced Teaching Techniques, offered in the Spring Quarter, emphasizes advanced pedagogical techniques including Bloom's taxonomy, concept maps, project and team management for developing leadership skills, teaching evaluations, proposal writing, and mentoring and being mentored.[7] ABET engineering criteria a-k are applied to syllabus development, and students hold a mock NSF review panel based on a proposed project in engineering education.[8]

20-EECE-955. The Academic Profession, offered in the following Fall Quarter, explores the

academic job search process and the range of academic careers available, the tenure process, time management skills, production of a teaching portfolio and a teaching philosophy statement, improvement of interview skills and, if possible, a grant-writing workshop. Furthermore, panel discussions with new faculty, hiring committees from teaching-oriented and research-oriented universities, and recently tenured faculty provide up-to-date information.

This paper describes the experience of a PFF student participant as well as the experiences of and benefits to his PFF program coordinator and research/teaching mentor during the 2006-2007 academic years. Overall, participating in the program helped the graduate student to improve teaching skills, learn pedagogical knowledge, and apply the concepts learned to actual teaching activities. Having two mentors for PFF program activities provided invaluable opportunities and feedback to prepare for an academic career. Not only is the program beneficial to the student, but the research/teaching mentor and the PFF coordinator gain benefits as well.

II. Experiences and Benefits to the Graduate Student Participant

I enrolled in the UC PFF program after being awarded the UC College of Engineering Rindsberg Fellowship. The purpose of the Rindsberg Fellowship at UC is to support engineering PhD candidates as they prepare for academic careers. Prior to joining the PFF program, all my time was focused on research and there was little opportunity to be exposed to teaching activities. Compared with graduate programs in mathematics, physics, chemistry, and biology, it is difficult for engineering graduate students to get a chance to teach undergraduate students. The PFF

Hours	Activities
_____	1. Teach an upperlevel undergraduate or graduate class
_____	2. Teach a freshman or sophomore class
_____	3. Give a talk on your research to students at UC or Xavier or NKU or Mt. St. Joseph; also discuss the benefits of going to graduate school
_____	4. "Shadow" an experienced teacher at UC or Xavier or NKU or Mt. St. Joseph and also discuss with them how they handle the responsibilities/challenges of their job
_____	5. Help to mentor an undergraduate or beginning graduate researcher
_____	6. Another activity approved by PFF coordinator

- Should plan to complete at least _____ hours of activities 1-2 and at least _____ hour(s) of activity 4.
- In addition to these _____ hours of activities, to attend _____ hours Mentoring Workshop will also be required.

Figure 2. The contract for mentored teaching activities.

program offered pedagogical knowledge and actual teaching contact with various levels of students. The PFF coordinator and the research/teaching mentor provided the teaching environment.

Teaching Preparation Courses:

PFF courses provided me with new basic and advanced teaching knowledge, which was a strong motivation to be involved in these classes. Kolb learning styles, active learning, problem-based learning experiences, Bloom's taxonomy, and ABET engineering criteria a-k were new concepts for me. Specific problems were discussed based on these concepts, such as how can each member in a team project be an active learner, and how can the difficulty level of questions in a test set be controlled. I realized that pedagogy is a well-established study field with solid logic. Using these concepts, classes can be evaluated, developed, and improved.

Since students enrolled in the PFF program had the same goal of becoming faculty members, the class environment was very active and it supported effective peer-review and peer-tutor relationships by student members. Those students came from diverse backgrounds, including mathematics, computer science, chemical engineering, biomedical engineering, environmental engineering, and electrical engineering. Presentation opportunities for the teaching seminar provided students with feedback by peers and faculty members. Presentation slides were reviewed to minimize text and abbreviation, since a broad audience had to understand them. When students took turns presenting, even font size, background color, eye contact, voice volume, and speed were discussed. To improve interview skills, strategies to avoid distracting mannerisms while lecturing and how to make the best use of 'the first ten minutes' of an interview presentation were also discussed.

In addition, individual teaching activities were shared as peer-tutoring in the PFF class. A student in the mathematics department gave a talk about how to effectively teach a large class. It is mandatory for each math graduate student to be a teaching assistant for an undergraduate-level large class. This particular student had the ability to grab the attention of a large group. Engineering graduate students who worked as teaching assistants for a laboratory class discussed teaching skills and safety issues in laboratory classes. In the final course, *The Academic Profession*, the academic job search process and writing actual job applications were explored. The samples of cover letter, curriculum vita, statement about teaching, and statement about research from the PFF coordinator helped us prepare our applications. Peer reviews were performed, with the students giving useful feedback to each other. Student members who already had finished their final defense and tried to find a position discussed their experiences.

The offered forums with faculty and students offered very helpful discussions of pedagogical ethics, faculty roles, and responsibilities under guidance of the PPF coordinator. For example, various opinions were shared for handling cheating, for developing homework due dates, and regarding additional opportunities for F-graded students. Some students applied a strict rule while the others were more flexible. My own pedagogical techniques were built through these forums. Cultural diversity and differences between faculty and students or among students were also discussed in the context of science and engineering classes. As an international student, I was able to learn more about the U.S. educational system. Domestic students described the

difference between school life in high school and in university, and between undergraduate and graduate school. The surprising thing was that domestic students thought they were in the minority in graduate engineering programs while international students also thought they were. It was a valuable forum to understand student diversity and differences.

Furthermore, new faculty, hiring committee members and recently tenured UC faculty members were invited to offer useful up-to-date information. A new faculty member shared his experiences in preparing applications, interviewing, and starting up as a faculty member. The faculty search committee who hired him explained the general faculty search process and how search committees chose to hire one specific faculty member from many candidates. A recently tenured faculty member shared his first failure and second successful experience with the tenure process. He described what he misunderstood about a faculty job and why he failed to get his tenure at his first trial. The balance of research, teaching, and service activities were discussed with him. A professor at Xavier University was invited to address different faculty roles and responsibilities in teaching-oriented universities. Although almost all student members of the class imagined becoming professors with research activities, there are clear needs to hire well qualified faculty members in teaching-oriented universities. Panel discussions gave invaluable information and made clear what faculty positions require.

Mentored Teaching Internship:

The mentored teaching experience was designed based on the contract in Figure 2. My research advisor agreed to be my teaching mentor. The individualized mentored teaching experience included teaching undergraduate and graduate classes, giving talks at research seminars, and mentoring students including beginning graduate students, undergraduate students for senior projects, one REU (Research Experience for Undergraduates) student, and a high school student for the summer internship in the Department of Electrical & Computer Engineering (ECE) at UC. Various methods for active learning, motivating students, problem-based active laboratory learning, and peer tutoring were applied to mentor undergraduate students.

Two upper-level undergraduate and graduate classes were offered for my classroom-teaching experiences. The two courses were *20-EECE-607. Introduction to BioMicroSystems* [Fall 2006], and *20-EECE-707. Biomedical MEMS* (*MicroElectroMechanicalSystems*) [Winter 2007].[9] Mentored teaching activities began with improvements to the course materials. Using recently published books and papers, presentation slides were updated from those of the previous year. I taught lectures with a teaching mentor present such that he could be an effective critic. This opportunity allowed me to apply the concepts learned in the Preparing Future Faculty courses and at the same time to supplement my teaching skill with a teaching mentor.

Three senior project teams with six undergraduate students were mentored for two years.[10] One of these senior teams has successfully finished the senior project and one of students extended his research as an NSF REU student during the summer quarter before he entered the graduate school as recently reported.[11] However, some pedagogical methods were not effective for some students. The more I helped them, the more they were passive. It was very difficult to motivate them and make them active learners. It took a lot of patience to teach and mentor them. I learned how to gradually introduce the material, without overwhelming students. It was very

important to motivate students before starting projects and to continuously encourage them during projects.

Two beginning graduate students were assisted with the guidance of a teaching mentor. Research topics were related to my proposed Ph.D. research. Reading, summary, and discussion of research papers as an active learning exercise motivated these students and introduced them to the state-of-the-art. Problem-based learning continued in an active laboratory experience. They produced excellent results, which were presented in two papers, one presented at the *IEEE Sensors Conference* and one published in *Sensors and Actuators B*.[12,13] The teaching mentor provided feedback to help improve teaching skills for all teaching activities. These experiences helped me realize that mentoring can be extremely rewarding. The challenge of being a teacher is to explain concepts as clearly, precisely, and simply as possible.

I had a chance to give a talk entitled "Integrated Multi-Analyte Microelectrode Sensors for *In Situ* Biological Applications" at the ECE Department seminar and to discuss my research with graduate students. As an international student, I found that the teaching mentor's feedback and repeat-practice improved my English skills and self confidence for presentation and discussion.

These mentored teaching activities were completed over the course of two years. Since I joined the PFF program after successfully defending my Ph.D. proposal and being admitted into candidacy in my third year of graduate studies, there was a strong focus on research. Nevertheless, the PFF program helped me to develop my multi-tasking and organizational skills which were highly beneficial in my research work. Overall, the PFF program has provided invaluable experience in teaching activities. These experiences with the PFF coordinator and the academic research mentor helped and encouraged me to prepare for an academic career.

Currently, I am pursuing post-doctoral training to gain additional research experience and further develop practical teaching skills for a future academic career. The post-doctoral position is enabling me not only to write proposals and do research, but also to mentor students in the academic domain.

III. Experiences and Benefits to the Academic Research Mentor

From the mentor prospective, the PFF program provides numerous valuable experiences to the student which yields direct benefits to the mentor. In general, the PFF program provides students with an overview of what an academic career entails, the tenure process, and the responsibilities in terms of research, teaching, and service. In Jin-Hwan's case, the program reaffirmed his desire to pursue an academic career.

As part of the program participation, Jin-Hwan got a unique opportunity to mentor a number of undergraduate students, including a senior project team and an REU student. This experience permitted him to develop and improve his project and people management skills. He also learned to better manage his time, to delegate tasks, and to share resources. Perhaps even more importantly for an international student, this experience permitted him to improve his communication skills and overcome cultural barriers.

As part of the required teaching activities of the PFF program, Jin-Hwan prepared and taught several lectures in my "Introduction to BioMicroSystems" course. As part of this activity, I attended his lectures to offer critiques and comments. Jin-Hwan learned how to be engaging and to present technical information in a concise and understandable manner. He also developed skills in handling in-class or after-class student's questions, as well as initiating and leading class discussions.

Another benefit of the PFF program was that Jin-Hwan gained a better understanding of the proposal writing process. Today, much focus is put on extramural funding, which is a critical component of the academic tenure process. Jin-Hwan received insight into the process beyond a grant writing manual, including developing and maintaining relationships with program managers as well as presenting ideas in an attractive manner.

Ultimately, from the mentor prospective, the PFF experience was beneficial as Jin-Hwan became a more productive member of my research group. By participating in the program, he matured and became more efficient, which ultimately permitted me to assign him more responsibilities. He also became more independent and reliable, and did not require close supervision, which ultimately led to less frequent project meetings. He became more productive, which was manifested in a greater number of publications and in his ability to test new ideas and conduct preliminary experiments. By mentoring students within my research group, Jin-Hwan passed on his knowledge via training or helping other group members. Having a student with such a high level of skills in the group improved the quality of the entire group. This was exemplified by unique ideas, better quality and larger number of publications, and more knowledgeable group members.

Overall, the most important benefit is that Jin-Hwan graduated with a strong academic and research record. Not only did his experience set an excellent example to new group members and raise the student standard in my research lab, but it also gave him all the necessary skills to be a successful academic.

IV. Experiences and Benefits to a PFF Coordinator

From the beginning, our PFF program has had at its core the three goals of the national PFF movement: to "address the full scope of faculty roles and responsibilities that include teaching, research, and service, emphasizing how the expectations for these responsibilities often differ in different campus settings", to allow participating students to "have multiple mentors and receive reflective feedback not only for their research activities but also for their teaching and service activities", and to "meet both of these goals in the context of a cluster of institutions, typically involving a doctoral degree-granting institution or department collaborating with various partner institutions or departments".[1] My colleague Prof. Gary Lewandowski of Xavier University and I designed our program to support the national goals, to be flexible enough that engineering students with heavy research loads could complete it, and to encourage Ph.D. students, especially in the field of Computer Science, which was experiencing a rapid growth in undergraduate majors without a comparable growth in faculty numbers, to consider academic careers. Initially

we focused on helping the students develop teaching skills and on making sure they knew about career opportunities both in Research I institutions and in more teaching-oriented institutions. As the program has evolved, however, it has become apparent that it can enrich the graduate student experience in many other ways by providing a peer group who can share their academic experiences and learn from one another and by providing mentoring in areas that may be overlooked in a research program. As Jin-Hwan's description above makes clear, the program is succeeding in the goals we originally articulated. The skills he developed by participating in the program and the teaching and mentoring experience he gained are important additions to his overall preparation for an academic career. The PFF program also reinforced his enthusiasm for the academic life. And his interaction with the other students in the program will stand him in good stead as the field of engineering continues to become more interdisciplinary. Jin-Hwan took full advantage of the opportunities PFF offers for enhancing his preparation, and he was well-supported by his research/teaching mentor, who provided him with a variety of mentoring/teaching situations and with important feedback on these activities.

As Jin-Hwan's mentor points out, the PFF training actually benefitted Jin-Hwan's entire lab. In addition, for me as the PFF coordinator, this program has had a positive impact on the three classical areas of an academic life, research, service, and teaching.

As PFF students discuss classes they might teach or practice their interview talks, they provide an exciting look at the diverse fields and research projects that are housed in our college and may even point to new research directions. For example, one student who recently finished the program was doing experimental work with her advisor on healing of wounds in skin. Their experimental work was closely related to a systems biology model some of my students were working on, and this commonality, which neither of us might have been aware of without the PFF interaction, is an opportunity for future research collaboration between our two labs. Such opportunities for professional networking and research collaboration are an unexpected benefit of coordinating the program.

The PFF program also offers extended opportunities to mentor the participants, which is a service to the academic community as well as a rewarding experience in itself. According to a recent article in the Chronicle of Higher Education[14], more and more highly talented graduate students are opting for jobs in government and industry because they view academic life as overly stressful and incompatible with other life goals. Through the PFF program we can address questions and misconceptions students have about academic careers and we can provide realistic answers to their questions. We can be positive role models and provide strategies based on our own experiences for managing their careers. As the program has developed, we have broadened the material on careers to extend beyond just finding the first academic position and to encourage students to think about their careers as a whole. For example, we now regularly discuss issues such as parenting and two-career couples in the *Academic Profession* seminar. Helping students to understand all aspects of their future careers and to be prepared to meet the challenges they will face in their professional lives is very important to me. As a woman and therefore a member of a minority group in the engineering field, I feel a special responsibility to help the PFF students learn how to identify mentors and to develop all the skills they will need to have successful careers, whether they choose to remain in academia or decide on a different path.

However, probably the most prominent benefit of coordinating the PFF program is the opportunity it provides for focusing on research and practice in education. Any instructor can always improve their teaching, and coordinating the PFF seminar is a good way to explore fresh ideas for how to better engage students. Engineering education itself is now a recognized discipline[15], and much of the research in this new discipline can be directly applied to improve our courses. Coordinating a seminar series which focuses on teaching is an excellent way to explore the engineering education research which is being done. In addition, the diverse backgrounds and viewpoints of the student participants provide ideas and inspiration which can be adapted to improve day-to-day teaching activities. Coordinating the seminar also increases opportunities for interacting with the students' teaching mentors, who themselves are often also interested in exploring new ideas and techniques in teaching.

Thus, for me, developing and coordinating the PFF program has been a very positive experience. As with any set of courses, there are always ways to improve it, and so it will continue to evolve, with the help of feedback from student participants and their mentors. Interest from students and other faculty remains high. At present, the program is part of my teaching load, counting as one course per year. This is a reasonable arrangement and it means that the program can be sustained with low cost to the department or college. Some additional support to formally assess the impact of the program on the careers of the participants would be valuable, but the informal feedback we have received over the years indicates that participants are very pleased with the program that we offer.

V. Conclusions

Overall, participation in the PFF program is an excellent experience for a graduate student, an academic research mentor, and a PFF coordinator. The basic and advanced pedagogical knowledge, critical and invaluable information, and mentored teaching activities enable a graduate student in the PFF program to prepare for an academic career. The PFF program coordinator and the academic research mentor provide feedback to improve teaching and mentoring skills. The academic research mentor gains a more productive student to train and mentor the other laboratory members. The PFF coordinator has an opportunity to focus on research and practice in education. Furthermore, graduate students, undergraduate students, and REU students are given the opportunity to gain hands-on experience in the research area under the guidance of a senior graduate student and a faculty advisor.

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