Journal of Pre-College Engineering Education Research (J-PEER)

Volume 2 | Issue 1 Article 3

2012

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Recommended Citation
Franchetti, M. (2012). An Analysis of Retention Programs for Female Students in Engineering at the University of Toledo. *Journal of Pre-College Engineering Education Research (J-PEER), 2*(1), Article 3. https://doi.org/10.5703/1288284314652

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Keywords

retention, female, engineering

Document Type

Article

Available online at http://docs.lib.purdue.edu/jpeer

Journal of Pre-College Engineering Education Research 2:1 (2012) 21–27
DOI: 10.5703/1288284314652

An Analysis of Retention Programs for Female Students in Engineering at the University of Toledo

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Abstract

This paper summarizes the findings of a five-year study aimed at improving the retention rates of female students pursuing careers in engineering. The study analyzed a series of programs implemented at the University of Toledo. The programs involve hands-on design projects, research experiences, communication tools geared towards females, mentoring programs, and on-the-job rotations aimed at sparking enthusiasm and interest in engineering. The effectiveness of the programs over time is measured from the rates of female retention from the freshman to sophomore year. These programs may serve as models for other universities interested in improving opportunities and success rates for female engineers.

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Introduction

Women in the field of engineering remain an under-represented group. Women comprise approximately 45% of the workforce in the U.S., but only 16% of the engineers and scientists (Kleiman, 2000). In the U.S., between 1983 and 2002, the percentage of women among bachelor recipients had only a small increase from 13.3% to 20.9% (Sonnert et al., 2007). This demonstrates a strong need to attract and retain female students in the engineering disciplines. Several colleges have developed programs to address these issues. Many of these programs focus on all under-represented groups, such as African Americans, Hispanics, and Native Americans in all Science, Technology, Engineering and Mathematics (STEM) fields. The common purpose of these programs is centered on improving recruitment and retention through providing hands on experience, mentoring, developing problem solving skills, and increasing awareness of career opportunities (Yelamarthi & Mawasha, 2008).

This study summarizes the findings of a five-year study aimed at improving the retention rates of female students pursuing studies in engineering. The study analyzed a series of programs implemented at a large public university. The programs involve hands-on design projects, research experiences, communication tools geared towards females, mentoring programs, and on-the-job rotations aimed at sparking enthusiasm and interest in engineering. The effectiveness of the programs was measured over time by examining the retention rates of female students using test and control groups. The programs discussed in this paper may serve as models for other universities interested in improving opportunities and success rates for female engineering students. The programs and initiatives are built upon previous studies, and focus on

helping female students choose majors freely and persist in these programs of study, not attempt to recruit as many female students as possible into engineering, one of the major pitfalls identified from a 2008 study (Donovan et al., 2008).

Connection with Existing Literature

Student retention in higher education has been a research subject for decades (Pascarella & Terenzini, 1980; and Tinto, 1975). Many notable studies have been published that discuss the theoretical framework to analyze student retention, persistence, and degree completion (Bean, 1982; Billson & Books-Terry, 1987; Cabrera et al., 1993; Gillespie & Noble, 1992; Ishitani & DesJardins, 2002). The purpose of these studies was to identify casual links between student retention and student background by examining student persistence based on large data sets from U.S. Colleges. These initial studies led to the development of statistically-based validation studies that created models to identify factors that predict or explain retention rates in higher education (Berger & Braxton, 1998; Braxton, Sullivan, & Johnson, 1997; Cabrera, Nora, & Castaneda, 1993). These studies also used student persistence data at U.S. colleges and among the factors that were identified that affect student retention were assimilation courses, student ethnicity, student gender, academic and social integration, and institutional support services. One notable 2005 study found that 24% of freshmen students chose to transfer or dropped out within one year (Herzog, 2005).

These studies supported the development of the theoretical model that was created for this study to examine student gender (specifically female) and the related support programs to enhance retention at College of Engineering at the University of Toledo. Several key studies generated empirical evidence that examined student persistence of under-represented groups and concluded that programs targeted at these groups can aid in increasing student retention rates (Fenske, Porter, & DuBrock, 1999; Hu & St John, 2001; St John et al., 2004). This is a critical issue, as the retention rates for female engineering students in the U.S. are substantially lower than their male counterparts by approximately 20% (Sonnert et al., 2007). This demonstrates a strong need to attract and retain female students in the engineering disciplines. Several colleges have developed programs to address this issue. Many of these programs focus on all under-represented groups, such as African Americans, Hispanics, and Native Americans in all Science, Technology, Engineering and Mathematics (STEM) fields. Some notable examples are the Wright Science Technology and Engineering Preparatory Program (STEPP) at Wright State University in Ohio (Yelamarthi and Mawasha, 2008) and the Northwest Engineering Transfer Talent Expansion Partnership (NW-ETEP) at Seattle Central Community College (Starbin & Laanan, 2008). These programs involve outreach with local middle and high schools that have high populations of under-represented groups in technical or scientific fields. These programs are special in that they specifically target under-represented groups in the engineering field. The focus of these programs is more related to recruitment, but the authors indicate there may be a relationship with student persistence for the students that participate in these programs. The goal of the theoretical model created for this study is to validate the initial findings that programs designed to retain female students are effective. This information can assist pre-college education in number of ways. Specifically, it showcases the variety of different support structures available at colleges that offer four-year engineering degrees and offers additional information related to the support structures that could be offered in the pre-college setting. In addition, the needs of incoming female engineering students were tracked, which offers insights on their pre-college experience and their perception of the university engineering environment. As Mary Mattis, as Senior Program Officer at the National Academy of Engineering, describes, the need to enhance opportunities for women engineers in higher education has intensified as the incidence of women starting high tech businesses has dramatically increased over the past decade (Mattis, 2004). Retaining female engineering students in higher education is a critical component to reaching this goal. The information provided from this study helps to accomplish this goal and identifies the most meaningful programs that increase retention rates among this student population. Additionally, a study conducted in the United Kingdom identified that gendered expectations and processes within organizations constitute the real dilemma for women's careers in technology, not lack of skill (Evetts, 1998). The programs discussed in the paper strive to recognize and address these dilemmas at the college level through education.

Description of Programs

The following sections provide a description of the retention programs available for female engineering students at the University of Toledo. The programs themselves are not entirely unique to the institution, but the combination of these programs is so. Following is a brief synopsis of each retention program, and includes overviews of each program, resource requirements, implementation issues, and results. In addition to the synopses, a brief overview of a female engineering student's perspective is provided in the co-operative education section.

The retention programs include: (1) a mentoring program which pairs female freshmen and senior engineering students; (2) the Society of Women Engineers; (3) the hiring of female faculty and staff; (4) integrated co-operative education programs; (5) the introduction of a

Freshmen Design Course; and (6) the Eberly Center for Women.

The Women in STEM Excelling (WISE) Mentoring Program

WISE links women science students with mentors, academic support, and a peer community during their first year of study. The primary goal is to ensure that all women students interested in a STEM degree will receive the necessary support and encouragement to have a successful career at the University and beyond. The WISE mentor program helps women science students achieve balance between their academic work and their participation in the broader University community. In addition it provides a peer, graduate student, faculty or professional mentor to undergraduate women enrolled in the program and also links students to tutoring services and academic support if needed. The program also provides opportunities for entering women students to meet accomplished women scientists from departments throughout the University. Support groups are a key element of this program. It provides regular opportunities for women STEM majors to come together, share experiences and support each other in their first year of study, and provides opportunities for female students in the sciences to serve as mentors to high school girls thinking about studying science or math in college.

The process to 'link' incoming female students with mentors occurs through the College of Engineering orientation process and follow-up emails/letters. When the female students attend a new student orientation session, the faculty advisor or a peer mentor meets individually with each student to discuss the WISE Program and its benefits. The peer mentor gathers contact information from the incoming student and schedules a meeting with the student during the first week of classes. Usually the students have lunch together during this meeting and discuss the challenges and opportunities for female students in engineering and science courses. One of the primary benefits of this interaction is that is allows the student to connect and identify with a like-minded person on campus.

A female mechanical engineering student that started at the university in the fall of 2008 participated in the program and commented:

> the WISE program allowed me to connect immediately with someone in engineering. When I first started classes, I felt somewhat alone and did not really know many people. To compound things, most of my classmates were males. To have a female student that I could call, text, or email at any time really made a difference, especially during the first month or so. She gave me great advice on classes, co-ops, and even places to eat near campus. We are still friends and stay in touch.

The WISE Program is also highlighted by the College of Engineering recruiting team during high school visits. When feasible, a WISE peer mentor will travel with the team to the high school visits to present briefly on the program and answer any questions from the students. This exposure for the female high school students gives them first-hand contact with a successful female in the engineering and science field and helps to break some false perceptions that only male students study engineering.

Society of Women Engineers (SWE)

SWE is a non-profit educational service organization dedicated to making known the need for women engineers and encouraging young women to consider an engineering education. The organization's four objectives are: (1) to inform young women, their parents, counsellors, and the public in general of the qualifications and achievements of women engineers and the opportunities open to them; (2) to assist women engineers in readying themselves for a return to active work after temporary retirement; (3) to serve as a center of information on women in engineering; and (4) to encourage women engineers to attain high levels of educational and professional achievement.

The University of Toledo Chapter of SWE was formed in 1972 and currently has 55 members (63% of the female engineering student population). The Chapter officers give brief presentations at the each engineering orientation class to advertise the group and encourage enrollment among female engineering students. The faculty advisor for this group commented that the Chapter allows female students to network with other female students while participating in activities that are of interest to them. For example, each year the SWE Chapter holds a wine and cheese tasting demonstration for the community and raises money for toys for tots. In addition, the group invites practicing female engineers to their monthly meetings to present on their experiences and career paths as female engineers.

Hiring of Female Faculty and Staff

The University of Toledo has made a strong commitment to diversity including nine separate diversity offices. The College of Engineering currently has seven female faculty members (19% of total faculty) and 13 female support staff members (65% of total staff). Adding female faculty and staff provides additional networking opportunities for female students and demonstrates that females can be very successful in engineering and science. For example, a female Assistant Professor of Mechanical Engineering at the University has been assigned to teach a freshmen level engineering course. One goal of this assignment is to demonstrate to both male and female students that women are very successful in this field. This also gives the university's freshmen engineering students an additional

opportunity to connect with a female engineer first hand. Many female students maintain this connection after completing the class and consult with her for advice.

The university has an equal opportunity employment policy, but does place special emphasis on hiring female faculty. For example, when a search committee is formed to hire a new faculty member, the university requires that a female is assigned to this committee. In addition, when a female applies for a faculty position, a campus visit is arranged to allow her to connect with the current female faculty and staff.

Co-op Program Support Group and Peer Mentoring for Females

The university offers extended services and support for female engineering students. A cornerstone of this support was hiring a female as the Director for Engineering Career Management. As a woman, she can offer special insights to female students and assist in quickly identifying and resolving common issues for these students. As part of her job, she requires each of her staff to meet individually with every student to discuss career goals. Her office staff offers insights to female students and matches female students beginning their first co-op with other female students that have completed co-ops. The purpose of these meetings is to answer any questions, provide peer-to-peer advice, and lower the level of anxiety.

The most common and overarching issues that the Director has identified with female engineering students relative to co-op are: (1) the role of co-op in choice of major and retention; (2) the role of external support in choice of major and retention; (3) the role of the social construction of gender in stereotypical male roles assumed by females, the chilly environment including a sense of isolation, sexual harassment, and generational differences relative to the perception of women in engineering; and (4) the role of relationships.

As Vickie Kuntz, the Director of the Engineering Career Manager Center at the University of Toledo, commented, these issues exemplify the importance of the mandatory co-op program relative to females choosing engineering, as well as females persisting in engineering. Numerous female engineering students have offered insight into how the mandatory co-op program either impacted her choice to pursue engineering and/or how co-op impacted her decision to persist in engineering. The feedback provided by these students clearly demonstrates the positive effect of the mandatory co-op program on both choice to pursue engineering and persistence in engineering. One female student commented that she was looking at other colleges, and "they didn't have anything like this where you were required to go out and work for semesters," and this was a deciding factor for her in choosing to enroll at the College of Engineering. For this student, as well as many others, the opportunity to gain work experience was important. The Director also noted the significant impact the mandatory co-op program had on female students' decisions to persist with their engineering coursework. Significant statements were made to support the argument that the mandatory co-op program positively influenced their decision to persist in engineering. The female students made statements such as how, prior to co-op experience, they seriously considered changing their major. In addition, female students commented how co-op helped them to gain a better idea and understanding of what they were learning. The students spoke of how co-op made them want to finish the program because they were actually doing the things they were learning about, and that encouraged them to broaden what they were learning because the material became more interesting and they could see the results. They spoke of co-op providing them with a new respect and appreciation for what they were learning in class. They also spoke of how co-op taught them to be more engaged in class as they became more interested in the lectures of their professors after returning from co-op.

Eberly Center for Women

The Catharine S. Eberly Center for Women (ECW) is an integral component of the university under the Office of the Provost for Academic Affairs. Its purpose is to serve the women of the University and the larger city communities by advocating for women's equity in education, work, and health. The mission of the ECW involves supporting learning, discovery and engagement, and enabling women to achieve their highest potential in an environment of diversity, respect and freedom of expression. One primary focus of the group is to provide monthly seminars related personal and education development for women. These programs range from computer courses to self-esteem workshops. As reported in a 2005 United Kingdom study, such centers are a critical part in restoring and promoting women's confidence in their abilities and by actively developing women's careers (Donovan et al., 2005).

Research Methodology

Given the need to measure and statistically validate retention program successes, the research approach for this study followed a similar method applied in a previous research (St John, 2000). This method objectively examined the data and statistically validated the results to determine conclusions. The St John study focused more so on the impact of financial aid as related to retention, whereas this study examined the impact of specific programs geared toward increasing retention of female engineering students. Accordingly, the methodology examines the first to second year retention rates over a five year period from 2003 to 2008 for a test group of female

engineering students that participated in the programs and a control group which did not participate in these programs. For the test groups, random samples of incoming female freshmen students in the College of Engineering were selected at the beginning of each academic year and asked to participate in the retention programs. Their participation was voluntary and complete disclosure and agreement in regards to The University of Toledo's human subject testing policy was confirmed with the group. The desired sample size for the test groups each year was 30 students. The control group for this study consisted of the incoming female engineering students that did not participate in the retention programs and retention statistics were collected from The University's Institutional Research Department. The following sections discuss the statistical method and data collection related to this study.

Statistical Method

To compare the retention rates of the test group versus the control group, z-tests were conducted at the 95% confidence level to determine if statistically significant differences existed between the retention rates from the freshmen to sophomore year from each year from 2003 to 2005 (five z-tests in total). The test statistic examined the proportion of students that persisted in the same engineering program from the freshman to sophomore year. This method has been applied in previous studies (Gillespie & Noble, 1992) with success. The method was chosen for this study as it provides a statistical basis for retention rate analysis and aids in quantifying the magnitude of the differences between each year of the study. For the test, the null hypothesis that the no difference exists in the retention rates for the test versus the control group was established along with the alternate hypothesis that the retention rates for the test group are greater than the control group (one tail z-tests at the 95% confidence level).

Post Survey

In addition, a post survey was conducted for the female engineering students that persisted from the freshman to sophomore year to examine which retention programs were perceived as most effective. The post survey gathered data from each student and requested them to rate each program on a standardized scale from one to six, as displayed in Table 1.

Table 1
Post Survey Scale

Scale	Meaning
1	Not useful in the least
2	Mostly not useful
3	Slightly not useful
4	Slightly useful
5	Useful
6	Very useful

The main purpose of the post survey was to identify which programs were perceived as most useful and meaningful in terms of student satisfaction and impact on the students' desire to remain in the program.

Analysis of Results and Implication

Table 2 provides a descriptive summary of the data for this study in terms of student enrollment. This table provides the number of new male and female students enrolled in the engineering programs at The University of Toledo from 2003 to 2007. In addition, the percentages of male and female students per year are displayed.

Eighty-eight female students were enrolled in the college of engineering in 2007; the ratio of male to female students has remained mostly constant with a slight increase over this timeframe.

Table 3 provides the raw data related to the student retention rates for male and female students from the freshman to sophomore years from 2003 to 2007. As shown in Table 3, the average female retention rate has increased to 73% from 52%.

Table 4 displays the results of the z-tests that analyzed the test versus control groups for each year. As mentioned in the research methodology section, these tests were conducted on the proportion of female engineering students that remained in the program for the test and control groups at the 95% confidence level.

As displayed in Table 4, the decision to reject the null hypothesis was reached for each year of the study. The null hypothesis stated that the no difference exists in the retention rates for the test versus the control groups; the alternate hypothesis stated that the retention rates for the test group are greater than the control group. The test statistics for each year were well above the critical value by over a factor of 10, indicating that a strong conclusion can be drawn that the retention rates for test group are

Table 2
Enrollment of New Undergraduate Students in the College of Engineering by Gender

	Fall 2003		Fall 2004		Fall 2005		Fall 2006		Fall 2007	
Female	77	10%	59	10%	69	11%	77	12%	88	13%
Male	708	90%	504	90%	538	89%	584	88%	590	87%
Total	785	100%	563	100%	607	100%	661	100%	678	100%

http://dx.doi.org/10.5703/1288284314652

Table 3
Undergraduate Student Retention Rates for the Freshmen to Sophomore Year in the College of Engineering by Gender

	Fall 2003		Fall 2004		Fall 2005		Fall 2006		Fall 2007	
Female	40	52%	32	55%	43	62%	54	70%	64	73%
Male	538	76%	378	75%	409	76%	444	76%	443	75%
Total	578	73%	410	72%	452	74%	498	74%	507	74%

Table 4
Test Results for Test Versus Control Groups

	Fall 2003	Fall 2004	Fall 2005	Fall 2006	Fall 2007
Test group	70%	71%	81%	84%	83%
Control group	41%	40%	46%	61%	67%
z test statistic	21.6	18.6	24.5	20.5	15.7
Alpha	0.05	0.05	0.05	0.05	0.05
Critical region	1.645	1.645	1.645	1.645	1.645
Decision	Reject Ho	Reject Ho	Reject Ho	Reject Ho	Reject Ho

significantly higher than the control group for each year. The results of this study conclude that the retention programs have had a positive impact on retention rates of female students pursuing engineering degrees at The University of Toledo. These data indicate that these programs may serve as a strong model to retain female engineering students.

The next phase of the study was to determine which programs had the largest impact on retention. This was completed by conducting a post survey given to the students that participated in the retention programs. The participating students were asked to rank each program on a scale from one (not useful in the least) to six (very useful). Table 5 displays the results of the survey. A total of 95 responses were received from over the five year timeframe of the study. The survey was given to the female students that participated in the program and distribution at the start of the sophomore year.

As displayed in Table 5, the freshman mentoring program was rated as most useful with a mean response rate of 5.3. This is not surprising, as this program provided the most one-on-one contact with a female engineering student in the similar age group. Involvement in SWE, the co-op program, and the freshman design course also had high mean response rates in the 4.2 to 4.8 range, indicating that these programs were beneficial from the students' perspective. The lowest ranking program with the Eberly Center for Women, this program has a mean response rate of 2.2, the only program with a mean response below the 'useful' ranking. This program is more utilized by older students and staff to discuss issues related to women in society. The feedback from the students indicated that some felt 'out of place' in some meetings and that the meetings were geared toward older groups.

Table 5
Post Survey Results

Program	Mean response
Freshman mentoring program	5.3
SWE	4.8
Co-op program	4.5
Freshman design course	4.2
Female faculty/staff	3.2
Eberly Center for Women	2.2

Conclusions

The impact of the College of Engineering's programs for increasing female students' retention rates has had a positive impact on The University of Toledo. In a five year period, the retention rate from the freshman to the sophomore year for female engineering students increased from 52% to 73%. In terms of enrollment for the College, this increased retention rate translates into approximately 14 additional female students remaining in the program per year. On a macro level, the programs impact the nation's engineering workforce in the following ways: (1) they benefit under-represented female engineering students by increasing retention through quality programs; (2) they demonstrate the importance of multiple, integrated programs to succeed in engineering fields; (3) they prepare female students for careers in engineering by valuing diversity; and (4) they enhance communication between female students, faculty, and staff.

In terms of connecting these findings to previous literature, this study validates the claims of previous studies that specific retention programs can be effective to improve student persistence (Fenske, Porter, & DuBrock, 1999; Hu & St John, 2001; St John et al., 2004). This study was unique in the sense that is focused entirely on female engineering students and included post-survey data to analyze the results further, contributing to

the knowledge of the dynamics of this specific student demographic.

In terms of limitations, the study examined only University of Toledo engineering students. Expanding the study to include other universities may be valuable to identify whether similar programs would have similar success at other institutions. Also, the study utilized a post-survey to determine which programs were most meaningful. A designed experiment that analyzes separate groups of students involved in the individual programs would generate additional information. This approach was prohibited by the small number of female students in the test group. Future research in this field will examine the cost/benefit of each program and track the students through the senior year to analyze graduation rates.

The results of this five-year study added to the university's knowledge base and aided the university in gauging the effectiveness of these programs focused on improving the female engineering students' experiences. These programs may also serve as models for other colleges interested in enhancing opportunities and success rates for female engineers. From a pre-engineering standpoint, this study offers insights on support structures that can be offered at the pre-college level to inform and educate potential engineering students. In addition, this study offers insights on the components and most appeal to incoming female engineering students to increase retention rates. The components could be integrated into the pre-college environment to target this group of students and prepare them to be more successful if they choose engineering as a field of study and future career.

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