A Learning and Serving Community Helps Female Students Succeed in Engineering

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Abstract

Female engineering student enrollment and retention rate has been a concern in the United States. For decades, different institutions and administrations have been making a variety of efforts on how to encourage more female students to explore engineering programs and supporting them to succeed in this area. How to bridge the gender gap in engineering areas and to promote the success of female students has also become one of the most important goals for many engineering schools and faculty to achieve.

Our institution, a small private Christian college, struggled in this area as well when it first launched its engineering program in the early 1990s. The obstacles seemed more difficult to overcome for this conservative Christian college than other public institutions. Up to the year 2005, there were fewer than ten female students enrolled in engineering. The female engineering student ratio consistantly ranged from 3% to 5%. To turnaround this situation, we established a unique learning and serving community in 2005. We designed some unique mentoring programs and a variety of service projects to form a supportive learning community for female engineering students. After a ten-year effort, the number of female engineering students has increased from less than 10 to more than 50 in 2017. The female engineering student ratio has reached over 11%. Female engineering students are now thriving in our learning and serving community through mentoring, building friendships with other female engineering students, and serving the local communities. This paper will describe the challenges our engineering department has faced in attempting to boost the female engineering student enrollment and retention rate. It will provide detailed information on how our learning and serving community has been gradually formed over the past 10 years, what kind of activities and service projects have been implemented, and how the mentoring programs are conducted. This paper will also explain why this unique learning and serving community in a small private college can help all female engineering students succeed.

Introduction

Our university is a private Christian college located in southwest Ohio, with over three thousand students. Founded in the 1880s, our university did not start its engineering programs until the early1990s. Being one of the few engineering programs available among Christian colleges in the region, and with devoted faculty providing excellent education and faithful service, the school of engineering has been growing steadily since it was launched. In spite of its steady growth, like most of the engineering programs in the states, our school faced the same challenges in the enrollment and retention rate of female engineering students.

Being a small private Christian college, it is well-known for its conservative and Christ-centered education. Besides the normal challenges all engineering schools are facing, its uniqueness makes the female student retention rate and enrollment situation even harder.

First, the majority of students are from Christian families. A traditional stereotype of a woman in those families is to be a godly wife and mother who stays home raising children and serving their families. As a result, majors in liberal arts such as humanities, social science and creative art are more popular than STEM majors. The enrollment of female engineering students has been a challenge from the beginning. Only a small portion of talented and bold girls are willing to take the challenge in the engineering program. The low enrollment further made the retention rate problem worse.

Secondly, isolation was the major problem that caused the low retention rate of female engineering students in our school. Due to the low enrollment rate, it was very common for a female engineering student to be the only female student in one class. It was hard for them to find another girl to study and discuss problems with. Our school is a relatively conservative college; the single-gender dormitory also has curfew at 12 o'clock. It is structured to ensure the safety of the students. It does, on the other hand, cause more challenges for female engineering students. If a male engineering student got stuck on his homework or a problem, even it is after 12 o'clock, he can find another engineering classmate easily in his unit who is working on the same problem and get help. But for a female engineering student, as a minority of the school, it is not easy to find another female engineering student in the same dormitory to offer help. They cannot get out of the dorm to ask male classmates once it is past curfew. This situation was worse in the early 1990s when social media was not yet common. As a result, the retention rate of female engineering students was only 15-30%. Many talented young ladies switched to other majors not because they were not capable of learning but because of the isolation and difficulties.

In order to improve the situation, our school hired its first female engineering faculty member in 2004, who, under the great support from the department, designed and implemented a series of mentoring and support programs through the Society of Women Engineers (SWE) local chapter to build a supporting and learning community for the female engineering students. After more than ten years of effort, the retention rate and enrollment rate have greatly improved. This paper will first describe the adopted programs and activities, then the outcomes and improvements.

The Current Status and Factors That Hinder Women in Engineer

The under representation of women and minorities in U.S science, technology, engineering, and mathematics (STEM) areas has caused much concern and may limit innovation, growth and responsiveness to the needs of a dynamic and diverse society [1]. Despite numerous calls by national policy makers, academic advisory groups, and many initiatives to improve the gender equity, women's representation in undergraduate engineering programs remains quite low: 19.2% in 2012 [2]. According to the National Science Board 2016 S&E Indicators Digest, "Despite accounting for one-half of the college-educated workforce, women in 2015 accounted for less than one-third of [science and engineering] (S&E) employment. Although the number of women in S&E jobs has risen significantly in the past 2 decades (from 755,000 in 1993 to 1,818,000 in 2015), the disparity has narrowed modestly." [3]

One major challenge is female engineering student retention rate. The U.S. Department of Education conducted a study of 16,680 first-time beginning students (FTBs) at any

postsecondary institution in the United States at the beginning of their third (2005-2006) and sixth (2008-2009) years after entry into postsecondary education. This study showed that 39.3% of enrolled women in U.S. undergraduate STEM majors switched to a non-STEM field by the end of their first year in college [4]. In Ferrare and Lee's (2014) research data analysis, 44.5% of women switched out of STEM majors by the end of their first year compared with 36.8% of men. The statistics show the ratio of women switching out of STEM majors after the first year was 1.51 times higher than for men switching out of STEM majors. And furthermore, women are less likely to switch into STEM majors regardless of their original major.

We further tried to narrow down the primary cause of the high major switching rate among female engineering students. Research has examined the causes of women's disproportional representation in STEM fields and suggests that socio-cultural factors are largely responsible for persistent disparities [5]. Decreases in academic performance and persistence of women in these fields have been attributed to individual factors tied to socio-cultural dynamics, including differential preparation [6] and psychosocial constructs, including social identity and stereotype threat [1].

Based on the above research, the causes of women dropping from engineering could be social isolation, lack of career affirmation and self-confidence in engineering.

By targeting these three major causes, our school designed and implemented our learning and serving community to help and support our female engineering students to succeed. This community is to support and encourage each other, to affirm the bright future career, and to build up self-confidence. It is through integrated services that all of these goals will be achieved.

The following actions implemented in our engineering school have achieved successful results:

Build the Learning and Serving Community to Improve Retention Rate

According to the above research and our unique Christian college culture, we find the major causes of low female engineering student retention rate in our College are isolation, lack of career affirmation, and low self-confidence. Our school designed and implemented programs to help build a supporting community for our girls to solve the isolation problem, to affirm that women can be success in engineering area too, and to build up female engineering students' confidence. The following actions were taken:

Freshmen Orientation

According to research, freshmen year is the time over when 30% of girls switch to non-STEM majors [4]. Our program starts with freshmen orientation. All new female engineering students are invited to this event, as well as all other female engineering students from sophomore through senior year. The event would be hosted at a local coffee shop, ice cream parlor, or in a classroom with pizza and soft drinks. During the orientation, the female faculty advisor welcomes every new student to the school. The SWE faculty advisor and student officers will address the challenges female students will commonly face in the future as being the minority in engineering. This helps most new

students mentally prepare to encounter various difficulties. The students are encouraged to take the challenge. During the orientation, the senior female engineering students are invited to share their experiences and also encourage the freshmen. We selected fun games to play afterwards to let the freshmen get to know the upper-level female students. The senior female students are good role models and offer encouragements for the new girls. It gives the new students motivation that they can be successful in the future. New students also realize that there is a community in our school where they can find support and belongings.

Picture 1: Freshmen Orientations

Monthly Dinner Fellowship

Any engineering degree is a very rigorous program of study. One can imagine that every engineering student is always busy once classes start. Our school is a small private college, so there is no extra budget to sponsor female engineering student fellowship programs. In order to foster the fellowship among the girls and offer help to our new students without costing extra money and without costing extra time from the students' busy schedule, we designed a monthly dinner fellowship meeting. For one dinner meeting each month, a long table will be reserved in the student cafeteria where students have their regular meals. All of the female students, new and old, will pick up their food and sit together to eat. During the dinner, new students can share their problems, ask advice, and even just vent their frustrations. The senior classmates will share their

experiences and tips, as well as encourage others to overcome the frustrations. Because it is the students' regular dinner time, this will not take up extra time; the students use their own meal plan, thus it will not cost extra money. But it helps in fostering the friendship among our female engineering students and building a supportive community. The freshmen girls know that there is a group of female engineering students out there caring about them and who are ready to help them succeed.

The Mentoring

First year of college is always the toughest. The transition from high school to college requires many adjustments. It is also the year most female students switch majors. We want to try our best to help our freshmen to survive their first year. We call on senior female students as volunteers to mentor freshmen through the year. The pairing with a mentor is made by SWE officers. They are paired according to their majors, characteristics and hobbies. The mentoring could be helping with a tough homework assignment or just a simple encouraging text message by phone. But it will make the freshmen know that there is somebody out there who has been in their shoes, who cares about her, and is willing to help her. Friendships are built with mentors and will last for years after their graduation.

Role Model

We all know that the power of a role model is critical. One major cause of the low retention rate is the career role affirmation. In order to encourage our students, we often invite a female engineer from a local company or engineering institute to give a presentation to all of our female engineering students. The presentation includes insight into what a typical workplace looks like, how they balance their job and family as female engineers, the biggest challenges they had to face as female engineers, and how they overcame those challenges. These presentations not only serve as big encouragement to our students, but also build networks between our female students and the invited speakers.

Picture 2. Presentations by Local Female Engineers

Service Projects

There is no doubt that women and men are different. They are different in thinking, observing, analyzing, interacting and expressing emotions [7]. According to Dr. Leonard Sax, educational psychologists have consistently found that girls tend to have higher standards in the classroom, and evaluate their own performance more critically than boys do. As a result, girls and boys experience academic difficulties very differently. "Girls generalize the meaning of their failures because they interpret them as indicating that they have disappointed adults, and thus they are of little worth. Boys, in contrast, appear to see their failures as relevant only to the specific subject area in which they have failed; this may be due to their relative lack of concern with pleasing adults." [8].

As a result, one of the major factors that prevents girls from being successful in STEM areas is that girls tend to lose their confidence easily. For instance, a boy could fail multiple tests and still feel confident about his ability; however, a girl could lose all her confidence from one poor homework assignment. Because the research data indicates that confidence is one of the major factors to the success of women engineers, we decided to build up our female student's confidence through service projects.

Female students pick one or two service projects each year. We would like our students to roll up their sleeves and contribute to our local community. By doing so, the students will see that they can help and that they have the ability to make a difference in other people's lives and improve their local communities. It will help build up their confidence. Working together with other students as a team helps them build friendships and be part of the supporting community. Service projects also help them learn to manage their time efficiently, help them to be persevere through difficulties in the projects, and most importantly they learn the meaning of being an engineer: Advancing technology and improving people's living conditions. Over the last 14 years, our female engineering students have been helping the local community and demonstrating leadership in variety areas. The following are some examples of the service projects we have done:

Picture 3. Raised Money for a Local Women's Center

Picture 4. Donated a Large Size Compost Tumbler for a Local Domestic Violence Center

Picture 5. Made Blankets for Children in a Local Children Hospital

Picture 6. Gave Presentations about Engineering and Helped Local Schools with Their STEM Projects

Picture 7. Hosted Vex Robotic Competitions

Picture 8. Caroling at a Nursing Home

Picture 9. Built a Picnic Table for Campus

Our female engineering students are becoming more confident, growing stronger together, and developing positive feelings toward engineering through serving others as a team.

Finals Week Package

Our other activities include a finals week care package. During the final exam week, we would pack some snacks for each student along with some encouraging notes. During this most stressful week of the semester, it will help ease their nerves and encourages them to finish strong. The students often have parties the weekend before finals. They can study for finals together and also bake desserts to relax.

National Society of Women Engineers (SWE) Conference

With the help of our school leadership team and NASA's Ohio Space Grant Consortium, we were able to send our senior students to National SWE conference often since it hosts a huge job fair just for female engineers. This also facilitates our female students to be successful in the job market. Due to our budget limitation, we only attend conferences that are within driving distance so that the students can carpool. Many of students landed jobs or internships by attending the National SWE conference. These senior students, in return, serve as good role models and a big encouragement for other female engineering students.

Picture 10. SWE National Conference

Research and Competitions

In order to motivate our female students to achieve full potential in careers as engineers and leaders, when there is a chance, the female faculty advisor will advise a small group of female students for competitions or research. The competition and research results are a great encouragement for other female engineering students. We have won multiple

prizes and honors, such as the second place in nationwide Game4Girls computer game design competition two years in row. We also won the first place award for a female engineering undergraduate research paper competition.

Picture 11. Second Place team in Game4Girls Competition

Picture 12. Won First Place in Undergraduate Research Paper Competition

All of the above activities stimulated female students' interest and passion for engineering academics. Prizes and honors either small or large all make a big difference in each student's life and their studies. The retention rate of the female students in the engineering school has been greatly improved due to these activities.

Improve Enrollment

Now that the retention rate has improved, we want to improve the enrollment as well. In order to recruit more female engineering students, our school conducted the following activities:

Engineering Day Presentation

Each year, The School of Engineering has an open house for all prospective high school students. Our school uses this event to give a presentation to all prospective high school girls who are interested in an engineering major. We introduce them to our mentoring program, tell them where our graduates are working, and most importantly, that there is a community here just for them. Questions and answers follow the presentations.

Picture 13. Introduction of our mentoring program to the prospective family

Calling Prospective Female High School Girls and Strengthen Connection

In order to reach out to those female high school students who visited our school and expressed strong interests in an engineering major, we also follow up with them by making phone calls to them. With the help of the admissions office, we compile the high school students' contact information. Then we organize our current female students to call each of them, answer their questions, and tell how to prepare before they come to our school. Our SWE advisor also writes post cards to encourage them to explore engineering fields.

The Changes and Outcomes

Our School of Engineering is growing, as is the number of female engineering students. The following table shows the growth of female student ratio.

Table 1. Female student ratio outcome

Year	Number of Female Student	Female Student Percentage %
2004	7	3.6
2005	11	3.2
2006	15	4.3
2007	23	6.9
2008	25	7.6
2009	25	7.6
2010	30	8.0
2011	34	8.7
2012	36	8.7
2013	41	9.3
2014	49	10.6
2015	50	11.2
2016	54	11.9
2017	55	11.7

In the past, the retention rate of female Engineering students was below 30% in our school. As of the year 2016, among the 54 female Engineering students, only 6 of them left Engineering. The retention rate is now close to 89%.

Table 2. Retention Rate outcome

Year	Retention Rate
2004	< 30%
2016	89%

As the Cedarville University School of Engineering continues to grow, we anticipate improving our percentage of female engineering students. We started a Civil Engineering (CE) program in fall 2019 and we expect a higher percentage of girls to be interested in the varied opportunities in fields such as structural, environmental, geotechnical, and infrastructure engineering.

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