AC 2011-2055: IMPROVING A PREPARING FUTURE FACULTY IN ENGINEERING PROGRAM THROUGH INCREASED COLLABORATION BETWEEN FACULTY IN ENGINEERING AND TECHNOLOGY

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Improving a Preparing Future Faculty in Engineering Program through Increased Collaboration between Faculty in Engineering and Technology

Abstract

The 12-year-old Preparing Future Faculty Program in Engineering at the research extensive University of Cincinnati (UC) is rare in its focus on engineering. It is also one of the older programs, originally established as one of the discipline-specific Phase 4 PFF programs. Enrolling 10-15 Ph.D. students from various engineering disciplines each year, the program has been organized as a typical PFF program. Currently, however, a number of circumstances, including a merger between the UC Colleges of Engineering and Technology, have mandated a fresh look at the program and a reorganization to prepare its participants to better meet the challenges facing new engineering educators. Although the merger with the College of Technology is a major change, other factors are also having a strong impact. These include the rise of the field of engineering education, changes in the undergraduate experience such as increased emphasis on research and entrepreneurship, and, in addition, changes in the academic engineering job market and in the importance of post-doctoral positions for those students who are focused on a research career in academia. At the present time, UC is also revising all its curricula in preparation for a move from quarters to semesters in Fall 2012. And also, like many large state universities, UC is dealing with many budget challenges. Here we describe changes in our PFF program to adapt to the many changes in our environment and to better prepare our students to be future academic leaders.

Introduction

Preparing Future Faculty (PFF) programs typically meet three standard requirements:

1. they focus on the full spectrum of faculty roles and responsibilities with regard to teaching, research, and service, and how these responsibilities may be interpreted in different institutions;

2. they provide participants with multiple mentors and feedback not only on their research but also on teaching and service;

3. to accomplish these goals, they involve a cluster of institutions, with one doctoral degree-granting institution partnering with a variety of other institutions.

The 12-year-old Preparing Future Faculty Program in Engineering at the research extensive University of Cincinnati (UC) is rare in its focus on engineering, as can be seen from a perusal of the Preparing Future Faculty (PFF) and related programs at the national PFF website.[1] For our PFF program, as well as for similar programs elsewhere for engineering graduate students, meeting requirement 3 can be difficult because of the lack of engineering programs at many four-year colleges. While it is possible to find faculty from baccalaureate institutions to participate in panels on how to find a job, for example, it is generally harder to identify faculty mentors at nearby schools who can work with the PFF participants in the classroom over an extended period. Also, in many cases, graduate students engaged in engineering research just do

not have flexibility in their schedules to accommodate teaching activities which take them too far from their home labs. A few of our PFF participants have in the past found teaching mentors at the nearby UC College of Applied Science, but the majority have ended up completing the teaching component of their program with a UC engineering professor whose primary focus is research. Recently, however, UC merged its colleges of engineering and applied science, replacing separate engineering departments and technology departments with integrated schools, with the goal of capitalizing on synergies in these programs which will strengthen both. This new structure provides our PFF in Engineering participants with the type of broad exposure to a variety of academic programs which was previously lacking.

There are also many additional benefits of this merger for PFF participants. For example, overall the technology faculty are much more focused on undergraduate teaching and much more knowledgeable about recent developments in engineering education. In addition, many technology faculty have chosen academic positions after extensive experience in industry. Thus PFF students not only learn how different academic programs are organized but can also get firsthand information on career paths which may include a faculty position but which also accommodate extensive industrial experience.

This major university reorganization has also given us the opportunity to rethink the content of our PFF seminars to better deal with the many other changes that are taking place in university and college engineering programs. These include the rise of the field of engineering education, changes in the undergraduate experience such as increased emphasis on research, changes in the academic engineering job market and in the importance of post-doctoral positions for those students who are focused on a research career in academia, increased emphasis on entrepreneurship, both for faculty and for students, and ongoing challenges related to funding, especially for state universities. Here we describe our plans for modifying our traditional PFF program to better prepare participants for professional success in the engineering field.

Current Program

Our current program consists of three seminars--Modern Teaching Techniques, Advanced Teaching Techniques, and the Academic Profession--together with a 10-hour mentored teaching experience. Participants also have the option of completing additional mentoring hours and earning a PFF certificate from the associated university-level PFF program. Since most of our Ph.D. students do little teaching during their time at UC, the program was designed to provide basic skills for organizing class materials, delivering content, and evaluating students, exposure to active learning techniques, discussion of engineering-related topics such as project and team management, ethics in engineering, and the ABET accreditation process, and help with understanding the application process for faculty positions, including application materials and the interview process. As we have been preparing to move to semesters, however, we have concluded that a number of additional areas need to be addressed, as outlined below.

Engineering Education

As outlined by Borrego[2], over the past ten or so years, engineering education has emerged as a separate discipline, focusing in particular on educating engineering undergraduates in the early

years and increasing retention and diversity of the student population. A number of schools have now established engineering education departments, with Purdue and Virginia Tech taking the lead[3,4] and some departments are now producing potential new faculty in this field. As a consequence, there is now a broad literature targeting effective teaching of engineering students, and potential new faculty need to be familiar with this research. They also need to understand the basics of conducting research on learning, which is grounded in the social sciences and requires somewhat different techniques from typical engineering research projects. Thus, along with basics about active learning, learning styles, team and project work, etc., students must master additional topics and skills. Although PFF participants may not themselves conduct research in engineering education, they need to be prepared to benefit from the knowledge being produced in this field and to interact constructively with colleagues in this field. As a basic introduction to this field, our new semester curriculum will include an introduction to engineering education, as well as assignments requiring participants to read and report on at least one experimental study whose results could be applied to a class they are teaching or might teach. In addition, faculty from the UC Engineering Education Department will be invited to make presentations to participants on their research. These faculty will also be asked to participate in the mock review panel to which PFF participants are required to submit abbreviated NSF REU grant proposals. Thus the new generation of engineering faculty that are being trained in our PFF program will be able to derive maximum benefit from the knowledge base being developed in the engineering education field and perhaps even to contribute to it themselves in the future.

Changes in the Undergraduate Experience

Among a number of changes in a typical engineering undergraduate curriculum, one that stands out is a focus on undergraduate research. While a senior design project, often with industry input, is a staple of most curricula, laboratory-based research under the guidance of a faculty member or senior graduate student is now also becoming a popular option, especially for undergraduates who are identified as good candidates for graduate work. This trend has been found to have positive effects for undergraduates and to be a strong factor in success for students from underrepresented groups.[5,6] Thus training in mentoring undergraduate researchers is an important aspect of preparing for a faculty career. Since many undergraduate research programs enroll students who may only have finished one or two years of the engineering curriculum or who may be participating as part of a targeted retention program, mentoring them will likely require additional skills beyond, for example, those needed to mentor a beginning M.S. student. This also gives many international graduate students a much better understanding of the strengths and weaknesses of the undergraduates they will be mentoring and teaching in future. This component of training will be addressed in the PFF program through contacts with established undergraduate research programs at UC, including a locally organized and funded summer research experience for undergraduate women.

Another emerging trend at the undergraduate level is an increased awareness of the benefits of training our students in entrepreneurship and of providing them with skills in business as well as in engineering. An understanding of how to integrate training in this area with the traditional math and science oriented training of engineering and technology undergraduates will become increasingly important. Currently UC is developing an Entrepreneurship Certificate program for

undergraduates. Information on this program and presentations from faculty involved in it is being added to the topics covered in the PFF seminars.

Merger with the College of Technology

As mentioned earlier, a major change taking place in the UC College of Engineering is the merger with UC's technology programs in the College of Applied Science. Thus, although separate technology and engineering degrees are being maintained at the undergraduate level, there are no longer engineering departments or technology departments. Instead, the faculty of each discipline, whether engineering or technology, participate together in a "School", and are expected to identify synergies and common courses in their curricula. As a consequence, PFF participants now have the opportunity to learn about a much broader set of degree programs. In particular, this change has removed one weakness of the original PFF in Engineering program, namely, the lack of teaching-focused engineering programs nearby that could provide mentoring experiences for PFF participants. While some PFF participants did connect with mentors in the College of Applied Science when it was a separate entity, most chose to work with a mentor in the research-oriented College of Engineering. But now the former Applied Science faculty, whose promotion and tenure criteria put a heavy emphasis on teaching and who have extensive experience with newer teaching techniques and with hands-on instruction, are in the same organizational and, in many cases, the same physical location. And so it is much easier for PFF participants to connect with one of these faculty for mentoring than it was in the past. This will enable PFF participants to form a much better picture of "the broad range"[1] of educational institutions where they might establish a career.

Engineering and Engineering Technology

When PFF participants look for academic jobs, they may find there are many faculty position openings in engineering technology programs. We have been asked the following question by PFF participants---"What is the difference between engineering technology and engineering?" To address that question, PFF participants are encouraged to read comparisons[7,8] and are guided to look at the difference between engineering and engineering technology from several aspects.

Generally speaking, engineering programs are more conceptually or theoretically based and are essentially engineering sciences. Engineering programs rely primarily on mathematics or basic sciences for their teaching materials and teaching techniques. On the other hand, engineering technology students learn engineering principles on an experiential basis. While engineering courses focus on the underlying theory of the subject matter, with an emphasis on developing the student’s conceptual abilities, engineering technology courses stress the application of technical knowledge and methods in the solutions of problems in industrial contexts, with an emphasis on developing students' application abilities. The engineering technology courses are lecture/laboratory based, with every course including a laboratory component. The application-based, hands-on approach in the laboratory component is what differentiates an engineering technology curriculum from its corresponding engineering program curriculum. This curriculum feature makes it possible for engineering technology graduates to immediately adapt themselves to all “engineer practitioner” positions.

Though engineering and engineering technology are separate, they are intimately related professions. We believe that our PFF participants, the future engineering and technology educators, should realize that the field of "engineering" comprises a broad spectrum of occupations requiring different abilities, interests and skills. Both engineering and engineering technology are viable professional paths that lead to rewarding and successful careers.

ABET Accreditation

Another component of our PFF course is the introduction of ABET accreditation, which is an assurance that a college or university program meets the quality standards established by the profession for which it prepares its students[9]. We believe that an engineering or engineering technology faculty member should be actively involved in ABET accreditation, and clearly understand that accreditation gives program faculty a structured mechanism to assess, evaluate, and improve the quality of their program. In addition to introducing our PFF participants to the general ABET accreditation process; we lead them to examine an example of a curriculum continuous improvement plan, i.e., an example of program educational objectives and student outcomes developed by one of the programs in the college[10]. The assessment methods for the program educational objectives and student outcomes, the evaluation procedure, and the curricular changes driven by the assessment and evaluation results together with their impact on the improvement of the program, give the participants a systematic picture of the quality control of an engineering/technology program. In studying this ABET continuous improvement plan example, PFF participants also further understand the roles of program constituencies, along with their impacts on the program educational objectives and on student outcomes.

Overall, PFF participants should have a good understanding that a program should provide documents regarding the extent to which the program educational objectives and student outcomes are being attained, and the results of assessment and evaluations should be utilized to effect continuous improvement of the program. In addition, all participants learn how to prepare a self study report for ABET accreditation.

Changes in the Academic Engineering Job Market

As mentioned above, one of the seminars in the current PFF program focuses on the academic job search. Over the years, the topics addressed by this seminar have increased, with more emphasis being placed on mentoring skills, establishing and maintaining a career after being hired, and grant-writing skills. In addition, information has been added on post-doc positions, since the number of engineering Ph.D. graduates who take post-doc positions has been growing steadily in recent years, and the length of time an individual spends in a post-doc position has also increased.[11] And a number of helpful references for those seeking to enter academia have been identified.[12,13] But the changing prospects for positions in academia, especially tenure-track positions,[14] along with the increase in other types of positions, including contract positions with titles such as "field service professor", have made the traditional approach to examining job possibilities, with the central question being "focus on research or teaching" and the goal a tenured professorship, much more complex. It is important to prepare PFF participants well for the realities of the job market and to help them understand the range of positions they will likely find in the job advertisements. To do the current situation justice, a much more complex picture

of academic positions and their responsibilities will need to be presented. In particular, it is no longer possible to separate institutions into "teaching-focused" and "research-focused" groups. In any teaching institution one is likely to find many research projects involving undergraduate researchers, so anyone focused on a teaching career will need the skills to fund and lead such projects. And in most research institutions there is a trend to identify a faculty member as research-focused or as teaching focused, so anyone interested in a career in such an institution will likely have more than one possible career path, with each path requiring different skills and emphasis. PFF participants need to understand this complex situation.

Changes in the Classroom

A number of factors, including increased reliance on technology and an increased awareness of the need to deliver a high-quality educational experience at an affordable price, are driving changes in teaching methodology and classroom techniques. Some important topics in this area are the challenges of providing distance learning or distributed learning, the need to manage large classes effectively, along with the ability to use technological tools to help with this management, and the need to make better use of student laptops in the classroom. In addition, the need to better motivate students through integration of engineering material with the basic mathematics and science courses is discussed, along with initiatives such as the freshman Matlab-based "Math and Models" courses being introduced at UC to help bridge the traditional gap between what freshman students learn in calculus and how they can apply this material in their engineering courses.

Conclusion

We have briefly outlined here some of the changes we are making in the well-established UC Preparing Future Faculty program in response to changes that have been occurring in both the delivery of engineering education and the job situation for engineers in academia, as well as to the reorganized College we now find ourselves in. Our semester-based PFF program, which will begin in fall 2012, will incorporate material addressing the challenges we listed above. We have already begun phasing in some of the material with our current quarter-based system. Preliminary assessments of the teaching-related material and of the additional mentoring training will be available by June, as a new PFF "class" has just started. What we learn now will help us to refine the program we will be putting in place in fall 2012.

Bibliography

1. http://www/preparing-faculty.org, accessed January 19, 2011.
2. M. Borrego, Development of engineering education as a rigorous discipline: A study of the publication patterns of four coalitions, *Journal of Engineering Education* 96 (1), 2007, pp. 5-18.
3. Purdue University School of Engineering Education, https://engineering.purdue.edu/ENE/, accessed January 19, 2011.
4. Virginia Tech Department of Engineering Education, http://www.enge.vt.edu/, accessed January 19, 2011.
5. S.H. Russell and M.P. Hancock, Benefits of undergraduate research experiences, *Science* 316, 2007, pp. 548-549.

6. B.A. Nagda, S.R. Gregerman, J. Jonides, W. von Hippel, and J.S. Lerner, undergraduate student-faculty research partnerships affect student retention, *The Review of Higher Education* 22 (1), 1998, pp. 55-72.
7. American Society of Mechanical Engineers, Mechanical engineering & mechanical engineering technology - which path will you take http://www.tryengineering.org/pdf/memet.pdf, accessed March 11, 2011.
8. Engineering vs. Engineering Technology, http://www.tech.purdue.edu/ECET/About-Us/about.cfm#ECETvsECE, accessed March 11, 2011.
9. ABET, http://www.abet.org/the_basics.shtml, accessed March 11, 2011.
10. K. Ossman, An assessment and data collection process for evaluating student progress on a~k ABET educational outcomes, *Proceedings ASEE Annual Conference*, 2010.
11. P. Stephan and J. Ma, The increased frequency and duration of the postdoctorate career stage, *The American Economic Review* 95 (2), 2005, pp. 71-75.
12. *The New Professor's Handbook: A Guide to Teaching and Research in Engineering and Science*, Cliff I. Davidson and Susan A. Ambrose, Jossey-Bass (Wiley), 1994.
13. *Tomorrow's Professor, Preparing for Academic Careers in Science and Engineering*, Richard M. Reis, IEEE Press, 1997.
14. G. Åkerlind, Postdoctoral researchers: roles, functions and career prospects, Higher Education Research and Development 24 (1), 2005, pp. 21-40.