

## **AC 2008-1248: IMPLEMENTING A MULTI-FACETED APPROACH FOR PROMOTING DIVERSITY IN GRADUATE ENGINEERING EDUCATION**

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# Implementing a Multi-faceted Approach for Promoting Diversity in Graduate Engineering Education

## Abstract

For the past several years, we have, through panel discussions and presentations, been engaged in exploring how to encourage diversity in graduate engineering education. 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. A diverse graduate population is important because engineers with graduate training will be at the forefront of leadership and change, in both academia and industry, as we confront the many ways in which we will need to make creative use of technology in the coming years. Participants in these discussions have included university faculty and staff and industry representatives. Our discussions have clarified some of the obstacles to diversifying the graduate population, including lack of mentoring and constructive advice, lack of a community for graduate students at a particular institution, and unwritten rules and assumptions which can affect graduate student admission and overall success. In this presentation we review the literature on diversity in graduate education and we describe, for each group of stakeholders in the process of graduate education, policies and activities that have been presented in the literature and that have emerged during our discussions that can help to overcome some of these obstacles. We discuss initiatives that can be carried out effectively by individuals or small groups, initiatives that can be supported by industry and by other groups external to the university, and initiatives that require institutional support. Not surprisingly, successful projects draw support from several of these groups. Major stakeholders who can affect graduate education at an individual institution include individual graduate students, student organizations, and supportive corporate sponsors. Major stakeholders who could help with institutionalization include not only university and college administrators and engineering faculty but also government and nongovernmental organizations, as well as corporate sponsors. Our goal in this session is to offer specific examples of successful initiatives and to begin to develop resources for others interested in encouraging diversity at the graduate level. Over the next year we will continue to collect information about exemplary programs, projects, and activities that facilitate increased diversity in graduate engineering education. Information on these initiatives will be maintained on the Graduate Studies Division web page, along with the papers which have appeared in this series of panel sessions and a summary of best practices.

## Introduction

While many excellent programs exist for increasing diversity among precollege and undergraduate students and among faculty, programs targeting graduate students have received less attention. While some programs designed specifically for students at the graduate level have been established, many others exist as add-ons, either to faculty development programs or as extensions of programs for undergraduate students. There are several reasons why encouraging diversity at the graduate level is more difficult. As noted previously in our discussions on this subject<sup>1,2,3,4</sup>, graduate student programs tend to be administered by individual departments rather than by central offices, and individual students may be recruited into specific laboratories.

Because of their size and their necessary focus on research programs, individual departments and faculty labs typically do not have the necessary resources or training to give attention to broader concerns, including diversity. However, increased diversity in the graduate population is an important component in diversifying the workforce in general.

In this paper we present a survey of programs which have been successful in targeting diversity at the graduate level. We have collected information from several sources, including the *Journal of Engineering Education*, presentations at the national ASEE conference and also at WEPAN and NAMEPA conferences, and websites for various programs such as NSF ADVANCE.

The paper is arranged as follows: we first review background studies on the problem and potential approaches; next we describe examples of programs which target increasing diversity at the graduate level; based on the suggestions in the literature and on our review of programs, we present a list of specific recommendations and we attempt to identify which groups of stakeholders need to participate in specific types of initiatives. For the purposes of this discussion, we have identified the following groups of stakeholders:

- university and college administrators
- engineering faculty
- university staff members responsible for diversity and mentoring programs
- government organizations
- professional societies
- nongovernmental organizations
- corporate sponsors
- student groups
- committed students

We present this information, which we do not claim is complete, as a starting point for anyone interested in encouraging diversity at the graduate level. Over the next year we will continue to collect information about exemplary programs, projects, and activities that facilitate increased diversity in graduate engineering education. Information on these initiatives will be maintained on the ASEE Graduate Studies Division web page, along with papers which have appeared in this series of panel sessions and a summary of best practices. An important goal of this ongoing discussion is to find ways to build a virtual community whose members can work together to share best practices and to support one another's efforts. The information collected here is intended to serve as a basis, with support from theory and experiment as documented in the literature, for ongoing research into how to build successful programs and for continued development of successful measures for increasing diversity among students enrolled in our graduate programs.

### **A Brief Survey of Research Related to Increasing Diversity at the Graduate Level**

Although a survey of articles in the *Journal of Engineering Education* for 1993-1997<sup>5</sup> does not even list diversity as a category and finds that only nine out of a total of 231 articles addressed issues of gender, several articles published in the *Journal* before 1997 and since that time do make important contributions to any discussion of diversity. In a 1993 paper, Batson et al.<sup>6</sup> present evidence that the establishment of the proper environment and support for students has a

significant effect on their decisions about whether or not to undertake graduate study. Baker et al.<sup>7</sup> have studied difficulties confronted by women students as they attempt to reinvent traditional societal roles in order to undertake graduate studies, while N.C. and M.A. Chesler<sup>8s</sup> have studied the importance of establishing a "caring community" for supporting women graduate students and young faculty and made recommendations for establishing such a community. Reichert and Absher<sup>9</sup> have suggested that, in studying diversity at the graduate level, more research is needed to address how to target the academically strongest students from underrepresented populations and how to differentiate between the particular conditions for students in different disciplines, rather than treating all disciplines as though they were homogeneous with respect to questions of diversity. Their study included a range of institutions, including historically black colleges and universities (HBCUs). They identified key components for successfully diversifying graduate programs, including providing a proper environment, increasing recruitment efforts, evaluating applications carefully, providing sufficient financial aid, providing academic support, including mentoring, establishing outreach programs, "gleaning" from M.S. programs, and expanding faculty comfort zones with respect to underrepresented students. They made several recommendations for increasing diversity, including establishing institutional advocacy, generating financial resources, establishing a recruiting pipeline, moving students out of specially created programs into standard programs as soon as possible, counseling or requiring students to obtain an M.S. degree before the Ph.D., and consulting the "experts", including several sources listed in their bibliography. Useful suggestions not specifically targeting graduate programs can also be found in the article by Chubin et al.<sup>10u</sup> which discusses the importance of diversity in this era of globalization, at the undergraduate, graduate, and faculty levels, the article by Watson and Froyd<sup>11</sup> which presents an interesting discussion, in terms of transmission lines and sufficient energy on the part of a student, on the "leaky pipeline" paradigm, and an older article by Hackett and Martin<sup>12</sup> which addresses the question of faculty support for programs targeting minorities and finds it somewhat positive, with faculty preference for academic and financial aid rather than for "clustering activities", with some variation among institutions. Two recent reports by Y. George and colleagues<sup>13,14</sup> describing work by the NSF Alliance for Graduate Education and the Professoriate (AGEP) show that, while much remains to be done, progress has been made on diversifying the engineering professions at the graduate level, as of 2005-2007. And some specific studies on how students from different groups approach graduate studies and how their perceptions and experiences differ also provide insight into how to better support graduate students from underrepresented groups.<sup>15,16,17,18,19</sup>

At the faculty level, the question of how to remove irrelevant considerations from the hiring process has been studied as a way to increase diversity. Since graduate admissions are almost always done at the department level, this is an area which also needs to be investigated with respect to graduate student diversity. One interesting study by House et al.<sup>20</sup> found gender differences in how well Graduate Record Examination (GRE) scores predicted graduate student success. This study did not include engineering students, but there is anecdotal evidence that GRE scores are not a good predictor of graduate student performance for domestic engineering students in general. Other studies have also pointed to discrepancies between GRE scores and overall performance for particular groups of students. In 1988 a large scale study involving 99 departments and more than 2000 subjects found that there was a "significant under-prediction of first-year grade average for older females in all graduate fields." Returning female students were found to have earned considerably higher grades than all other groups. The study went on to

recommend that "graduate admissions committees broaden efforts to identify non-traditional evidence of talent, motivation, and accomplishment in applicants from this group."<sup>21</sup> Again in 2002, the Educational Testing Service admitted that the GRE underestimates academic success for women, especially those over the age of 24<sup>22</sup>. Yet for most programs the GRE continues to be an important component of admission decisions, especially for Ph.D. programs.

A related question for faculty is how to equip both hiring and promotion and tenure committees with skills which will enable them to make decisions not based on unrecognized prejudices or what JoAnn Moody calls "cognitive errors"<sup>23,24</sup>. Moody discusses errors such as "longing to clone, elitism, seizing a pretext, and negative and positive stereotyping"<sup>24</sup> and dysfunctions which "include rushing and overloading evaluation committees, failing to coach an evaluation committee before it begins its work, and requiring no accountability with the committee process and no accountability for results"<sup>24</sup> and suggests remedies which include "careful coaching and practicing of an evaluation committee...using a matrix to keep committee members on track; insistence on 'show me the evidence rather than accepting mere opinions...and a non-voting process person (a senior faculty member from outside the department) participating in all aspects of the committee's work, to keep members away from cognitive quicksand."<sup>24</sup> Clearly these ideas can also be applied to the graduate admission process.

A great deal of additional research directed at problems facing women faculty has also been carried out in recent years, especially in conjunction with the National Science Foundation's ADVANCE program<sup>25</sup>. Useful references for the results from this program include the book by LaVaque et al.<sup>26</sup> and Virginia Tech's summary Advance Portal Website<sup>27</sup>. Fundamental causes of the disparities in advancement in academia are addressed in Virginia Valian's seminal work,<sup>28</sup> where the concept of "small inequities which build up over time" is explored in detail. Much of the research described in these references is applicable to the problem of increasing diversity among engineering graduate students, either directly or with appropriate modifications.

## **Initiatives Which Support Diversity in Graduate Programs**

### **A. Undergraduate Research Programs**

Undergraduate research programs have long been recognized as an effective tool to attract students to graduate study. Many programs to provide such experiences currently exist, and more are established each year. For example, three articles in the *Journal of Engineering Education*, from 1995<sup>29</sup>, 1998<sup>30</sup>, and 2002<sup>31</sup>, address the effectiveness of undergraduate research programs in encouraging students, both minority and majority, to undertake and to successfully complete graduate work. Other programs which provide research experiences as a means of encouraging graduate studies, many of which specifically target members of underrepresented groups, have been described, for example, by Dukhan and Jenkins<sup>32</sup>, Bhansali et al.,<sup>33</sup> Anderson-Rowland and Johnson,<sup>34</sup> and Smith.<sup>35</sup> At the 2004 ASEE Annual Conference, an entire session, sponsored by the Minorities in Engineering Division (MIND), was devoted to discussing how research experiences for undergraduates could promote interest in graduate education.<sup>36,37,38,39,40</sup> The number of such programs has increased greatly, especially with the support of the NSF Research Experiences for Undergraduates (REU) program, which specifically encourages the involvement of students drawn from underrepresented minority groups "... (African Americans,

Hispanics, American Indians, Alaska Natives, and Native Hawaiians or Other Pacific Islanders.)" and which recommends involving students at early stages of their college career so that they will be more likely to persevere in majors and careers in science.<sup>41</sup> Some of these programs add additional components such as enhanced emphasis on mentoring, development of career plans and actual graduate applications, dealing with time management and work-life balance issues, and identifying a supportive peer group. Such programs have been described by Purdy et al.<sup>42</sup> and by Crosby et al.<sup>43</sup> While many of these programs are highly effective, they do not always have stable funding. .

## **B. Mentoring**

As noted by Purdy and Wasburn<sup>2</sup>, "a continuing concern for all graduate students is how to find sufficient mentoring and role models. This need is not limited to academic subjects. Much more than undergraduate students, graduate students are establishing themselves as independent adults, and possibly taking on family responsibilities. These can be particularly overwhelming for a student who may be far from friends and relatives and who needs advice on how to combine the heavy student responsibilities with other important responsibilities. Advice on how to handle stress is very necessary. Programs which provide mentoring, either by faculty and staff or by graduate student peers, can be an effective way to increase graduate student success. Various mentoring programs and their efficacy have been described, for example, by Frehill et al.,<sup>44</sup> Wheeler et al.,<sup>45</sup> Turns et al.,<sup>46</sup> Wasburn,<sup>47</sup> Hancock and Norton,<sup>48</sup> and Jessop.<sup>49</sup> Several studies have been carried out to determine how best to adapt traditional mentoring programs for graduate students<sup>50</sup> and to compare the efficacy of mentoring programs for various groups.<sup>51</sup> Of particular interest are the well-established program at Purdue, which has been providing mentoring for women graduate students in engineering since 1994<sup>52</sup> and a community of support developed by members of the National Society of Black Engineers (NSBE) to encourage graduate study.<sup>53</sup> Mentoring programs to encourage undergraduates to continue on to graduate school can also be set up independently of research initiatives. For example, Oakes et al.<sup>54</sup> describe a seminar series, run with support from a student ASEE chapter, designed to provide undergraduates with detailed information about the benefits of graduate school, the application process, and the graduate school experience.

For members of underrepresented groups in the engineering profession, it is often difficult to find enough appropriate mentors. One solution to this problem is to broaden the pool of mentors through some form of e-mentoring. The most successful e-mentoring program for engineering students, including those at the graduate level, is Mentornet.<sup>55,56</sup> E-mentoring and assistance with finding academic jobs, with emphasis on serving a diverse pool of applicants, is also available through the Faculty for the Future<sup>57,58</sup> web site, although this site does not provide the one-on-one mentoring that the Mentornet site provides.

## **C. Teaching and Professional Development**

More and more graduate programs now provide students opportunities to develop better professional skills, in areas such as teaching, writing, and making presentations. These programs can also provide a means for forming support communities, both for members of underrepresented groups and for graduate students in general. They can also provide mentoring

in areas such as learning to write research proposals and general career development, as well as providing opportunities to educating participants about the importance of promoting diversity in the engineering profession and about strategies for achieving diversity. For example, Pawley et al.<sup>59</sup> have developed a course to improve future engineering faculty members' understanding of issues of diversity. Other programs deal with diversity during a sequence of courses on improving teaching skills and succeeding in an academic career<sup>60</sup>. Many of these professional development programs have been established as part of a national "Preparing Future Faculty" initiative<sup>61</sup> to provide graduate students with multiple mentors in addition to the research advisor and to improve their preparation for all aspects of an academic career, not just research. More and more programs to improve faculty understanding of issues in engineering education, including diversity, are also being established. For example, Scales et al.<sup>62</sup> describe an initiative to set up study groups of engineering faculty at Virginia Tech to explore issues related to engineering education.

#### **D. Student Initiatives and Organizations**

Individual graduate students are also writing and thinking about issues related to diversity and to other aspects of engineering education. Their experiences can provide valuable information to students in underrepresented groups as well as to engineering graduate students in general about how to succeed in graduate programs, how to develop skills in areas such as teaching, and how to overcome problems, from doing well in doctoral qualifying exams to coping with loss of funding.<sup>63,64,65,66,67,53</sup> Well-established student organizations, such as the Society for Women Engineers (SWE),<sup>68</sup> the National Society for Black Engineers (NSBE),<sup>69</sup> and the Society of Hispanic Professional Engineers (SHPE)<sup>70</sup> can also help to provide support through mentoring programs, scholarship programs, and community activities, although these organizations tend to be more focused on careers in industry. Students are even taking the initiative, on occasion, to formally assess their academic programs and to suggest improvements.<sup>71</sup>

#### **E. Institutional Programs**

While institutional programs to improve diversity at the undergraduate level and for engineering faculty are more common, many institutional initiatives do include specific activities targeting the graduate student population. In addition to those already mentioned above, several general initiatives have recently been described in the literature.<sup>72,73,74,75</sup> Many of the best strategies to encourage members of underrepresented groups to obtain graduate degrees in engineering have historically been developed in Historically Black Colleges and Universities and other Minority Serving Institutions, most recently through the NSF AGEP program.<sup>76</sup>

#### **F. Student Financial Support**

Many well-established programs have provided financial support and internship opportunities for many years to members of underrepresented groups. Many of these programs are sponsored by corporate supporters, who are well aware that the engineering profession desperately needs a diverse set of leaders to deal with current and future technological problems and issues of globalization. One of the most prominent of these programs is the National Consortium for Graduate Degrees for Minorities in Engineering and Science, Inc. (GEM), which was founded in

1976 and which brings together corporations, universities, research centers, and U. S. government laboratories to provide support for graduate study, including fellowships and workshops on how to apply for graduate school.<sup>77</sup> Another long-standing source of fellowships and internships for women and under-represented minorities in science and engineering is the AT&T Labs-Lucent Bell Laboratories Ph.D. fellowship program,<sup>78,79</sup> which celebrated its thirty-fifth anniversary in 2007. Other fellowships are also provided through various National Air and Space Administration programs.<sup>80</sup> Several ASEE sessions over the years have highlighted the NASA fellowship programs. Fellowships are also by other organizations, including the American Association of University women (AAUW).<sup>81</sup>

## Recommendations

The sources referenced in above brief survey of research on increasing diversity at the graduate level and of programs designed to achieve such diversity provide many good strategies for achieving diversity, as well as examples of areas where more research to develop additional strategies is needed. While many strategies are closely related to successful strategies for improving diversity at the undergraduate and/or faculty levels, some issues distinct to graduate education also exist. In summary, we can identify eight areas where efforts need to be concentrated:

- research on graduate diversity
- recruitment
- undergrad research
- preparation for grad school
- admissions evaluator training
- financial aid
- community building
- mentoring

In Table I below, we list these areas and the stakeholders who can best support each one of them. While progress in achieving diversity at the graduate level continues to be made, true diversity will only be achieved by each of these groups continuing their efforts and sharing their knowledge.

**Table 1: Summary of Key Strategies and Stakeholder Responsibility**

	Adminis- trators	Faculty	Diversity Program Coordi- nators	Govern- ment	Professional Societies / Nongovernment Organizations	Corporate Sponsors	Student Groups	Students
Research on graduate diversity		X	X	X				
Recruitment	X		X			X		
Undergrad research		X	X	X				
Preparation for grad school		X	X				X	X
Admissions evaluator training	X		X					
Financial aid	X			X	X	X		
Community building		X	X				X	X
Mentoring	X	X			X	X	X	X

## Conclusion

While some institutions may be slow to take action on issues related to diversity at the graduate level, individuals can affect the situation in positive ways, at least for themselves and their colleagues. But true diversity will require the participation of all the stakeholders listed above, in at least the areas identified above. Our goal here has been to offer specific examples and to begin to develop resources for others interested in encouraging diversity at the graduate level. Over the next year we will continue to collect information about exemplary programs which will be maintained on the Graduate Studies Division web page, along with the papers which have appeared in this series of panel sessions. This paper and the related session are also calls for input for additional ideas and examples that will help meet our diversity goals.

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