

Establishing a Women in Engineering Program at an Urban University

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Abstract— As an urban institution, the University of Houston (UH) Cullen College of Engineering faces some unique retention challenges, particularly for female students, compared to many schools. The college's student body is extremely diverse and is reflective of the Houston community. As of Fall 2005, undergraduate engineering student demographics consisted of 33% Caucasian, 24% Hispanic, 20% Asian, 12% International and 8% African American students. A large number of students are first-generation college students, and many are also the first generation in their family born in the United States. Nearly all (94%) UH students commute to campus from the metro-Houston area, and a large number of students transfer to the university from community or junior colleges. Most students work part or full-time to pay for their education.

The department of Electrical and Computer Engineering (ECE) is the largest engineering department in terms of student enrollment, but contains the smallest percentage of women (currently 16%). Historical enrollment data for this department reveal that approximately 60% of the female students who started a degree in ECE dropped out of engineering entirely, and nearly 65% of the "leavers" did so within their first two semesters.

This paper reports on how the qualities attributed to our urban student body influence the efforts of a newly-established women in engineering program, called WELCOME (Women in Engineering Learning Community for Maximizing Excellence). In addition, we report the results from the Longitudinal Assessment of Engineering Self-Efficacy created by the Assessing Women in Engineering Project, which was administered to a sample of female engineering students at UH.

Background and Context

The University of Houston (UH) is an urban university located in the fourth-largest city in the United States. The university's student body boasts a rich diversity; in fact, UH is the most ethnically diverse research institution in the country (US News and World Report, 2006). As of Fall 2005, 52% of the 1,533 engineering undergraduates at UH reported belonging to an ethnic minority group (24% Hispanic, 20% Asian, and 8% African American students). The remainder of the students classified themselves as Caucasian (33%) or International students (12%), while 3% did not report ethnicity. The UH Cullen College of Engineering (CCE) faces some rather unique recruitment and retention challenges, particularly for female students. To better understand these challenges, one must understand our students. A large number of students are first-generation college students, and many are also the first generation in their family born in the United States. Nearly all (94%) UH students commute to campus from the metro-Houston area, and a large number of students transfer to the university from community or junior colleges.

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Most students work part or full-time to pay for their education. Approximately 22% of the undergraduate students in the Cullen College of Engineering are female, a number higher than

the national average. Our concern is not solely with enrollment numbers, however, but with retaining female students until graduation. Retention data indicate that large numbers of our female students not only change their major before graduating, but leave engineering entirely. As an example, the Department of Electrical and Computer Engineering (ECE) is the largest engineering department in terms of student enrollment, but contains the smallest percentage of women (currently 16%). Historical data for this department reveal that approximately 60% of the female students who started a degree in ECE dropped out of engineering entirely (rather than switching to another engineering department), and nearly 65% of the "leavers" did so within their first two semesters. This pattern of "leavers" making their decision not to persist in engineering early on in their academic career is consistent with published studies (Brainard, 1998; Seymour, 1997). Recognizing that our goal of increasing the number of female engineering graduates depends on both recruiting more females to the college as well as retaining our existing female students, we recently initiated a women-in-engineering (WIE) program, called Women in Engineering Learning Community for Maximizing Excellence (WELCOME).

Unique Challenges of an Urban University

Literature on self-efficacy (Brainard, 1998; Anderson, 1994; O'Hare, 1995; Felder, 1995), psychological sense of community (Berger, 1997; Goodman, 2002; DeNui, 2003), and gender differences in engineering persistence (Seymour, 1997; WEPAN, 2005) has helped inform and develop plans for our new program. Watson (2004) asserts these losses in the "diversity pipeline" occur from two main "leaks": lack of cognitive preparation and isolation. While other retention programs in our college (Paskusz, 1994; Paskusz, 1995; Shattuck, 2005) focus on plugging the first leak by improving academic preparation for both male and female students, WELCOME aims to primarily address the second leak—feelings of isolation among female students.

As we started this program at the University of Houston, it became clear that it was not appropriate to apply a "one size fits all model" to WIE programs. In many cases, adapting "best practices" from successful WIE programs at other institutions has not been feasible (or even relevant) due to the differences in our urban student body and those at many other universities. For example, for many successful WIE programs (Purdue, Texas A&M University, and Virginia Tech, to name a few), clustered housing forms the backbone of the program. While this approach has been shown to be effective in creating a sense of community (Berger, 1997; DeNui, 2003), this is not a viable option for an urban university with a commuter student population.

DeNui (2003) has reported that psychological sense of community is higher among students who participate in campus events, particularly for those who devote a significant amount of time to a few selected activities. This also presents a paradox for our students. Not only is ours a commuter population, which has been shown to be negatively correlated to persistence, (Berger, 1997) but the majority of our students work (many 20 or more hours a week) in addition to their full time coursework to pay for their education. As a result, students do not generally spend time on campus when they do not have class. Students are often only on campus Monday through Thursday, usually in the afternoons and evenings, when most engineering classes meet. In

addition, many of our students are considered “non-traditional” in the sense that they may be older than typical college students (the average age for undergraduate females in engineering is 22.2 years), have prior work experience, and/or have families. The result for the students is a limited amount of time to spend on any “extracurricular” activity, and from a programming point of view, limited timeslots during which to offer WIE activities.

Our ethnic diversity is one of the strengths of our study body, but it also presents additional challenges when it comes to retention of female engineering students. Female minority students cannot be lumped into one “under-represented” group, as women from various under-represented ethnicities face individual pressures and challenges based on their specific ethnic and cultural systems (Seymour, 1997). We anticipate that attrition of female engineering students at our university is linked to factors determined by their ethnic and cultural background that contribute to their engineering self-efficacy, feelings of inclusion, and ultimately, their decision to persist or leave engineering. Much of the current engineering education literature has not been able to address issues specific to females belonging to various under-represented minority groups simply because access to a diverse student population has been limited in most studies (Felder, 1995; Seymour, 1997; Hartman, 2005; Takahira, 1998; Borrego, 2005; Besterfield-Sacre, 2001; Grandy, 1997). Even cross-institutional studies (*e.g.* Besterfield-Sacre, 2001) that specifically aim to address gender differences based on ethnicity have yielded sample sizes too small to draw meaningful conclusions, and have suggested that additional, unexplored factors are at work. Seymour and Hewitt (1997) offer some data that suggest that students of color face different challenges than Caucasian students, and these issues are specific to each ethnic group. Their findings, while not specific to females in engineering majors, showed that many Hispanic students in their sample faced significant pressure to make regular financial contributions to the family income, which often competed with their academic work. In contrast, many Asian-American students in their study were expected, even pressured, by their families to give their total attention to their school work. These ethnic and cultural differences illustrate another reason why a “one size fits all” model is not appropriate for shaping the activities of WIE programs, particularly at an institution as diverse as UH where less than one third of the female student population is Caucasian. We are currently seeking funding for an extensive ethnographic study of our female student population in order to better understand and serve them. Future programming will be strongly influenced by the results of study, once they are available.

Program Elements

Like many WIE programs, WELCOME is soft-funded with a limited staff (a graduate teaching assistant and a faculty member funded by partial summer salary). Our intention was to start with manageable programming goals for the first year and expand later if resources allow. The focus of the program thus far centers around two goals (Felder, 1995): providing female students with role models and mentors, and providing personal and career guidance. The programming element is still very much a work in progress; adjustments are ongoing as we learn more about the specific needs of our unique student population. A student advisory board was recently created to guide future programming.

The goal of providing students with role models and mentors is being accomplished by increasing access to female faculty and successful professionals at WELCOME activities, and by establishing a mentoring program. One way in which we have effectively addressed the

challenge of working with a commuter population in a large city is to design a mentoring program that is primarily electronic in nature. The program consists of student-student mentoring pairs (a freshman paired with an upper division student) and professional-student mentoring pairs (working female engineers in the local community paired with upper division students). The electronic focus of the mentoring program allows for frequent communication without the necessity of commuting to a scheduled visit at a mutually agreeable time. Face to face interaction is also encouraged when feasible, and many pairs choose to meet in person when their schedules allow. Participants to date report a high level of satisfaction with the email mode of communication.

The second goal of the WELCOME program is to provide personal and career guidance as well as emotional support. To this end, we initiated a seminar series entitled “Engineer Your Success”. Some topics are geared toward helping lower-division students make the transition to college, while others aim to prepare upper division students for the life in the “working world”. Because our students have so many obligations, we periodically poll interested students regarding their availability. We also combine seminars with meal times when possible, since most students are on campus during the lunch and dinner hours.

The need for the WELCOME program was demonstrated at the first meeting, which was held during the first week of classes. Fifty of the 334 enrolled females attended. As the room began to fill, upper-division students overheard entering the room and exclaiming, “I never knew there were so many girls in engineering!” These comments reinforced our belief that the program was long overdue in the college, and that the mere presence of other female students may provide emotional support and decrease feelings of isolation.

To market the new program, feminine-cut t-shirts with the WELCOME logo were distributed for free to all female students who wanted one, as well faculty and staff who have regular contact with students. A website (www.egr.uh.edu/welcome) was developed to increase visibility and provide information to external entities. To further the program’s visibility among students, faculty, and alumni, several industry-funded women-in-engineering awards were created in conjunction with the UH Engineering Alumni Association banquet, which is held annually during Engineers Week.

Engineering Self-Efficacy

Students in attendance at the first WELCOME meeting were invited to take the Longitudinal Assessment of Engineering Self-Efficacy (LAESE) survey developed by the Assessing Women in Engineering Project (AWE) (2005); 45 elected to do so. Other female students were recruited to take the survey by having the WELCOME teaching assistant visit several classes. A total of 53 females took the survey. We recognize that some self-selection exists since the majority (50) of respondents attended at least one WELCOME activity during the semester. *We are not attempting to generalize the results to the entire female student population, but rather look at these results with an interest in guiding future programming and better understanding those students who wish to participate in WIE activities.*

Results from AWE LAESE

The LAESE instrument has been tested and validated for female students by the AWE Project. We intend to collect longitudinal data on our female students to determine if correlations can be made between participation in WELCOME activities and changes in engineering self-efficacy. Students from all seven undergraduate majors in the Cullen College of Engineering were represented in the sample; Chemical Engineering (32%) and Electrical Engineering (23%) more so than others. Ethnic demographics are shown in Table 1, along with the enrollment demographics for the previous year.

Table 1: Ethnic breakout of respondents.

	Percentage Represented in Fall 2005 Survey Sample	Percentage Represented in Fall 2005 Female Undergraduate Population
1=African/Black American	11%	11%
2=American Indian/Alaskan Native	2%	0%
3=Asian & Pacific American	30%	18%
4=Latino/Hispanic American	26%	26%
5=White American	21%	29%
6=Foreign National on student visa	8%	13%
7=Foreign National/U.S. Resident (green card)		

The ethnic diversity of our sample generally reflects the diversity of female students in the college. It is important to note that categories 6 and 7 include students who belong to an ethnic minority group. The discrepancy in the American Indian/Alaskan Native may be due to the student in question choosing not to report ethnicity in the official college enrollment report. Fifty nine percent of the respondents came directly from high school, the 28% transferred to UH from other schools, and a small number (4% and 8%, respectively) came from military service or full-time jobs.

Among the survey sample population, the breakdown by academic year was as follows: first year, 28%; second year, 8%; third year, 26%; fourth year, 11%; fifth year and beyond, 26%. One source of confusion in analyzing these results is the potential for confusion by respondents in answering the question that asks them to classify themselves as first year, second year, etc. Since many (28%) of the students entered the university as transfer students, we are not certain whether a student who has completed two years at a previous institution but is new to UH would report being a third year student or a first year student. For the purposes of building community among females in the Cullen College of Engineering, we would consider such a student a first year student, even though she may have previous college experience. In analyzing the data, we were unable to ascertain how students interpreted this question.

The LAESE employs a Likert-type scale, assigning a numerical value to Strongly Disagree (0), Disagree (1), Slightly Disagree (2), Neither Disagree nor Agree (3), Slightly Agree (4), Agree (5), and Strongly Agree (6) as they relate to statements on the survey. Respondents may also chose a “Don’t Know” option, which was not assigned a numerical value and therefore was not

included in the numerical results shown here. The number of “Don’t Know” answers is indicated parenthetically after the average and standard deviation.

Results from two subpopulations (first year students vs. “all others”) were examined in addition to the entire cohort because we anticipated that results may differ for students who had only been on campus five days (*i.e.*, first year students) than for students who had been part of the engineering community on campus for at least one year, and in most cases, several years. Results for the six AWE subscales are shown in Table 2.

Table 2: Results from six subscales for first year respondents, all others, and the entire cohort.

Subscales	1 st Year (n=14)		All others (n=39)		Entire Cohort (n=53)	
	Avg±SD (‘don’t know’ answers)	% in agreement (responses >3)	Avg. ±SD (‘don’t know’ answers)	% in agreement (responses >3)	Avg. ±SD (‘don’t know’ answers)	% in agreement (responses >3)
1. Engineering career success expectations (7 items)	5.4 ±0.9(3)	93	5.2±1.1(7)	87	5.3±1.1 (10)	89
2. Engineering self-efficacy I (5 items)	5.3±1.0(3)	95	4.6±1.6(3)	78	4.9±1.4(6)	86
3. Engineering self-efficacy II (6 items)	4.6±1.9(5)	70	5.0±1.4(12)	87	4.9±1.6(17)	86
4. Feeling of inclusion (4 items)	4.0±1.4(5)	66	4.3±1.4(6)	72	4.2±1.4(11)	71
5. Coping self-efficacy (6 items)	5.1±1.3 (2)	88	5.0±1.5 (3)	86	5.0±1.4 (5)	86
6. Math outcome expectations (3 items)	5.1±1.2 (1)	83	5.1±1.3(4)	86	5.1±1.2(5)	85

Individual items within each subscale were studied for statistical significance between the two student populations using a t-test. Only two individual items were statistically significant at the 95% confidence level. For item 21 from subscale 2, “I can succeed in an engineering curriculum while not having to give up participation in my outside interests (*e.g.* extra curricular activities, family, sports)”, the first year students agreed more strongly than the others (average 4.8 ± 1.5 vs. 3.7 ± 1.9). For item 28 from subscale 1, “A degree in engineering will allow me to obtain a well paying job”, the first year students again agreed more strongly than the others (average 5.7 ± 0.5 vs. 5.2 ± 1.1). The results from item 21 are not surprising, as the first year students had yet to experience the rigors of the engineering curriculum. We are puzzled by the difference in item 28, since many upper-division students in the college participate in internship programs and therefore should be aware of starting salary ranges.

Overall, students reported positive career expectations, feelings of efficacy and math outcome expectations. While the majority of students (70% of the cohort) reported agreement for the items in subscale 4 (feelings of inclusion), these scores were lower than the rest of the subscales and indicate an opportunity for WIE programming that addresses female students’ feelings of inclusion. It is telling that there was no statistical difference in subscale 4 (feelings of inclusion) responses between the first year students, who took the survey during the first week of classes, and students who had been part of the engineering college for at least a year. This result from the LAESE instrument signals the need for WIE programming that addresses the needs of both

upper and lower division students and enhances their feelings of inclusion within the college of engineering.

Conclusions

Results from the LAESE instrument have provided an initial baseline of results to help guide and inform the new WELCOME program at the University of Houston. Our goal is to increase positive feelings of inclusion (subscale 4) over time through WIE activities. Current activities include student-student and professional-student mentoring, as well as a seminar series which will increase the visibility of female students in the college, and provide them with opportunities to interact with female faculty and role models. A discussion of future plans follows in the next section.

Future Plans

Future WIE activities will be implemented as resources allow. The student advisory board will recommend appropriate activities that will further address the needs of our unique population. Short term plans include sending postcards advertising WELCOME to all incoming female students during the summer prior to their first semester. The postcards will serve as an introduction to WIE activities, and will invite them to participate in the peer mentoring program and seminars. Incoming students will be given an opportunity to be assigned a student mentor before the semester has started, so that the mentoring relationship can begin as early as possible. We will continue to seek involvement from the local engineering community to grow the professional-student mentoring program and expand seminar offerings.

Our long term vision for the program includes creating a true “learning community” by clustering incoming female students in the same sections of introductory classes and college-wide “academic excellence” workshops which are tied to specific freshman and sophomore level courses. Clustering in this way will maximize interaction time among female students during times when they are already committed to academic activities, rather than presenting another potential scheduling conflict for our busy students.

For students who are able to participate in additional extra-curricular activities, we plan to establish a WELCOME “ambassadors corps” to help recruit female students from local high schools and community colleges and perform outreach at local K-12 schools and Girl Scout Troops. By engaging students in the local community and allowing them to share their experiences with others, we hope to increase their sense of community among female undergraduates and as well as positively influence their engineering self-efficacy.

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