Encouraging Women to Transfer into Engineering Programs from 2-Year to 4-Year Colleges

Authors: Lucia Riderer, Harmonie A. Hawley Physics Department, Citrus College, Glendora, CA /Department of Civil and Environmental Engineering, California State University, Fullerton, Fullerton, CA

Abstract

Women have long been an underrepresented group in the engineering community. Currently, research is being conducted throughout the United States on methods to retain women in engineering programs. Women in junior, or 2-year colleges, are often overlooked as potential members of the engineering community; however there are many women interested in engineering at junior colleges. Encourage and Engage Women In Engineering (EEWIE) at Citrus College is a program intended to guide and keep women on track to transfer from a 2-year college to a 4-year college with a major in an engineering discipline. The program has successfully operated for one complete year (2012). Over the past year the women who joined EEWIE have worked with peers at 2-year and 4-year colleges, women faculty from 4-year colleges, and women engineers in the industry who provided honest opinions to the group about the fields of engineering.

Vital to the success of this program was linking the group with students and faculty at 4-year colleges. This collaboration allowed EEWIE members to interact with women engineers who were in college or graduated and were able to help them with the transition from general education courses to engineering courses. Meeting women who succeeded in the engineering curriculum gave the students confidence that they could be engineers. Connecting the EEWIE women with female peers in engineering programs offered credible insights and encouragement for the women as they could relate to peers with similar problems. This is a model program from which many other colleges, universities, and students could benefit.

Introduction

Women have long been an underrepresented group in the engineering community. It is estimated that in the United States only 17.8 % of bachelor degrees were obtained by women in 2009¹. Currently, research is being conducted throughout the United States on methods to retain women in engineering programs². Another area of research is how to get more women interested in Engineering majors. Women in junior, or 2-year colleges, are often overlooked as potential members of the engineering community; however there are many women interested in engineering at junior colleges.

Community colleges can be institutions of high significance in bridging students to baccalaureate institutions to pursue a degree in Science, Technology, Engineering, and Mathematics (STEM) disciplines. The results of a study conducted by Tsapogas³ showed that about 44 percent of

students who earned a bachelors or masters degree in a STEM-related field have been enrolled in classes at one or more community colleges during their academic career at a four-year university. In addition, more women attend community colleges than four-year institutions, as indicated by the U.S. Department of Education⁴. It has been shown that community colleges play an important role in increasing the number of women in STEM disciplines and careers⁵.

Citrus College is a 2-year college located in Glendora, CA, in Los Angeles County. The Fall 2010 enrollment was 14,386 students. According to the Citrus College Fact Book⁶ about 54% of the students enrolled in classes at Citrus College are female. The percent enrollment of female students in higher level mathematics and physics courses (i.e. courses needed to transfer to a 4-year Engineering program) is much lower. In Spring 2011, 79 students were enrolled in Multivariable Calculus and Differential Equations of which approximately 19% were women. In the same semester, the student enrollment in Trigonometry and Introduction to Physics courses were about 50% women (250 total students). A survey conducted by the faculty member of the lower level courses found that only one female out of the 32 female students who participated in the survey was interested in Engineering and 12 were undecided. The undecided students were further asked if they would consider a major in Engineering; the most common responses from the students were "I am scared that I am not going to be successful in higher level math and physics", "I don't know anyone who is an engineer," and "I am not a hands-on person."

Earlier studies have noted that many women do not finish engineering programs because of a lack of self-confidence as opposed to poor performance in course work⁷. Brainard and Carlin⁷ found that female science and engineering students ranked the Women In Engineering Initiative and the student group Society of Women Engineers as factors influencing their decision to stay in engineering and science disciplines. It can be deduced from the Brainard and Carlin⁷ study that a support network was important to female students. Marra et al.² also found that women in engineering did not have a sense of inclusion or sense of community in the engineering field.

The primary mission of EEWIE was to foster interest in Citrus College female students in engineering through interaction with undergraduate female students majoring in engineering at baccalaureate institutions and faculty mentors who possess a deeper understanding of engineering in a welcoming environment conducive to discovering engineering disciplines⁸.

Methodology

The EEWIE program operated for the entire calendar year of 2012. EEWIE was a multicomponent program designed to create a support network and community for women enrolled in mathematics and science courses at the Junior College. Mathematics and physics courses were chosen as the most conducive courses to transfer to a 4-year, baccalaureate degree, Engineering program.

There were three main components of the program. The first component was "Tools For Engineering"; peer led workshops associated with mathematics and physics courses. The second component was "Focus on Engineering:"; a multi-level peer mentoring program that involved

students at 4-year colleges, Citrus College students, and elementary and middle school students (grades 3 to 8). The third component was "Links to Engineering". The third component is the focus of this paper and is described in detail.

Links to Engineering was designed to link Citrus College female students in EEWIE to female engineers at 4-year colleges and in the industry. There were three main components of Links to Engineering. The first part was presentations and discussions by faculty and students at 4-year universities. The second portion was field trips. The third portion was participation in research projects related to an engineering discipline.

Results

Seventeen (17) women students from Citrus College participated in the EEWIE program. Ten (10) of those students are still at Citrus College with plans to graduate from Citrus College and transfer to a 4-year institution. Six (6) of the students transferred to 4-year universities; the universities were University of California Los Angeles, University of California San Diego, Columbia University, California State University, Los Angeles, and California Polytechnic University, Pomona. The students are currently majoring in Mechanical Engineering, Chemical Engineering, Computer Science, Biochemistry, Biology, and Accounting.

The first component of Links to Engineering was accomplished through two presentations and peer mentoring (which falls under the Focus on Engineering task and is therefore not further discussed here). Faculty member Dr. Harmonie Hawley, accompanied by a graduate student and an undergraduate student who was the President of the Society of Women Engineers at the time, conducted an open forum style discussion on April 13, 2012. The three presenters were all affiliated with the California State University, Fullerton. The Engineering disciplines represented were Civil & Environmental, Mechanical, and Chemical Engineering. The open forum style allowed the Citrus College students to ask questions and promote discussions amongst the faculty and students. Some of the main topics discussed were the different engineering majors, what can be done with an engineering degree, how to obtain funding for graduate school and the benefits of graduate school, and what standardized exams exist for engineers. A second presentation was held on June 1, 2012 by Dr. Joann Eisberg from Chaffey College. Dr. Eisberg discussed the role of women in science and society; she encouraged the EEWIE members to study at the graduate level and to pursue their career dreams.

Three field trips were held throughout 2012 as part of the second component of Links to Engineering. Several EEWIE members visited the Jet Propulsion Laboratory in Pasadena, CA and the Uninhabited Aerial Vehicle Laboratory at California State Polytechnic University, Pomona during the summer, 2012. Two of the EEWIE participants attended a three-day NASA Advanced Rocketry Workshop in Huntsville, Alabama from July 18 to 21, 2012.

The final component of Links to Engineering was to have students work on Engineering-related research projects. Members were not required to conduct research, but several students opted to do so. Three EEWIE members joined the Citrus College Rocket Owls (total team size was six

students); the Rocket Owls are participating in the 2012-2013 NASA University Student Launch Initiative competition (USLI). USLI required students to design, build, and launch a reusable rocket one mile above ground level. Two EEWIE members linked with students at the California State Polytechnic University, Pomona to create a High Altitude Balloon (HAB) team. The students are working to design, build, and fly a device to take dosimetric measurements of ionizing radiation at different altitudes. The students plan to launch their device in Spring 2013. One member of EEWIE performed a research experiment during Summer 2012 entitled "Efficiency of Compressed Air Energy Storage".

Discussion

Surveys were given out to members of EEWIE to assess student engagement and the applicability of the program. Nine responses were collected from the program. The results showed that the participating women found the Links to Engineering program to be useful and encouraged them to evaluate engineering as a major. There were five potential answers to each of the 35 questions: strongly agree, agree, neutral, disagree, and strongly disagree. Only questions related to the Links to Engineering component are discussed in this paper.

Component One: Presentations and Discussions

When asked to respond to "Inauguration and Meeting Mentors (1/5/2012) contributed to my sense of community, engagement and encouragement (Or check if you did not attend____)", seven students responded Strongly Agree and two students did not attend the event. This question was not explicitly related to Links to Engineering events, but both authors attended the event and met with the students. The inauguration was attended by Deans and Faculty of Citrus College as well as outside mentors from California State Polytechnic University, Pomona (peer mentors) and the California State University, Fullerton (faculty).

When asked to respond to "Open Forum with Dr. Harmonie Hawley (4/13/2012) contributed to my sense of community, engagement and encouragement. (Or check if you did not attend____)", five students responded Strongly Agree, one student was neutral, and three did not attend.

When asked to respond to "Lunch conversation with Dr. Eisberg (6/1/2012) contributed to my sense of community, engagement and encouragement. (Or check did you did not attend_____)", four students responded Strongly Agree and five students did not attend.

When asked the open ended question "In what ways could the Encourage and Engage program change/improve?", there were five typed in responses. Three of the five responses were related to "Links to Engineering" in that outreach and understanding the different engineering disciplines were important. The first comment was "Invite more people to talk about the career field after graduating". The second related response was "Have speakers come and tell us about different fields, students and teachers could tell us how to best prepare for school or the work life. A day in a life as an engineer would be interesting to know". The final related comment was "I suggest have more outreach experiences so that we can have more hands on experience

and feel interested in engineering". Lent et al.⁹ concluded that understanding the outcome expectations of a career was shown to be a factor in retaining students in engineering disciplines. This study also found that understanding the career outcome was important to the women students.

Similar results were found in other programs. Citrus College has a program entitled "Support and Inspire" Program for Women in Mathematics. The main goal of this program is to increase interest in mathematics by acting as peer mentors and interacting with professional women mathematicians. In 2010, surveys were conducted with members of the program and data analysis showed that Citrus College female students were inspired by female role models¹⁰. Muller¹¹ reported that mentors from the engineering industry are important role models for women engineering students and is a method shown to improve retention of female students. Mentors who are more experienced than the students can enlighten the students about career opportunities and provide support, advice, and encouragement. Marra et al.² concluded that there is a need for extracurricular activities, such as academic success seminars, to retain women in engineering.

Hartman and Hartman¹² conducted a study on engineering students who stayed in Engineering and students who left engineering at Rowan University. Their findings were that women had the same or higher retention rates than their male counterparts during the study. The authors concluded that the program was "female-friendly". Further analysis was conducted on the women who stayed in engineering versus women who left engineering. Hartman and Hartman¹² found that the women who left engineering were worried about the freedom of a job in engineering and, relatedly, problems with conflicts over career and family. Engineering women who participated in the Society of Women Engineers and women who had internships/employment in engineering were less likely to perceive career-family problems. This suggests a reason for female attrition in engineering; however it appears to be alleviated by professional experiences in the Industry or by a support network. Hartman and Hartman¹³ conducted another study from 2002 to 2006. This study again found that perception of careerfamily conflicts was a problem for women, as was a lack of female role models. These issues can be alleviated by joining student groups, such as Society of Women Engineers or EEWIE, and speaking with professional women engineers.

The previous studies focused on retaining female students at 4-year institutions and found that support networks and mentoring were important for the students. This study focused on engaging 2-year college students in activities to increase their interest in transferring to engineering programs. The authors were unable to find research directly related to the transfer of females to engineering from 2-year colleges. This shows that more work in this area is needed to assess recruiting and retaining engineering students. There are potential female, and male, engineers that may be overlooked.

Component Two: Field Trips

There were no specific survey questions related to the field trips. It is the authors' advice to specifically ask questions regarding the field trips in future work. Support and Inspire¹⁰ evaluations showed that field trips were ranked highly as an important feature of the program.

Component Three: Engineering-Related Research Projects

The students who participated in research projects were asked to evaluate the usefulness of the research using the aforementioned scale. Of the three EEWIE women who joined the Rocket Owls, two students responded Strongly Agree and one student responded Not Applicable. When ask to analyze the High Altitude Balloon (HAB) project, two students responded Strongly Agree and one student responded Not Applicable. It can be assumed the student/s that responded "Not Applicable" were not members of the project, but responded to the question. The results from the survey indicate that projects had a positive influence on the students' success.

In general, undergraduate research has been shown to positively impact engineering and science education¹⁴. Though not specific to retention of students, the study shows that students gain beneficial experience by conducting research. There are Universities throughout the United States that require engineering students to conduct research or clinics to graduate with a Bachelors degree, including Worcester Polytechnic Institute and Rowan University.

Conclusions

The EEWIE successfully operated for the year of 2012. The women participants were encouraged to evaluate STEM fields for a Baccalaureate degree, with six graduating females attending four year universities. Vital to the success of this program was linking the group with students and faculty at 4-year colleges and Engineering professionals. Research projects were shown to have a positive influence on the women students.

Acknowledgements

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