Enrollment of Women
In Undergraduate Civil Engineering Programs

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INTRODUCTION

Given the importance of a diverse student body in providing both a diverse work force and the largest possible pool of practicing civil engineers, an investigation was undertaken to determine the state of enrollment of women in undergraduate Civil Engineering programs. As part of the study, the state of enrollment for women in civil engineering programs at similar institutions and possibilities for improving the situation institution were explored.

CURRENT STATE OF ENROLLMENT

Available data describing the enrollment of women in civil engineering (and similarly named) departments nationally were compiled. Table 1 lists the nationwide percentage of women graduating with a B.S. in Civil Engineering over a period of years. The percentage of women steadily rose during the 1980's and 1990's, but has stabilized in the most recent decade at about 20 to 22 percent. For comparison, the 2004 national average for women graduating with engineering B.S. degrees for all engineering disciplines, which was 20.3 percent (Gibbons, 2004).

Figure 1 shows the percentages of women in the 2005 B.S. classes in Civil Engineering for 233 programs across the country as a function of the number of students graduating. There are six universities that clearly stand out as "very large" programs. These include (in order of largest to smallest) Purdue, Polytechnique University of Puerto Rico, Georgia Tech, North Carolina State University, Texas A&M, and Penn State, ranging in graduating class sizes from 152 to 176. For these universities, the percentage of women in the graduating class of 2005 in civil engineering is fairly uniform, ranging from 18 to 24%. Figure 1 also shows that the smaller the size of the graduating classes, the more variability in the percentage of women.

The data associated with Figure 1 also yields some interesting information about the distribution of women in various CE undergraduate programs. Table 2 provides some descriptive statistics for various groupings of programs. It is interesting to note that the average percentage of women does not change significantly within the larger schools; however, the variability of the data around the average (as evidenced by the coefficient of variation) increases significantly as increasingly smaller programs are included. As discussed in the previous paragraph, for the very large programs (defined as having more than 150 graduates), there is minimal variability in the percent of women graduating, with a coefficient of variation of only 0.10. For the next largest group of schools, those with more than 100 graduates in the CE class of 2005 (18 schools), only one (UC Davis) has more than 35% women. The variability for this group is considerably greater with a coefficient of variation of 0.38. In the largest 100 programs, none have more than 50% women and 10 have more than 35% women. The coefficient of variation is 0.41, slightly greater than the largest 18 schools. By contrast, in the smallest 100 programs, 12 schools have more than 50% women and 30 have more than 35% women. With one exception (Carnegie Mellon University), all of the schools with more than 50% women in their 2005 graduating class had class sizes less than 25. As noted above and shown in Table 2, there is also considerably greater variability in the

Table 1. National average of percentage of women graduating with B.S. in Civil Engineering since 1978. (Data taken from ASCE, 2005).

Year	Percentage Women
1978	7
1979	9
1980	9
1981	10
1982	11
1983	13
1984	13
1985	13
1986	12
1987	13
1988	14
1989	13
1990	15
1991	15
1992	16
1993	17
1994	18
1995	19
1996	19
1997	20
1998	21
1999	22
2000	23
2001	22
2002	23
2003	22
2004	22
2005	23

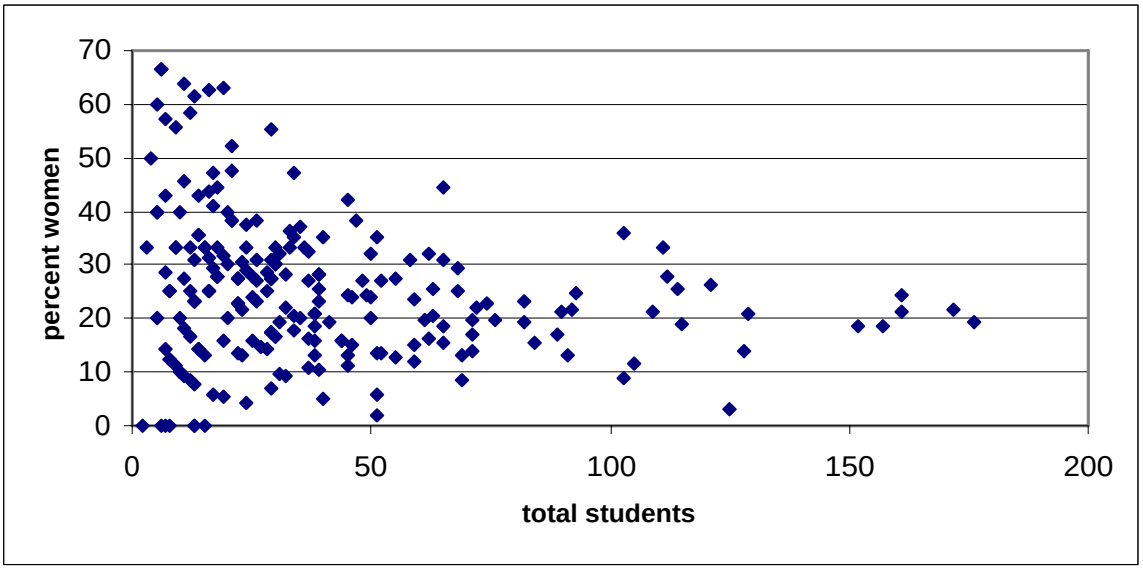

Figure 1. Percent women as a function of class size in the 2005 graduating classes from 223 undergraduate Civil Engineering programs. (Data taken from ASCE, 2005).

Table 2. Statistics for the percent women in the 2005 undergraduate civil engineering programs for various sizes of programs. (Data taken from ASCE, 2005).

Statistic	>150 students	>100 students	largest 100	smallest 100
Number of schools	6	18	100	100
Average (%)	21	21	22	29
St. Deviation (%)	2.1	7.8	8.9	16
Coef. of Variation	0.10	0.38	0.41	0.58

percentage of women for the small programs, with a coefficient of variation of 0.58. This is not surprising since the size of the classes range from two to 26 students. Such small programs are bound to have greater variability since a change of enrollment of just one women student can greatly affect the resulting percentage.

PRIOR STUDIES RELATED TO WOMEN IN ENGINEERING

Although few studies have been published that discuss issues of recruitment and retention of women specifically in the area of civil engineering, a number of studies discuss the problems of low numbers of women in the general field of engineering and several provide suggestions for increasing the

numbers. Engineering has the smallest percentage of women in their graduating classes of any profession, including medicine, law, and others (Tietjen, 2005). The situation in engineering practice is worse yet. The percentage of women engineers in engineering practice has never reached even10 percent (Isaacs, 2001). Data indicate that retention is not as big an issue as recruitment (Gibbons, 2004). In a study conducted by the National Science Foundation (2005), it was determined that high school girls take science and math courses at approximately the same rate as boys. However, boys enter university engineering programs at much greater rates than girls. According to a survey published in the Chronicle of Higher Education (Hoover, 2006), only 8.4% of students entering college in 2005 were planning to major in engineering. A very small portion of those students, 0.3%, were women planning to major in Civil Engineering.

There are many reasons why women have not populated engineering degrees or the engineering profession. Numerous authors have speculated that the engineering profession suffers from an image problem (e.g., Johnson et al., 1992; Hersh, 2000; Isaacs, 2001; May and Chubin, 2003; National Science Foundation, 2005; Tietjen, 2005; Widnall, 2006). Few pre-college girls know what engineering is or what engineers do. According to Tietjen (2005), this problem can be at least partly attributed to the fact that we all have interactions with doctors, dentists, and other professionals, but not typically with engineers. In addition, many television shows and movies are related to people working in legal, medical, and other professions. Engineers are rarely the topic of television shows and movies. Another reason commonly cited for the shortage of women entering engineering majors in colleges is the lack of encouragement by high school counselors and teachers, relatives, and other influential people in the lives of young women (Johnson et al., 1992; Bix, 2004; Widnall, 2006). Other reasons for the shortage of women in engineering may include climate, social value, and peer influence (Johnson et al., 1992).

Based on a survey of 85 high school girls, the National Science Foundation (2005) found that there is a disconnect between motivating factors for high school girls in selecting a career path and the message communicated by the engineering community. They found that high school girls emphasized the following factors: enjoying their work, having a good working environment, making a difference, earning a good income, and having flexibility. The message from the engineering community, on the other hand, indicates that engineering is challenging, is difficult but rewarding, and requires math and science to solve problems. None of these factors are motivators for the young women surveyed. This idea is echoed by Tietjen (2005). She theorizes that women pursue professions in which they see value; if they do not know what engineers do, they cannot assess the value of their work. In addition, the engineering profession is sometimes viewed as the cause of environmental destruction, further hurting the image of engineering particularly for women (Hersh, 2000).

One important strategy to recruiting women students into engineering lies clearly in the information and encouragement given to high school girls. The National Science Foundation (2005) study concluded that recruitment of girls into engineering programs at the universities will require that the engineering community develop and test messages that would go out to both the girls as well as their career influencers through various materials and training.

A second way to increase the percentage of women in undergraduate engineering programs is to change the admissions policies. This has been the approach taken at MIT, for example. Following a study of math SAT scores as an indicator of academic performance, it was determined that women perform better than their math SAT scores indicate (Widnall, 2006). Admissions criteria were then changed accordingly. The following year, the percentage of women in the entering engineering class increased significantly. The 2005 MIT class graduating with a B.S. in Civil Engineering had 63% women (out of a class of 19 students) (ASCE, 2005). The incoming freshman class for all engineering typically has about 50% women (Widnall, 2006).

FOCUS GROUP AND SURVEY RESULTS AT PENN STATE

Two focus group sessions were held, where the first group consisted of freshman and sophomore women who were in the engineering college and had indicated Civil and Environmental Engineering as their preferred choice of majors (at Penn State, students in Engineering do not choose their major until the end of the sophomore year). The second focus group consisted of senior women in the CEE undergraduate program. This group answered the same questions as the first group for comparison with the results from the freshmen and sophomores. The civil engineering image issue described above came through very clearly. Surprisingly, both freshmen and senior women alike used the words "dirt", "bridges", and "men/dad" to describe civil engineers. In both groups, almost every woman said that there was no information in high school to introduce them to engineering careers. As in the NSF study, the response of both focus groups to the question of important factors to consider for their future job, all of the answers were geared toward social aspects rather than the engineering community message of being good at math/science and having a challenging job. The response of these women was quite similar to those in the NSF high school survey, even though half of them were seniors. They still placed importance on personal satisfaction, location, comfortable living, etc. When asked how to improve recruitment of women, both groups suggested that most young women do not know what CE's do, and therefore, need some information. The younger students said that they gained their information on what Civil Engineers do on-line and expressed the importance of seeing people in the pictures on the websites rather than just words.

As a follow up, a general survey was conducted for the purpose of gaining an idea of student familiarity with the Civil Engineering Department at Penn State and to obtain opinions of the male students as well as the females. It was also used to analyze and suggest strategies for improvement in the area of recruitment of women into the civil engineering department.

DISCUSSION

The results of the focus groups held for the freshmen/sophomore and senior women and the survey conducted for male and female students all showed that the women students seem to reiterate much of what has been shown in the literature and in survey given to high school girls. In particular, it is clear that girls in high school are not provided with knowledge of what civil engineers do or the value of civil engineering and are not encouraged to consider Civil Engineering as a college major. The responses indicated a reasonable level of comfort within the program, which suggests that retention is not as critical as recruitment.

The results of this study are noteworthy in terms of developing recruitment tools to increase the percentage of women in the program. First, outreach to the high schools and training of high school counselors and teachers to provide information to the girls in high school is crucial. Given that the vast majority of students showed a very strong tendency to look to the internet for information, creating departmental websites that contain information for high school students is a good place to start. This portion of the website could describe recent graduates of the undergraduate program, where they have gone to work, what they do now, and the value of their work to society. This site could also provide evidence of the value of Civil Engineering, job opportunities, and other information geared toward the factors that was established in the NSF (2005) study, providing specific information for high school students.

Second, the Women in Engineering Programs (WEP) should be prominent and have a high level of activity. This is a primary outreach organization to high school girls around the country. WEP can

also be a powerful organization for creating an image of engineering that is welcoming to high school girls and young women. WEP can show them that they will have friends in their engineering major and subsequent jobs and a career that has social value, factors repeated in all of the surveys.

Third, Civil Engineering departments should provide a culture and climate that is encouraging to women. No female student should ever feel a bias against women by their engineering professors. While this may be unintentional on the part of the professor, it is discouraging and has no place in our educational system. Thus, diversity training should be conducted for all faculty and new instructors on a regular basis.

Fourth, it would be worthwhile to examine the admissions process for engineering. As described earlier, MIT changed their process and significantly increased the percentage of women in their engineering programs. Given the differences in sizes and resources, a direct comparison between large, public universities, such as Penn State, and small private schools may not be appropriate. However, an examination of admissions policies might highlight an area where we can make a difference for the entire engineering college.

CONCLUSION

The Civil and Environmental Engineering Department at Penn State graduated 18% women in its 2005 class with the B.S. degree. While this percentage is similar to that in the five other very large civil engineering departments in the country, the percentage is declining in the incoming classes. This study presented some of the important factors in recruiting young women into engineering in general and civil engineering specifically. Several suggestions were provided for immediate and longer term improvements. The most glaring area where we can make a difference is through an information flow to high school students.

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