

# **RETAINING FRESHMEN WOMEN ENGINEERING STUDENTS THROUGH INCLUSIVE LEARNING COMMUNITIES**

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## **ABSTRACT**

Interest in engineering by freshman college students is near a 20-year low. In addition, freshman men are over five times more likely to be interested in an engineering career than freshmen women. Of the freshmen students who select engineering for their major, less than half will graduate with an engineering degree. Engineering is a difficult major and many students enter the field without a vision that it is a “profoundly creative” discipline that offers many rewards and challenges. In addition, universities are increasingly being asked to account for their efforts in terms of recruitment and retention. Traditionally, women and underrepresented minority students have not been retained in engineering as well as male Caucasians.

The College of Engineering and Applied Sciences (CEAS) has made a commitment to the support and retention of its students. The college houses a solid infrastructure for an Office of Student Affairs led by an Associate Dean of Student Affairs and Special Programs. The following are included in this office: the Women in Engineering Program, the Minority Engineering Program, a Recruitment Office, an Internship Office, and an Inclusive Learning Communities (ILC) Program. A faculty member, who supervises graduate and undergraduate students, directs the ILC program, supported by the NSF-funded Foundation Coalition. The two primary programs are academic mentoring and career mentoring. The ILC Program is also designed to value diversity. The ILC Program utilizes cluster classes and interfaces with the Freshmen Engineering Dormitory community, the University Freshmen Year Experience, and the Co-curricular Program in the University, as well as the Women in Applied Sciences and Engineering (WISE) Program.

The paper focuses on the need for and the effect of activities that have been run by the ILC Program, specifically as they relate to the women engineering students. Included in the discussion are the collaborations with other campus programs, a prototype web-based mentoring system, the lessons learned, and the results. Evaluations were done with participating students both by survey and focus groups. Future plans for the ILC Program will also be presented.

## INTRODUCTION

The Fall 1998 survey of American Freshman showed that the interest in an engineering career by freshman students in two- and four-year colleges and universities is still near the twenty year low of 1975.<sup>1</sup> Only 15.5 percent of male freshmen listed “engineer” as their probable career. Only 2.1 percent of female freshmen cited “engineer” as a probable career. Much research has been done to identify why female enrollment in engineering is so low. The “Women in Engineering Program Advocates Network” (WEPAN) was begun in 1990 by Daniels, Metz, and Brainard<sup>2</sup> “in an effort to provide greater access for women to careers in engineering.” The low enrollment and retention of women in engineering (the dwindling pipeline) was documented<sup>3</sup> by Dr. Bassam Shakhshiri of the National Science Foundation, as well as others, in the first WEPAN Conference held in 1990.

In spite of many efforts to increase the enrollment of women in engineering and the number of women graduates in engineering, the national percentages remain around 18-20%. A 1998 Harris Poll, commissioned by the American Association of Engineering Societies (AAES), revealed that about 75% of women were not well informed about the work that engineers do and how engineers contribute to society. This body of knowledge means that when the time comes to choose a career and a college to attend, engineering is not even an option from which many young women choose.

Dr. William A. Wulf, President of the National Academy of Engineering, states that engineering is a profoundly creative career.<sup>4</sup> As in any creative profession, what comes out is a function of the life experiences of those who do it. Engineers solve problems and seek to find the “best” solution within the given constraints of the problem. There is no one correct answer. Without diversity, the set of life experiences that are applied to a problem is limited. Without diversity, an opportunity cost is paid – a cost in products not built, in designs not considered, in constraints not understood, in processes not invented. Dr. Wulf goes on to say that engineering is not usually associated with creativity. He believes that the lack of diversity in engineering correlates with the misconceptions about the field. A natural consequence of this conclusion is that we have to do a better job of getting the message out that engineering is an exciting and challenging career which many women would enjoy doing if they only knew more about it.

Of the freshmen students who select engineering for their major, less than half will graduate with an engineering degree. Engineering is a difficult major and many students enter the field without a vision that it is a “profoundly creative” discipline that offers many rewards. Universities are increasingly being asked to account for their efforts in terms of recruitment and retention. Arizona State University, for example, several years ago set a 78% retention rate for freshmen students to be accomplished by the year 2003. Historically, women and underrepresented minority students are not as well retained in engineering programs, as are Caucasian males.

SECOND STAGE TRANSFORMATION: CREATING A NEW VISION IN THE 21<sup>ST</sup> CENTURY

2000 **WEPAN** National Conference

Research has shown that for minority and non-minority students, selectivity is the most important predictor of engineering degree attainment. Selectivity is measured by the percentage of applicants accepted, high school class rank, and standardized test scores of enrolled freshmen.<sup>5</sup> Arizona State University (ASU) as a public institution has an acceptance rate of approximately 80%. By contrast, schools such as Harvard and Princeton have only a 13% acceptance rate that translates to graduation rates of 97% and 96%, respectively.<sup>6</sup> In addition, the ASU College of Engineering and Applied Sciences (CEAS) is set in a metropolitan university with many non-traditional students. Less than 40% of the freshmen engineering students live on campus, over half of the freshmen work (many over 20 hours per week), and the engineering students are diverse with 20.5% women and 16.0% underrepresented minority students. Women engineering students in the CEAS are retained at a higher rate than men engineering students in the university, but at a lower rate in the CEAS. Most of the women who leave the CEAS are in good academic standing.

The CEAS has made a commitment to the support and retention of its students. The college houses a solid infrastructure for an Office of Student Affairs led by an Associate Dean of Student Affairs and Special Programs.<sup>7,8</sup> Included in this office is a Women in Engineering Program, a Minority Engineering Program, a Recruitment Office, an Internship Office, and an Inclusive Learning Communities (ILC) Program. The Women in Applied Sciences and Engineering (WISE) Program directs a comprehensive program<sup>9</sup> for the recruitment and retention of women in engineering. The programs include: working with mathematics and science teachers and school counselors at both the junior and senior high school level,<sup>10,11,12,13</sup> summer recruitment programs for junior high,<sup>14</sup> senior high,<sup>15</sup> and entering freshmen engineering women; retention programs;<sup>16</sup> and programs encouraging women engineering graduates to go on to graduate school.<sup>17,18,19</sup> The WISE Program also holds workshops on time management, resume writing, interviewing, and on what engineering is really like, presented by panels of women engineers. WISE has their own student room for studying, socializing, or a place to eat lunch. The room is equipped with lockers for the convenience of commuter students. In addition, WISE supports a student chapter of the Society of Women Engineers and a mentoring program with women engineers in industry. Engineering floors in a campus residence hall were created a few years ago to provide additional support for freshman engineering students. The students are placed in their room and suite with other engineering students based on information from a roommate survey.<sup>20</sup> In the Fall 1999 semester, 49 of the 198 students (24.7%) on the three engineering floors were women, roughly the same percentage as the freshmen women engineering students for that semester.

The Inclusive Learning Communities Program is a program designed to help retain engineering students, recognizing the special needs for support of diversity. A faculty member, who supervises graduate and undergraduate students, directs the ILC program quarter-time with additional support in the summer. The program was initiated by financial support from the NSF-funded Foundation Coalition, of which the CEAS is a member. The two primary programs are academic mentoring and career mentoring. The

ILC Program utilizes cluster classes and interfaces with the Freshmen Engineering Residence Hall floors, the Freshmen Year Experience, and the Co-curricular Program in the University, as well as WISE.

### **THE NEED FOR AN ILC PROGRAM**

Diverse strategies have been implemented to help retain engineering students. As mentioned, the WISE Program in the CEAS exists to help recruit and to retain women engineering students. However, some women engineering students do not want to be associated with such a program, believing that their participation will further marginalize them as a female engineering student. Approximately half of the over 800 undergraduate women engineering students take advantage of the WISE center and programs. The Minority Engineering Program serves approximately 50% of the 650 underrepresented minority undergraduate engineering students. Clearly, support is needed for students not targeted or drawn to these two programs. Engineering student organizations and free tutoring services help. An additional retention strategy was the development of the Inclusive Learning Communities Program. The first item on the agenda was to conduct a needs assessment. That is, we wanted to assess the needs of the primary recipients of these programs—the CEAS student population. This assessment began with the local development of a freshman survey instrument. We constructed our assessment to capture not only the needs of freshmen, but to be context sensitive. In this sense, we wanted to be responsive to our own culture.

In the Spring 1999 semester, the survey was given to 285 students, primarily freshmen, who were enrolled in the introductory engineering course. The survey effort attempted to assess participation in and attitudes toward 1) formal and informal tutoring and 2) formal and informal mentoring during the academic year. Some of the student identifiers on the survey were missing or unrecognizable in the larger ASU database when the research team attempted to identify student gender. Therefore, the female and male samples are actually smaller than the overall sample. There were 181 males and 65 females identified in the survey sample. The female representation in this sample, 26.4%, is only slightly larger than the 23.6% female representation among the students who comprised the Fall 1998 semester first-time, full-time freshman cohort. This section of the paper presents female responses regarding formal tutoring, informal tutoring, formal career mentoring, and informal career mentoring, noting similarities and dissimilarities to the overall student data and to male data.

### **Tutoring**

The majority (81%) of females has not been part of a formal ASU tutoring program this academic year, which is a consistent finding with the overall student population. However, when we disaggregated the data by gender, we found that females were slightly more involved in tutoring than engineering males. While 13 percent of males were involved in tutoring, 19 percent of the females participated in some type of formal tutoring program. However, the difference is not statistically significant. Of the females

who were part of a formal program (19%), one third of the tutoring was arranged through the Minority Bridge Program (MEP). The remaining females were primarily enrolled in “Other” tutoring programs such as the Learning Resource Center (LRC) and the Freshman Year Experience (FYE) program. For the majority of females, mathematics was identified as the course that tutoring supported most often, which was similar to the male responses. Most females (85%) indicated that their formal ASU tutoring was free and that they were involved in an academic tutoring event about 3.67 hours per week, slightly higher than the overall average of 3.5 hours. Although 88 percent of the males participated in “free” tutoring, they averaged slightly fewer hours than the females (3.10 hours).

Females were asked to discuss their participation in informal tutoring during the academic year. More female students were involved in a free, informal tutoring program (45%), citing that their tutoring events averaged 3.45 hours per week; in contrast, males only spent 2.63 hours. Although females had up to 3 tutors, the majority of males typically used only one tutor during the semester.

Students were asked to rate the overall benefits of all tutoring experiences and to indicate if they were free or fee paid. Additionally, they were asked to select from the following list of tutors: 1) Peer, 2) Graduate student, 3) Upper classman, 4) Faculty, and 5) Other. Although females used a combination, they most frequently used faculty and upper division undergraduate students most often as tutors. On average, males use peers and upper classmen most often.

Special categories regarding the programs were developed from student responses. Data collection and analysis were designed to capture whether, for example, students perceived that programs were only worthwhile if they were costly. The following categories emerged from the data: the program was 1) helpful and paid; 2) helpful and free; 3) made no difference and paid; 4) made no difference and free; 5) helpful; and 6) made no difference. The most typical category was “helpful and free.” Of the helpful and free category, females believed that faculty, upper classmen, and peers were most helpful. Typically, females selected “Paid” tutors more often than males. More specifically, 40 percent of the females paid graduate students for help while only 29 percent of the males selected alternative modes for tutoring. See Tables 1 and 2 for more detailed information.

Table 1 Female Choices for Tutoring

	Peer %	Graduate Student %	Upper class man %	Faculty %	Others %
Helpful, Paid	4.17%	40.00%	8.70%	0.00%	16.67%
Helpful, Free	79.17%	40.00%	82.61%	90.00%	83.33%
No difference, Paid	0.00%	0.00%	0.00%	0.00%	0.00%
No difference, Free	12.50%	10.00%	8.70%	0.00%	0.00%
Helpful	4.17%	10.00%	0.00%	0.00%	0.00%
No Difference	0.00%	0.00%	0.00%	10.00%	0.00%

Of the females participating in tutoring, over 80 percent stated that they would continue, consistent with overall student responses. Of those not participating currently, 69 percent believed that a tutoring program would be helpful. Eighty six percent of the females would engage in a tutoring program if it were free, significantly higher than the male response (73%).

Table 2 Male Choices for Tutoring

	Peer %	Graduate Student %	Upper class man %	Faculty %	Others %
Helpful, Paid	2.44%	4.76%	0.00%	0.00%	28.57%
Helpful, Free	95.12%	85.71%	93.55%	76.92%	57.14%
No difference, Paid	0.00%	0.00%	0.00%	0.00%	0.00%
No difference, Free	0.00%	4.76%	3.23%	7.69%	0.00%
Helpful	0.00%	0.00%	0.00%	15.38%	14.29%
No Difference	2.44%	4.76%	3.23%	0.00%	0.00%

## Mentoring

The majority of females (94%) have not participated in a formal ASU mentoring program during the year. Similarly, they have not been involved in an informal mentoring program (90%). Of those involved, 38 percent were matched up with a “practicing engineer” and had 4.29 contact hours per month during the semester. Contact hours include for example, meetings, company visits, email messages, telephone calls, and professional society meetings. All females indicated that all mentor categories, Peer, Graduate Student, Upper Classman, and Faculty were Helpful.

Respondents were given the opportunity to indicate their future plans for mentoring. Although the responses were not as positive as those associated with academic tutoring, the majority of students favored the mentoring experience. Sixty-seven percent of the students who had mentoring this year said they would continue. The majority of students without mentors felt that this experience would be beneficial (74%) which was higher than the tutoring response.

## THE ILC PROGRAM

This section addresses career and academic mentoring, in general, and then the impact on female students. The career and academic mentoring programs were implemented in pilot studies during the Spring 2000 and Fall 2000 semesters. A survey of the Manzanita Residence Hall engineering freshmen was conducted at the beginning of the Spring 2000 semester. The survey results are presented at the end of this section.

## Career Mentoring

Career mentoring within the ILC program comprises the relationship of the professional engineer (mentor) and the engineering student (mentee). The mentee is an undergraduate ASU engineering student who desires a mentoring relationship with a professional engineer. The mentor is a professional engineer who is willing to volunteer time to

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encourage and to guide undergraduate students. The professional mentor can serve as a positive role model, teacher, and advisor. This mentoring relationship helps to retain women in the field of engineering by providing support, guidance, and connection with the workplace.

Mentors and mentees are required to participate in a training session that will ease their initial meeting, while providing basic information about mentoring relationships. After completion of the training session three to four students (mentees) are matched with two engineers (mentors) from industry based on application forms that provide information on the mentees' and mentors' areas of interest in engineering. In addition, each individual completes an agreement form, that outlines objectives, frequency of communication, duration of relationship, and various roles the mentor finds comfortable.

Engineers provide support and guidance to the students through email, telephone, and face to face meetings. These meetings can include attendance at professional society meetings, discussion of journal articles or new technology, and review of student projects. Workplace tours are arranged for the students, as well as exposure to project development and completion.

Freshman engineering students must often wait until they are upper class engineering students to connect with the work world through internships. Career mentoring provides a link between the academic world and the work place. The ILC program provides freshmen students the opportunity to begin the process of experiencing and observing engineers at work, capturing engineering students early in the pursuit of their engineering degree. Exposure to the different types of engineering work gives the student the opportunity to determine the area of engineering that can meet their needs and interests. During the Fall 1999 semester, 17 students participated in the career mentoring program, 11 (65%) of them were women.

The career mentoring relationship helps to maintain engineering students' self-confidence in the midst of completing many difficult classes. A connection with a working engineer helps the freshman student see the contribution and application of knowledge gained in the classroom. One mentee stated, "I was looking for some professional advice and she makes me real comfortable when I talk to her. It has been a good experience and I look forward to the next semester." Students are given a vision of future career possibilities for them with an engineering degree.

### **Academic Mentoring**

The academic mentoring portion of the ILC program has been concerned with the pre-calculus, calculus I, and calculus II course sequence. During the pilot studies during the Spring 1999 and Fall 1999 semesters, visits were made to individual mathematics classes to present the benefits of participating in the academic mentoring program. Based on the visits, there was an initial 10% response from the students for participation. Through follow up communications and word-of-mouth advertising, the participation rate

increased to 15% of the students enrolled in the mathematics classes selected for the pilot studies. In the Fall 1999 semester, 27 students regularly used the academic mentoring program, 18 (67%) of them women.

The students who enrolled in the academic mentoring program were formed into clusters of four to five students with one academic mentor, who was a graduate student. The clusters were first based on the particular mathematics class and second based on other demographics, such as gender, culture, or first generation college attendance. The mentors worked with the mathematics instructors on what material was being covered, what homework was being assigned, and when the students were to be expecting examinations and quizzes. The students let the mentors know where they were having doubts and the cluster meetings were developed to meet the needs of the students along with the instructors pace and expectations. In addition, there were collaborative exercises that were available only because the students were in clusters meeting with mentors. Practice tests were provided as a basis for building confidence on material mastered and identifying where each student needed additional work.

Most of the students who participated in the program believed that their level of success in the mathematics courses was a direct result of participation in the academic mentoring program. One academic mentee said: "The mentor knows a lot about Mathematics and Calculus and was very helpful." The mentors were able to work with the students and see the success on a small-scale basis that resulted in an improved overall effort. In general, the mathematics instructors were appreciative of the program because of the level of improvement for the students who participated in the academic mentoring program.

### **Engineering Freshmen Dorm Floor**

Freshmen engineering students (198) lived on three floors of the Manzanita Residence Hall (close to engineering classes) during the Fall 1999 semester, with most continuing to live there for the Spring 2000 semester. The ILC program interfaced with the freshmen engineering dorm floors through a "Meet the Dean" meeting each semester, well-attended "Dinner with a Professor" evenings for each major, the placement of the academic mentoring program on the first floor of Manzanita, and with the placement of an engineering graduate student in an apartment on the first floor of Manzanita. This graduate student was given room and board by the ASU Residence Life and the CEAS paid a stipend. The graduate student was placed there to be an additional support and tutor for the engineering students.

Freshman engineering students living in the residential dorm were given a survey to elicit attitudes towards engineering activities, academic needs, and how residential life may impact academics. The 58 survey respondents were comprised of 19 female and 39 male engineering students. The data was analyzed overall and then examined for gender differences. As a result, we found only slight differences among the two groups. However, one significant discrepancy was evident. Although the majority of all students



believed that living on an engineering dorm floor was a positive experience, females (3.6 on a 4.0 scale) were more likely to recommend the engineering floor to an incoming freshman than males (3.3) and the gender difference was statistically significant ( $p=.02$ ).

The majority of females and males (84% each) study two to three times a week with other engineering dorm floor students. They study mathematics and engineering courses approximately 7 hours a week in these dorm groups. The majority of females (63%) were more satisfied than males (56%) with the number of CEAS contacts and activities during Fall 1999 semester. Similarly, females (73%) were also more satisfied than males (64%) with their "Academic endeavors" for the Fall 1999 semester at ASU. However, students identified a need for additional academic help from the CEAS. Females, more often than males, requested help from the CEAS regarding "Individual tutoring" in calculus and engineering concepts.

The students were asked if it was helpful to have an engineering graduate assistant living in an apartment in the building. The graduate assistant for the Fall 1999 and Spring 2000 semesters is male. Of the 19 women who responded, 47% said "yes," 2% said "no," and 51% were "not sure." When asked if they had ever talked to the graduate assistant, 53% of the women said "yes" and 47 % said "no," which is consistent with the 51% who said they were "not sure" if he was helpful. The comparable ratings from the men were not statistically different. ASU Residence Life places two resident assistants (RAs) on each floor of Manzanita. On the three engineering floors, each floor had one female and one male RA. The engineering students were queried if the RAs were helpful. Of the women, 79% said "yes," 11% said "no," and 10% were "not sure." The responses of the men were not statistically different from those of the women.

## DISCUSSION

Although targeted retention programs for undergraduate women and underrepresented minority engineering students exist in the CEAS, many students do not take advantage of the programs or do not participate because they do not belong to the target audience of these programs. The tutoring and mentoring survey showed that many students were not getting either tutoring or mentoring assistance in their studies. In particular, women engineering students have not participated in either type of program. Although gender differences were not statistically significant, they were noteworthy. More females were involved in mathematics tutoring programs than engineering males and spent slightly more time in tutoring each week. The majority of females chose free tutoring programs and selected faculty and upper division undergraduate students most often. In contrast, males chose peers most often. Females also paid for tutoring more frequently than males and selected graduate students the majority of the time. Most women in engineering found tutoring and mentoring helpful and would participate in such programs if offered in the future. Furthermore, those without mentors currently believed that this experience would be helpful.

When we planned the academic mentoring programs for the Fall 1999 semester, we limited the participation to the students in seven sections of pre-calculus, calculus I, and calculus II. We did not know what the response rate would be. We chose sections that were a part of the engineering cluster classes, so that over half of the students in each of these classes were engineering students. The academic mentoring program was offered to all students in the sections, so that some of the students participating in that program were not engineering students. We advertised the career mentoring through orientation letters and email. When we have asked our students why more have not participated in our academic and career mentoring programs, they have said that they only heard about it once and that we should have advertised it more often and had immediate sign-up sheets available when class visitations were made advertising the program. We have followed their advice. For example, at the "Meet the Dean" evening held in the lobby of Manzanita Hall, announcements of the programs were made and sign-up sheets were available.

Based on the survey results from the students living on the engineering floors, the students are quite satisfied with the engineering residence program. The requests for more academic tutoring may be due to lack of information. Although the floor RAs seem to be serving the engineering floor women, efforts need to be made so that all of the students on the engineering dorm floors are aware of and have spoken with the engineering graduate student in residence.

It is difficult to ascertain at this time if the small participation in these programs is due to a lack of interest, a lack of understanding of how the student could benefit, or a lack of communication with our students in advertising the ILC program. Since well over half of the freshmen live off campus, email would seem the best way to communicate. However, it appears that only a few of the freshmen students are using the ASU email address that was assigned to them. Most of them are still receiving messages from high school friends and thus are using the email address that they had before they came to ASU. With the introduction of the Mascot Network system (an internet system designed to be the forum and information exchange for all student activities in the CEAS) this year, we now need to have the high school email account, the ASU email account, and the Mascot Network configured to work together. Student organizations are able to post their meetings through the Mascot forum. The Mascot Network will also provide a forum for career mentors and their mentees to communicate.

## **FUTURE PLANS**

We believe that participation in the ILCs has been limited by the lack of a good communication system with our students, especially freshmen students. A team of technicians is currently working to blend the two emails and Mascot Network channels of communication. With this single channel of communication through the Mascot Network, we should be able to communicate more effectively with our students. Beginning the Fall 2000 semester, the rooms on the four engineering floors in the Manzanita Residence Hall will be equipped with Ethernet connections for each student.

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2000 **WE**PAN National Conference

It is expected that with their own computer in their room, students will be more likely to use the Mascot Network and to read college email messages since they can receive all of their emails on the same account. We will then also be able to query the students on services that are offered (for continuous improvement) and to invite suggestions from them on ways to make the engineering environment more supportive.

We need to be more aggressive in our advertisement of the free academic and career mentoring that is available, as well as the free one-on-one tutoring that is available. We will also work with our graduate student in residence to make sure that all of the students are aware of him and have had an occasion to speak with him.

For the Fall 2000 semester, over twenty cohorts have been formed through the freshman registration system. In this program, each cohort will include approximately 20 engineering freshmen, who will be registered together in three of their basic first semester classes. It is anticipated that this program will work well with our other efforts to retain more freshman women and men engineering students.

Often freshmen students do not realize that they need help until it is far into the semester. We plan to use our students who have benefited from the ILC programs to help advertise it through quotes in a letter or brochure or as members of a student panel, addressing incoming freshmen during Orientation Days. We also plan to publish a brochure on the support programs as an additional means of advertisement. Through the ILC program and the WISE programs, we hope to reduce the number of women who leave engineering for another major at ASU.

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