Achieving Diversity in Graduate Engineering Education--What Are the Major Issues?

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Abstract

What are the benefits of diversity in graduate engineering education? Reasons for increasing diversity among undergraduates also apply at the graduate level—a larger pool of highly trained workers, increased technical expertise among the overall population, the potential for enhanced innovation due to multiple perspectives, and greater economic and professional opportunities for the students involved. Moreover, engineers with graduate training will be at the forefront of leadership and change, in both academia and industry, giving additional impetus to efforts to increase the diversity of this group. However, while the percentages of women and minorities earning engineering graduate degrees are increasing, they still (except for women at the masters' level) lag behind the percentages earning bachelor's degrees. Many initiatives for improving diversity at the undergraduate, K-12, and faculty levels, as well as extensive industry programs, already exist or are being developed. But at the graduate level initiatives are more limited and their success rate has been lower. While some programs for increasing diversity at the undergraduate level can be extended to the graduate level, other factors must also be taken into account. For example, at the undergraduate level only 7.1% of B.S. in engineering degrees awarded in 2002 went to foreign nationals, while at the graduate level the percentages were 42.6% for M.S. degrees and 54.9% for Ph.D. degrees respectively. This greater cultural diversity certainly impacts both understanding and dealing with issues of diversity in graduate engineering education. Here we discuss some of the major issues whose impact on diversity in graduate education needs assessment. These include both issues which are crucial at the undergraduate level, such as workplace, climate, critical mass, and support systems, and also issues specific to the graduate level, such as increased family and financial responsibilities and the structure of graduate degree programs and academic engineering research.

1. Introduction

The need for increasing the representation of women and minorities at all levels of engineering has been well-documented:\textsuperscript{1,2,3,4}:

- The overview of the National Science Foundation's 2002 ADVANCE Program for Institutional Transformation states "The pursuit of new scientific and engineering knowledge..."
and its use in service to society requires the talent, perspectives and insight that can only be assured by increasing diversity in the science, engineering and technological workforce."

• The September 2000 Report of the Congressional Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development (CAWMSET) states "If we are to compete effectively in the global marketplace, we must advance the full and equitable participation of all Americans in science, engineering, and technology fields."

• A study by M. Macdonell-Laeser, B.M. Moskal, R. Knecht, and D. Lasich reported at the 2001 Frontiers in Education Conference finds "There are compelling economic reasons to seek to increase the number of women in engineering. For example, a recent report by the National Science Foundation has raised concerns that there has been an overall decrease in graduate enrollment in engineering. They have warned that this decrease is likely to have a negative impact on the economy in the United States. The U.S. government has responded to these concerns by increasing the annual number of temporary, professional-worker visas from 65,000 to 115,000 for a three-year period in the American Competitiveness and Workforce Improvement Act of 1998. This number was increased for another three-year period, to 195,000 through the American Competitiveness in the Twenty-first Century Act of 2000. After this period, it is hoped that the availability of U.S. trained scientists and engineers will increase to the level that is necessary to fill the available positions. One manner in which to increase the overall pool of trained engineers is to increase the participation of women in these fields."

Many initiatives, from K-12, through the faculty level, have been and are being undertaken to increase the diversity of the engineering workforce. Notable contributions to the discussion include, for example, those outlined in 5,6,7 at the undergraduate level, and the NSF ADVANCE program for women faculty in engineering and the sciences2. Research has also focused on the graduate student experience8 in general and in science and engineering in particular9,10,11,12,13,14,15. However, at the level of graduate study, initiatives are more limited and their success rate has been lower.

In this paper we focus on factors which impact diversity in graduate education. Our aim is to stimulate increased discussion and research into the question of how to increase diversity in graduate education. As in the cases of undergraduate education and faculty policies, we expect that strategies which increase the proportion of underrepresented groups in graduate engineering programs will also improve those programs for all participants.

2. Obstacles to Success for Underrepresented Groups in Graduate Programs in Science and Engineering

Obstacles to the full participation of underrepresented groups in graduate-level science and engineering programs can be categorized according to whether they are likely to arise from underlying and often unvoiced assumptions which shape graduate education in general or from circumstances specifically affecting specific groups. Many of these obstacles have been discussed, for example, in 8,9,11. Some factors which may negatively impact the progress of any graduate student in science and engineering include
lack of information about how to choose a graduate program;
change of focus from class-based work to research, with its much less structured format and associated requirements for independence on the part of the student;
lack of guidance in choosing an advisor;
lack of procedures for changing advisors if the relationship becomes problematic;
isolation in a small or badly run research group;
outside demands from research sponsors;
differing standards among research advisors in the same department;
lack of managerial skills on the part of research advisors;
advisors' own unpleasant graduate experiences, which they may have come to view as necessary to their success;
lack of oversight of faculty supervisors and of administration support for programs that would improve the quality of graduate student life;
lack of information about how to prepare adequately for comprehensive exams;
lack of training in necessary skills such as giving a presentation or writing a grant proposal;
lack of career guidance;
competitiveness or hostility among research group peers;
lack of feedback on progress towards the degree;
unclear and often unreasonably long timelines to degree completion;
budget constraints which lead to low stipends and uncertainty about continuing financial support.

Some of the factors which may be especially important for women include
the traditional view of science and engineering as a “monastic” discipline with the concomitant need for complete dedication to research;
the need to juggle work and family responsibilities and to have a balanced life;
faculty disdain for part-time students or for students who do not have a continuous career history;
onexistent or ineffectual policies on sexual harassment;
differences in traditional working styles between men and women;
differences in how men and women communicate their ideas;
lack of female role models in supervisory roles;
faculty who are dismissive of women, either overtly or implicitly.

Some factors which may be especially important for other underrepresented groups include:
• differences in how people from different cultures interact and communicate;
• stereotypes, conscious or unconscious, which colleagues may need to overcome to work effectively together;
• feelings of isolation arising from lack of peers or role models with similar world views.

3. Strategies for Increasing Diversity

a. Increased Research:
In order to increase diversity in graduate education, we must better understand how the factors listed above, and others, affect today’s graduate student population. Thus there is a need for continuing research projects, with a broad enough scope and over a long enough period of time, along the lines of the studies reported in 8 and 13. Many questions about the efficacy of today’s graduate education, in terms of attracting and retaining our best students, need to be answered.

b. Increased Information:

In addition to more comprehensive research in general, it would be very useful to have a national "clearinghouse" for reporting on the efficacy of support programs for graduate students from underrepresented populations. An overview of what works and what doesn't, and of what resources are required to sustain effective programs, would be a powerful tool for faculty and administrators who are concerned with increasing the diversity of their graduate student population. For example, many of the factors affecting graduate students listed above, such as lack of career guidance and isolation in a badly run research group, could probably be overcome or at least minimized by providing students with mentors, either other students, faculty, or administrators in already existing support programs for women. However, information about successful ongoing mentoring programs for graduate students and about the resources needed to sustain such programs is currently not readily available in one central location.

Bibliography

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