AC 2007-388: MINORITY STUDENT ENROLLMENT IN ENVIRONMENTAL ENGINEERING, GENERAL STUDENT PERCEPTIONS OF THE DISCIPLINE, AND STRATEGIES TO ATTRACT AND RETAIN A MORE DIVERSE STUDENT BODY

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Minority Student Enrollment in Environmental Engineering, General Student Perceptions of the Discipline, and Strategies to Attract and Retain a More Diverse Student Body

Abstract

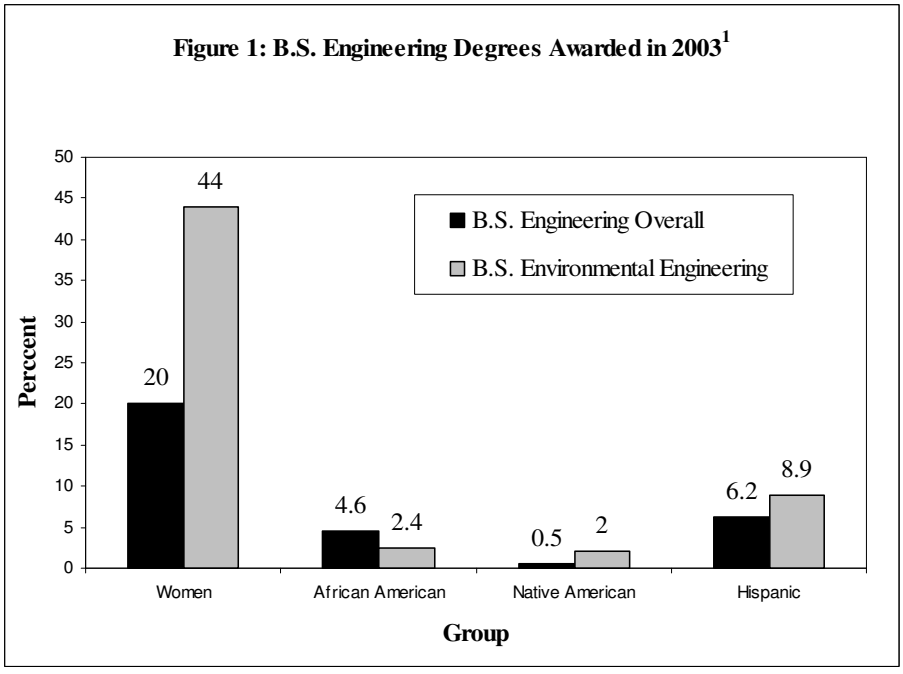
Environmental engineering, as a discipline has celebrated success at incorporating women into its ranks among undergraduate students. It appears that the discipline may also share a similar success at attracting Native American and Hispanic students. Data presented at the 2006 ASEE conference indicates that, across the nation, the discipline attracts more Native American and Hispanic students than engineering overall[1]. However, this paper takes a closer look at this data, which indicates that just a few schools across the nation are enrolling minority students within environmental engineering.

Perceptions of a discipline can alter career choice among first year students. This paper presents studies regarding the perceptions of the discipline among k-12 and first year students, and highlights the need for research regarding the perceptions of the discipline among minorities and factors influencing career choice of minority students. Finally, some suggestions are made for strategies which may increase the attraction and retention of minority students to the discipline.

Diversity within Environmental Engineering

Data from the American Society for engineering Education (ASEE) and the Engineering Workforce Commission (EWC) regarding enrollment and degrees awarded to women and minorities by engineering discipline for 2003 was compared and complied for a paper at the 2006 ASEE conference[1]. Figure 1 shows the percentage of bachelors degrees awarded to women and minorities for environmental engineering and engineering overall. It can be seen that the discipline has successfully integrated women into its ranks, graduating a larger percentage of women (44%) than engineering overall (20%). In fact, environmental engineering graduated more female engineers than any other discipline in 2005[2]. Environmental engineering has emerged as a leader among the disciplines of engineering that attract women at higher percentages than engineering overall. The

Figure 1: B.S. Engineering Degrees Awarded in 2003[1]



"pink collar" disciplines also include biomedical engineering, industrial engineering, and chemical engineering.

Environmental engineering is well on its way to closing the gender gap within the discipline. However, the enrollment statistics for minority students within the discipline are still woefully low.

At first glance, environmental engineering appears to exhibit a relative success in graduating Native American engineers, also shown in Figure 1. In 2003, the discipline graduated four times the percentage of undergraduate Native American students (2%) than engineering overall (0.5%)[1]. However, among 42 ABET-accredited environmental engineering programs in the nation, only 5 reported any Native American students in environmental engineering[1]. Thus, the national percentage of Native Americans enrolled in environmental engineering is misleading. It is not the discipline that is successful at attracting Native Americans, but just a few select programs. One could assume that these programs are likely to be in states with high percentages of Native Americans. The data in Table 1 compares the percentage of Native American students enrolled in each environmental engineering program, with the percentage enrolled in engineering overall, and the percentage of Native Americans among that state's population. No correlation exists between the two. The success of these programs must then be based on efforts of the individual programs.

Table 1: Percentage of Native Americans enrolled in engineering overall, environmental engineering, and state background population[1]

Institution	% Native American		
	All Engineering	Environmental Engineering	State Residents
North Carolina Agriculture and Technical Sate University	2	3	1.2
Montana Technological at University of Montana	0.9	5	0.8
MIT	2.2	9.1	0.2
Northern Arizona University	11.1	22.2	5
Southern Methodist University	10.2	33.3	0.6

In 2003, Hispanic students also represented a higher percentage of environmental engineering B.S. graduates (8.9%) than engineering overall (6.2%)[1], as shown in Figure 1. Among 42 ABET-accredited environmental engineering programs, 12 reported any Hispanic students in environmental engineering[1], shown in Table 2. Similar to the trend with Native American students, the success of the profession at attracting Hispanic students in greater percentages than engineering overall is not standard across the institutions. Table 2 also compares the percentage of Hispanic students enrolled in engineering overall, the percentage enrolled in environmental engineering, and the state background percentage of Hispanic residents. No relationship exists between Hispanic student enrollment in environmental engineering and either the state population or the enrollment of Hispanic students in engineering overall. Thus, the schools that did successfully attract Hispanic students into environmental engineering were not more likely to

be in states with a large Hispanic population. The success of these programs must then, once again, be due to the individual efforts of those programs to attract minority students.

Table 2: Percentage of Hispanic students enrolled in engineering overall, environmental engineering, and state background population[1]			
Institution	% Hispanic		
	All Engineering	Environmental Engineering	State Residents
Utah State University	0.5	20	14.2
Stanford University	7.2	50	32.4
MIT	11.9	9.1	6.8
Northern Arizona University	3.8	11.1	25.3
University of Southern California	8.6	20	32.4
North Carolina Sate University Raleigh	2.0	15	6.1
New Jersey Institute of Technology	13	50	13.3
University of Miami	29.1	33.3	19.1
Manhattan College	15.3	30	15.1
University of Florida	12.2	17.6	19.1
Cal Poly San Luis Obispo	9.3	5.3	32.4
University of Central Florida	10.6	11.8	19.1

A comparison of Tables 1 and 2 shows that only two schools, MIT and Northern Arizona University, reported enrollment of both Native American and Hispanic students in environmental engineering.

Table 3: Percentage of African American students enrolled in engineering overall, environmental engineering, and state background population[1]			
Institution	% African American		
	All Engineering	Environmental Engineering	State Residents
US Air Force Academy	3.4	16.7	12.2
Northwestern University	3.6	9.1	14.7
North Carolina Agricultural and Technical State University	78	71	21.6
Louisiana State University	7.5	8.3	32.5
University of Delaware	8.2	16.7	Not reported
University of Central Florida	7.2	5.9	15.1

The percentage of African Americans among undergraduate environmental engineering conferred (2.4%) in 2003 was below that of engineering overall (4.6%), as shown in Figure 1. Among the 42 ABET-accredited environmental engineering programs, only 6 reported any African American students enrolled in environmental engineering[1], as shown in Table 3. Again, no correlation existed between state demographics and enrollment of African Americans in environmental engineering programs within a state. Recall the previously mentioned trend of

lower percentages of African Americans enrolled in environmental engineering when compared with engineering overall across the nation. Examination of Table 3 indicates that 4 of the 6 programs that attracted African American students did so at a higher rate than engineering overall at those schools. Additionally, the percentage of African American enrollment in environmental engineering at the 6 schools was much greater than the national average of 1.5%[1].

A comparison of Tables 2 and 3 show that only one school, University of Central Florida, included both Hispanic and African American students among their environmental engineering enrollment. Comparing Tables 1 and 3 shows that only one school, North Carolina Agricultural and Technical State University, attracted both Native American and Hispanic students to environmental engineering.

In the case of all three minority groups, enrollment of students from one of the groups in environmental engineering occurred at only a select few schools. Additionally, none of the schools managed to attract all three groups to environmental engineering, and only 4 schools(MIT, Northern Arizona University, University of Central Florida, and North Carolina Agricultural and Technical State University) managed to attract two of the minority groups to the discipline. Thus, enrollment of minority students in environmental engineering occurs within select programs, which tended to exhibit a unique success with regard to a specific minority population. It is likely that this success is based upon specific efforts to recruit and retain a target minority population on the part of the programs. The problem still remains, for the overwhelming majority of ABET accredited programs, of attracting minority students to the discipline.

However, among the schools that do manage to attract minority students into the discipline, they tend to be present at higher percentages than engineering overall. However, due to the relative lack of integration of minorities into the field across all the universities, it is impossible to determine if the field itself is actually more appealing to minority students. Further research is required to better understand the motivating factors behind minority student career choices. A better understanding of the values of these students could lead to more tailored and successful recruiting efforts.

Environmental engineering has been extremely successful at overcoming the gender gap existing in other disciplines. Women have traditionally been attracted in high numbers to serving or nurturing types of professions, such as nursing or teaching. Environmental engineering is often touted as a service profession, contributing to society and helping humanity. This image of the discipline has worked positively to attract women. In a recent study at the University of Colorado-Boulder, fist year 58% of females in a first year engineering course indicated an interest in serving society, compared with only 21% of the males[3]. Female students at this school also joined professional societies with a service focus, such as Engineers Without Boarders, at higher percentages than more traditional discipline specific societies, such as American Society of Civil Engineers.

Helping others matters to women. The success of the discipline in attracting female students may very well be that the primary goals of environmental engineering sync well with the altruistic desires of women. A deeper examination of the perceptions of the discipline and the factors

which motivate discipline selection for minority students may provide some insight with regards to the comparative failure of environmental engineering to attract minority students. Recruiting efforts for minority students could be targeted to address their motivating factors behind career selection.

Perceptions of the Discipline

It is well known that the demand for environmental engineers is on the rise. Despite the fact that it is among the fastest growing engineering professions, there is a shortage of students enrolling in environmental engineering. Market demand and image of a discipline are known to be among the major motivators for selecting a discipline. As the market demand for environmental engineers is high, the image of the discipline has been suggested as a cause for both low overall and low minority enrollment[4].

Because environmental engineering practitioners emerge from a variety of academic roots (civil engineering, chemical engineering, biochemistry, etc.), and work in multiple specialties (water, wastewater, air, remediation, etc.), environmental engineering lacks a common definition as a discipline[4]. There is even a lack of agreement within educational institutions regarding the relationship of environmental engineering to other disciplines. Some schools include environmental engineering as a sub-discipline of civil or chemical engineering, some schools have created multi-disciplinary degree programs, and some consider environmental engineering a stand alone discipline[4]. The nebulous nature of the discipline causes confusion, and potential students often do not understand exactly what environmental engineering entails.

If incoming students lack a strong concept of environmental engineering, they are making uninformed decisions about their major. Students that select environmental engineering as a major often are aware of current environmental issues, and have a strong desire to save the world[5]. One recent class introducing the discipline to fist-semester environmental engineering majors at Michigan Tech resulted in significantly less confidence in choice-of-major and satisfaction with the major among the students. Reasons students provided for their decreased happiness with the major included the discovery that environmental engineering work is not performed outside, but mainly done in an office setting; the amount of math and science classes required; and that the field did not focus on animals[5]. These results indicate that those students that had selected environmental engineering as incoming first year students had little to no understanding of environmental engineering coursework, and did not understand the primary focus of the field.

A recent study examined the perceptions of engineering disciplines among high school students taking STEM courses in Rolla, Missouri[6]. Students were asked to identify their familiarity with various engineering disciplines on a scale of 1-5. Students indicated less understanding of environmental engineering (1.8) than the mean of all disciplines (2.53). Students were also asked to provide one word or a phrase they associated with the various disciplines. The students could accurately identify the themes, materials, or technologies associated with the more traditional engineering disciplines. For example, students associated the terms “electricity, circuits, wires, wiring” with electrical engineering. On contrast, students associated the terms “environment, trees, tree huggers” with environmental engineering.

It has been shown that high school students and first year environmental engineering majors did not have accurate perceptions of the environmental engineering field[5-6]. The student's perceptions of the discipline were more along the lines of environmentalism than engineering. In fact, environmental engineering requires the application of math, science, and technology to mitigate the impacts of human activities on the environment. However, students interested in engineering, may not view the disciple as technically rigorous as other engineering disciplines. To attract more students into the discipline, the "engineering" nature of the discipline needs to be more accurately conveyed to young students. What is missing in the reported views of the discipline is a sense of the design and application of technology. It is this author's belief that the simplest and most accurate definition of the environmental engineering is the design and implementation of pollution control technology. Most in-coming students do not share this concept of the discipline.

However there is hope for changing students' perceptions of the discipline. Recent hands-on engineering education programs aimed at first year engineering students and high school students in Virginia resulted in increased awareness of the interdisciplinary nature of engineering[7]. Additionally, the introduction of an NSF STEM teaching fellow into K-12 classrooms resulted in an increased understanding of the different fields of engineering, and the ability of students to portray more disciplines more accurately[8]. Thus, students' perceptions of an engineering discipline can be changed, resulting in first year engineering students who are more accurately informed about the discipline.

As minority students are still woefully underrepresented within the discipline, there is a need for educational outreach specifically aimed at introducing the discipline and its objectives to minority students. Additional research is needed to determine minority student motivators for career choice and perceptions of the discipline.

Existing Efforts for Increasing Diversity within Engineering Overall

Many schools are recognizing the need to increase diversity within engineering programs. Efforts to increase diversity include efforts to both attract and retain minority students to engineering. Lessons can be learned from efforts to attract minority students to general engineering programs that may be applied within the discipline.

In recent years, decline in engineering enrollment has led to efforts to educate students prior to college about the engineering profession. The short term goals of K-12 programs are to provide hands on engineering experiences to children, increase their knowledge of engineering as a profession, and create awareness of the different disciplines. The long term goal of K-12 engineering programs are to increase enrollment in engineering programs. K-12 programs targeting minority groups are among the existing efforts utilized to recruit minority students into engineering[9-10].

K-12 programs could be utilized to educate students early and accurately about the discipline. Every parent is familiar with the kindergarteners' obsession with poop-based humor. This is a perfect age to introduce the concepts of sewage collection systems and wastewater treatment. As

students age and are introduced to the concepts of picking up litter and recycling, solid waste management can be addressed. Basic concepts behind landfill design, such as design life and liners could be covered. High school students can be exposed to the more complex issues of chemical pollutants and remediation techniques. Age appropriate minority outreach should attempt to create a new generation of incoming college students that are familiar with the discipline.

K-12 programs are often aimed at increasing the diversity of incoming freshman classes. However, efforts can also be made to increase diversity beyond the first year of college. Thus, some schools facilitate community college transfers into engineering programs, as a means of increasing minority student enrollment[9-10]. Outreach should also be addressed to community college populations. Students enrolled in math and science classes should be targeted for their interest in core concepts. Additionally, educational materials about the discipline could be made available to enrollment counselors.

Funding is often an issue for many first generation college students. Increasing diversity in engineering programs means attracting students whose parents often did not attend higher educational institutions. Thus, some schools are increasing their efforts to identify funding for minority students[9]. Efforts should be made to identify funds specifically for minority students within the discipline.

Graduation is not ensured just because minority students are enrolled and their education is funded. In fact, individual schools that successfully attract minority students often have issues with the retention of minority students[9]. Thus, many schools are developing new programs aimed at increasing retention rates. First year introduction to engineering courses are being offered by many schools as an effort to increase the retention of engineering students[10]. The goal of these courses are to provide students with the basic skills for success as engineering students, familiarize students with the various disciplines of engineering, assist students in selecting a major, increase student sense of identity and belonging as engineers, increase student interest in engineering, and provide hands on engineering problem solving and design experiences earlier in the educational time line[11]. Recognizing the importance of hands-on learning for attracting a wider diversity of students to engineering, many programs are restructuring these classes to include more experiential learning techniques in an effort to increase retention among engineering students.

Early evidence exists that first year experiential learning based engineering courses increase retention. One recent study of a first semester engineering technology course at Old Dominion University found increased retention of students within the college, and more students transferred from engineering to engineering technology[12]. It is possible that students that may normally be averse to the traditionally reflective math and science course work of engineering, may be attracted to the more active and applied classes offered in engineering technology. If the loss of these students was due to the desire for more experiential learning, the implementation of these techniques within engineering classes could increase retention.

Another introduction to engineering course at the University of Virginia focused on teaching engineering in context (EIC), through a semester long project. EIC emphasizes the “application

of the engineering problem-solving method to a current challenge or opportunity, coupled with more focused consideration of problem identification and definition and the potential impact of a solution." The EIC class replaced a traditional class based on the engineering science model, which focuses on the classroom presentation of technical knowledge and skills out of the context in which they are applied. Students taking this class provided a higher overall course rating and exhibited a slightly higher retention rate than previous students under a more traditional format[13].

First year experiential learning courses should address the various disciplines in an effort to aid student selection of a major. Students interested in environmental engineering should be engaged with hands-on projects as early in their academic career as possible, sustaining their interest through the more fundamental math and science classes of the early years.

Many schools also recognize the importance of industry partnerships that provide minority students with engineering co-op and intern experiences prior to graduation[9-10]. Industry partnerships with companies that value diversity can provide essential mentors and role models for minority students, in addition to the valuable hands on work experience.

Mentors can also be provided within the university setting. Some schools are recognizing the importance of mentoring and advising for increasing the retention of minority students[10]. Engineering educators are increasingly called upon to initiate dialogue about students' development and skills. Educators can provide essential advice to facilitate student success.

Another tool for increasing student retention is to encourage undergraduate research projects for minority students[9-10]. These projects also provide valuable hands on experiences that increase student identity as engineers and interest in engineering. They also provide ample opportunity for developing deeper mentoring relationships with students.

Conclusion

Environmental engineering has been comparatively successful at attracting female students. However, significant efforts need to be made to increase minority enrollment within the discipline. Currently only a handful of institutions are attracting minority students into environmental engineering programs. Minority recruitment and retention efforts practiced by general engineering programs should be further employed by individual environmental engineering programs. Additional research is needed to understand the factors influencing career selection among minority students.

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