AC 2009-275: GENDER DIFFERENCES IN IN-CLASS AND OUT-OF-CLASS EXPERIENCES THAT INFLUENCE THE INTENT TO COMPLETE AN ENGINEERING DEGREE

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Gender Differences in In-Class and Out-of Class Experiences that Influence the Intent to Complete an Engineering Degree and to Pursue Engineering as a Career

Engineers contribute to national interests in business and industry, allowing the U.S. to maintain economic competitiveness [1]. Due to the contributions made by the engineering workforce to the national economy, undergraduates' career goals as they relate to engineering [2, 3], students' experiences while enrolled in degree programs [1,4] and the numbers of women attaining an engineering degree [2,5] are of interest to many groups, including engineering educators.

When looking at the engineering workforce, the underrepresentation of women among engineering undergraduates as well as the lack of female engineering degree earners gives rise to concern [5,6]. In 2005, women represented approximately 20% of the bachelor's degrees awarded in engineering[6], yet females represent more than half of all undergraduates enrolled at the postsecondary level. In addition, a retention study conducted by the Society of Women Engineers shows that 71% of men and only 61% of women who responded were employed as an engineer within the first three years of graduating college. This trend is further exacerbated over time as longitudinal data reveals that 20 years after graduation, only about one-third of women engineering degree earners but about half of the men were still in engineering jobs. Among those who indicated that they were no longer in an engineering job, one quarter of the female engineering degree earners were either unemployed, not in the labor force, or employed in jobs they saw as very different from engineering. At the same time only 11% of men indicate being in these same types of positions[3].

Given the under-representation of women, determining to what extent in-class and out-of-class experiences are inclusive and promote the academic achievement of women as well as men in engineering and engineering-related subjects such as science, math, and technology is a major focus of study [1,4]. In particular, these trends have called attention to the undergraduate experience

of engineering students to determine whether students are sufficiently prepared when they the workforce as well as whether experiences while enrolled explain, to some extent, why women appear less likely to enter a career in engineering. The educational experiences of aspiring engineers are being examined to determine whether students are developing specific attributes and whether experiences address the needs of a changing demographic population[1]. For instance, across grade levels and at the postsecondary level engineering curricula and instructional methods used in engineering classrooms are being examined to determine whether analytical skills and leadership qualities are being developed[1,7,8,9].

Other studies have focused on gender differences in elements of the in-and out-of-class experiences of undergraduates within the college environment in an attempt to explain female undergraduate departures from STEM fields[10]. Incidences of sexism and sexual harassment are higher in institutions where the representation, if not the total numbers, of women among the student body are relatively low [11]. Women students report engaging in effective instructional practices such as participating in class discussion and playing an active role in class discussions less frequently than male peers while they appear to interact with faculty members in educational settings at equal rates[10].

Fewer studies have looked specifically at gender differences among engineering undergraduate students and their interest in remaining in engineering as a career as well as what elements of students' in-and out-of-class experiences may be related to their intent to work in engineering in the future[10]. This study looks at differences in the career aspirations of undergraduates enrolled in engineering programs by investigating the intent to remain enrolled in engineering as a major and the likelihood that students plan to be in engineering ten years from

now. In-class and out-of-class experiences that are significantly related to students' career aspirations are also investigated.

Three research questions served as the basis for this study:

1. What are the differences in career aspirations among undergraduates enrolled in engineering programs by gender?
2. What are the differences by gender among in-class and out-of-classroom experiences that are associated with interest in the major and intent to pursue engineering as a career?

Methodology

The research project employed a concurrent mixed methods research design with the quantitative methods being dominant. The sample involved students in engineering at nine institutions distributed throughout the U.S..

Using information from *2003 Profiles of Engineering and Engineering Technology Colleges* [12], we selected private and public institutions from among institutions graduating at least 50 female engineers in 2003. We eliminated the category of baccalaureate-granting institutions because so few graduated 50 or more women engineers in a given year. Table 1 identifies the institutions participating in the study and the average number and proportion of female graduates over a five year period.

Table 1. Average Number and Percent of Female Graduates in Engineering, by Institution, 2003-2007

Institution	Number of Bachelor's Degrees in Engineering Awarded to Females	Percent of Bachelor's Degrees in Engineering Awarded to Females
1: Boston U.	62	24%
2: Brigham Young U.	41	10%
3: Dartmouth	32	26%
4 Tufts	57	32%
5: U. of KY	54	16%
6: Cal Poly – Pomona	74	16%
7: RIT	44	14%
8: Oregon State	77	14%
9: MIT	212	35%

Data collection procedures occurred in two phases occurring within a six month window. During the first phase, an institutional liaison at each site worked with one of the principal investigators to negotiate human subjects clearance, to provide contact information for all full-time undergraduate students in engineering, and to oversee the administration of the faculty and student questionnaires. The Survey Research Center (SRC) at the home institution administered the on-line distribution of the questionnaires and oversaw the follow-ups of non-respondents. The SRC removed any connection to personal identifiers before distributing a copy of the data set of questionnaire respondents for each institution.

Members of the research team developed a student and faculty questionnaire from parts of The *Student Persisting in Engineering Survey* developed as part of the Assessing Women and Men and Engineering Project (AWE). *The Engineering Student Survey* contains 114 questions. After a set of demographic items, the questionnaire is organized in seven sections: (a) Important Factors in Career Choice, (b) Self-Assessment of Abilities, (c) Classroom Experiences, (d) Support Networks, (e) In- and Out-of-Class Engagement, (f) Opinions about University and Departmental Climate, and (g) Family and Educational Background. *The Engineering Faculty Survey* contains 134 questions, organized in five sections: (a) Involvement with Recruiting Activities, (b) Departmental and University Environment, (c) Professional Development, (d) Involvement with Undergraduates, and (e) Personal Information.

The second phase of data collection included a review of documents and a campus visit. During the campus visit, one of the principal investigators and a second person conducted individual and group interviews with faculty, administrators, and students. In all cases, the person accompanying one of the co-principal investigators is an engineer with prior experience in interviewing. Group interviews were conducted with faculty members and undergraduate

students in the two engineering departments with the largest female enrollments. Individual interviews were conducted with the institutional liaison, the dean of the school or college, selected female faculty members in engineering identified by the liaison, and other faculty members and administrators with an interest or involvement in activities designed to promote women's interest in engineering. All interviews were recorded and transcribed. Students received a $10 incentive for participating in the group interviews.

A single semi-structured interview protocol was tested and refined during the first year of the project. The interview protocol followed the major research questions and contained questions about (a) characteristics of undergraduates, (b) skills and abilities required to complete an undergraduate degree, (c) experiences considered essential to educating an undergraduate engineer, (d) strengths and weaknesses of the institution in supporting undergraduates, and (e) recommendations about what the institution could do to promote participation of women in engineering.

Quantitative and qualitative analyses were conducted to examine the data and answer the research questions for this study. In terms of the quantitative analysis, two items served as the dependent variables for this study: a) If I had to do it over again, I would still major in engineering, b) How likely is it that you will be in an engineering-related field ten years from now. To answer the first question, respondents could select Strongly Agree, Agree, Disagree, Strongly Disagree, or Do Not Know. Responses to the second question could include: Very Likely, Somewhat Likely, Somewhat Unlikely, Very Unlikely, or Not Applicable. Responses that included Do Not Know or Not Applicable were not used in this analysis. A chi-square analysis was conducted for each item by gender to determine if there were significant differences between males and females.

In order to examine which in-class and out-of-class experiences were related to career aspirations, a series of items from the survey were selected to serve as the independent variables. Students could indicate the extent to which they agreed or disagreed with a series of statements by selecting Strongly Agree, Agree, Disagree, Strongly Disagree, or Do Not Know. Statements included items such as 'I am satisfied with the quality of teaching in my engineering classes,' 'Instructors in my engineering classes treat me with respect,' 'I am treated with respect by male students in my engineering classes,' and 'The workload in most of my engineering classes is reasonable.' Do Not Know responses were removed from the analysis. Mean scores for each item were computed as well as for the dependent variables. Pearson's correlation coefficients were used to determine which independent variables were significantly related to the dependent variables for both males and females. This method allowed us to determine whether there were differences by gender on items measuring elements of in-class and out-of-class experiences that correlated with career aspirations among undergraduate engineering majors. Once significant items were identified through the analyses outlined above, transcripts were reviewed for convergent themes as well as for discrepancies.

A total of 1,629 students completed the survey and submitted their responses. Student respondents were mostly male (70.0%) and white (79.6%).

Results

Results from this study reveal that females (89.9%, n=466) are as likely as males to agree that they intend to remain in engineering as a major (91.7%, n=1085). Despite these similarities, there are significant differences by gender with regard to the long-term career outlook held by students. Males (92.4%, n=1048) were significantly more likely than females (84.8%, n=428) to

agree that they will be working in an engineering-related field 10 years from now (X^2= 19.571; p=≤ .000).

In terms of classroom experiences significantly related to the intent to remain in the major, feeling as though instructors treat students with respect and positive interaction with peers were positively correlated for both males and females. Feeling as though engineering professors care about student learning was also related to students indicating they planned to finish their engineering degree. Out-of-class experiences such as interacting with effective faculty role models were also positively associated with the likelihood of completing a degree for both groups.

Peer interactions are one common element of the instructional experience for both males and females that is positively and significantly correlated with the intent to remain in the major as well as pursue a career in engineering. Positive interactions with peers both in-class as well as out-of-class are significantly correlated for both males and females to the intent to pursue a career in engineering ten years from now. Interaction with effective faculty role models as well as satisfaction with the quality of teaching were variables that were significantly related to long-term career aspirations of students. The perception of being respected by female peers was significantly related to the career aspirations of male students but not female students.

Qualitative data provided through interviews with male and female students provide context for understanding in- and out- of-classroom involvement that shape the career goals among undergraduate students and how these experiences differ by gender. One element in particular, peer interaction in the form of group work, appears to be a critical element of the undergraduate experience, influencing the intent to remain in the engineering major as well as influencing the long-term career outlook among students.

Students explained that group work is the primary means through which coursework is accomplished and that team work was critical for helping them manage a challenging academic course schedule. Academically focused group work was also the venue through which they met future roommates and other close confidants. It is not surprising that academic interaction among peers would lead to friendships; however, these findings taken on added significance when the role of gender is considered. Students that are unsuccessful at "fitting in" to the cultural norm in engineering degree programs may decide to leave due to feelings of isolation rather than the inability to complete coursework.

Discussion and Implications

Findings from this study highlight the importance of peer interaction characterized by respect in shaping the intent to remain in the engineering major as well as whether students see themselves in an engineering-related field ten years from now. While these findings apply to both males and females, results indicate that the career goals of females are heavily influenced by group work experiences tied to engineering coursework. There are several practical implications that programs can implement based on the significant findings from this study.

Among females the intent to pursue an engineering degree does not translate directly to pursuing a career in engineering. Group projects provide one venue through which perceptions about how work is accomplished in the field are formulated. Experiences on teams as well as the degree to which women manage their minority status, shape whether females see themselves working in an engineering field long-term. Given the amount of group activities that go unmonitored by faculty in engineering degree programs, gender biased behavior and male dominated cultural norms may negatively impact the undergraduate experience of females in engineering degree programs. These findings are underscored by other studies that show female

students are hesitant to challenge male-dominated cultural norms that have been established in engineering departments [4]. Attending to group dynamics among engineering undergraduates can have substantial impacts on the career goals of men and women.

In addition, feelings of being respected by both peers and faculty had an impact on undergraduate engineers' intent to remain in the major and to pursue engineering. For both female and male respondents, perceptions of being respected by instructors in engineering courses and by both male and female peers was positively associated with the intent to remain in an engineering major. Results strongly suggest that educators must manage the group dynamics during in- and out-of-class activities class related assignments. Faculty members may consider doing this early on in the semester by establishing guidelines for how work is accomplished in group settings, making sure that students have equal and ample opportunity to take a leadership role, and providing advice on how to handle off-hand comments that are biased or sexist.

Faculty members' can also serve as role models by the way they react to inappropriate comments or behaviors that occur in-class. Ignoring such comments can be interpreted as endorsement for them. Intervention in the case of a sexually suggestive remark, for example, can be as simple as pointing how offensive the remark might be to others and by asking a student to rephrase their comments. Addressing peer-to-peer civility in the classroom and among group members is a concrete way for faculty members to communicate the critical role respect among students plays in retaining students both in engineering majors and careers. Agreeing to a set of ground rule for interaction on teams is a concrete way for faculty members to communicate their concern for preparing students to work effectively in a diverse workplace.

This study highlights components of the instructional environment in undergraduate engineering programs. Unlike research with an individualistic focus that target students' ability

the factors that emerge as important in this study are those within the purview of educators to address.

Bibliography

1. National Association of Engineering, (2005). *Engineering Research and America's Future: Meeting the Challenges of a Global Economy*. Washington, D.C.: National Academies Press.
2. Regets, M.C. (2006). *What do People do After Earning a Science and Engineering Degree?* Washington, D.C.: National Science Foundation. http://nsf.gov/statistics/infbrief/nsf06324/
3. Society of Women Engineers (2008). *SWE Magazine*, Summer.
4. Women's Experiences in College Engineering [WECE] (2002). Cambridge, MA: Goodman Research Group, Inc.
5. National Science Board (2008). *Science and Engineering Indicators 2008*. Retrieved August 7, 2008. Available: http://www.nsf.gov/statistics/seind08/c0/c0i.htm
6. Brainard, S. G., & Carlin, L. (1998). A Six-Year Longitudinal Study of Undergraduate Women in Engineering and Science. *Journal of Engineering Education, 87*(4), 369-375
7. Bernold, L.E. 2007. "Preparedness of Engineering Freshman to Inquiry-Based Learning." *Journal of Professional Issues in Engineering Education and Practice, 133*(2): 99-106.
8. Eskandari, H., S. Sala-Diakanda, et al. (2007). Enhancing the Undergraduate Industrial Engineering Curriculum: Defining Desired Characteristics and Emerging Topics. *Education + Training, 49*(1), 45-55.
9. Heywood, J. (2005). *Engineering Education: Research and Development in Curriculum and Instruction*. Hoboken, N.J.: IEEE Press.
10. Zhao, C.M., Carini, R.M., & Kuh,G.D. (2006). Searching for the peach blossom Shangri-La: Student engagement of men and women SMET majors. *Review of Higher Education*, *28*(4), 503-525.
11. Creamer, E. G., Burger, C. J., & Meszaros, P. S. (2008). *The Impact of Elements of Institutional Culture on the Enrollment of Women in Engineering*. Poster. National Science Foundation (NSF) 2008 HRD Joint Annual Meeting. June 16-18, 2008. Washington, D.C.

12. American Society for Engineering Education (2004). *2003 Profiles of Engineering and Engineering Technology Colleges.* Retrieved April 15, 2005, Available at http://www.asee.org/publications/profiles/index.cfm