Piloting an Undergraduate Engineering Mentoring Program to Enhance Gender Diversity

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Abstract

Many female undergraduate Engineering students struggle during their first and second years of college with finding their place and questioning whether they belong in Engineering. It has been shown that mentoring programs can help encourage women to stay in STEM. The purpose of this study is to implement a women in science and engineering mentoring program within the STEM disciplines at the university. The focus of the initial pilot mentoring program includes: 1) orientation to the program, networking, community building and defining the program's goals; 2) understanding the imposter syndrome and strategies for dealing with it; 3) networking with female STEM faculty; and 4) professional advice and career paths. The initial mentoring program design was developed through two Lean Six Sigma projects, where they collected voice of the customer (mentors and mentees) data, and designed the program. The program was piloted in Fall 2019, spearheaded by the Women Engineering Program in the School of Engineering, the director and a student graduate assistant. The success of the pilot program was assessed in three ways: 1) number of mentor/mentee pairs starting the program, compared to the initial number interested; 2) retention of women in engineering and science during the program periods; and 3) through mentor and mentee reflections. In the initial voice of customer data collection, we identified 14 possible mentors, and in the pilot program, we had over 40 mentor/mentees pairs for the program. This program will provide mentorship to women engineers throughout their college career as well as support them for a career in engineering in the workplace.

Key words: Science, Technology, Engineering, Mathematics, STEM, Women, Minorities, Mentoring, Education

1. Introduction

Many female undergraduate students in STEM (Science, Technology, Engineering, Math) struggle during their first and second years of college with finding their place and questioning whether they belong in engineering. It has been shown that mentoring programs can help encourage women to stay involved. A research study completed last year analyzed the benefits of organizing a mentoring program for female engineers. This paper applies the previous research that applied Lean Six Sigma tools and the DMAIC (Define-Measure-Analyze-Improve-Control) methodology to design a mentoring program, to begin the first pilot program, to connect freshman in STEM with upperclassmen at the university. The university has about 10,000 undergraduate students and 3,000 graduate students with a very large School of Engineering consisting of one out of every six students in the university. The Women in Science and Engineering (WISE) program exists at the university to build connections between students and professionals in their field. This program will be leveraged to begin the peer mentoring program to retain women and enhance the women's engineering program experience at the university. There is a need to increase diversity, especially women in STEM fields. This paper is a work in

progress and explains the first semester of piloting a mentoring program, explaining its purpose, goals, organization, and results.

A study completed by Kloos and Furterer, *Designing an Undergraduate Engineering Mentoring Program to Enhance Gender Diversity through Application of Lean Six Sigma Methods and Tools,* led to the creation of this mentoring program [1]. The research revealed that women make up about 50% of a university's students across the United States but only 13 to 33% of those students are in STEM, with the lowest in engineering degrees [2]. Females in STEM frequently show self-doubt despite having the same abilities as their male counterparts. Research showed that perception of school experience can influence confidence in STEM fields. Mentoring programs across the United State were implemented to decrease self-doubt and increase interest in STEM fields. One study showed that females with peer-to-peer mentoring obtained nearly a 100% retention rate [2]. Schools as early as kindergarten strive to close the gender gap in STEM and demonstrated that mentoring programs lead to success.

The University contains several mentoring programs across campus, but none are specifically for women in STEM. The Women in Engineering and Science (WISE) decided to implement its first mentoring program for specifically women in STEM. The WISE program was designed to provide support and community to women in engineering and science programs at the university. The WISE program contains other aspects like the Integrated Learning and Living Community (ILLC) where the freshmen live together on the same floors. Due to its similar goals and nature, the WISE program was able to help kickstart the mentoring program by pulling from their resources and contacts.

The initial mentoring program design was developed through two Lean Six Sigma projects, where they collected voice of the customer (mentors and mentees) data and designed the program. Kloos created a Why-Why Diagram (figure 1) explaining the low proportion of female to male students in STEM:

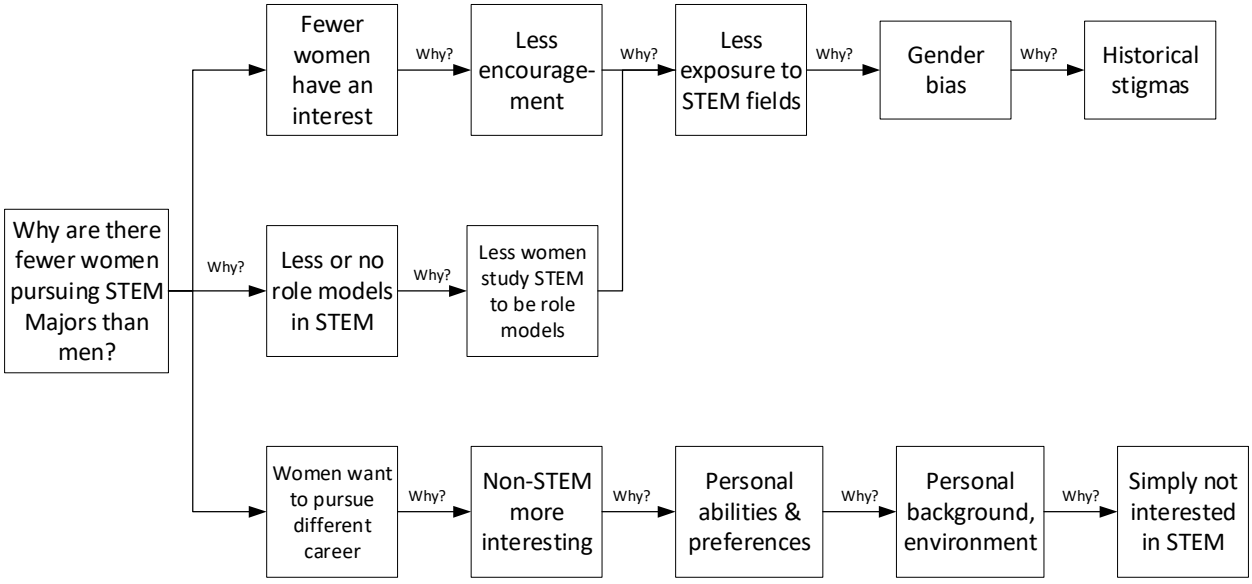

Figure 1: Why-Why Diagram explaining Low Numbers of Females in STEM [1]

A group of 19 WISE females were surveyed on their thoughts on mentoring programs. Fourteen or 74% of the women claimed they would definitely be interested while 4 were hesitant and one was not interested [1]. This paper analyzes the program piloted in Fall 2019, spearheaded by the Women Engineering Program in the School of Engineering, the director and a student graduate assistant.

2. Literature Review

Kloos and Furterer completed a literature review exploring the research regarding the lack of women in the workplace in STEM fields within engineering programs, the lack of confidence of women students in STEM, and already existing mentoring programs. This literature review will include an updated review of the similar literature focused on: 1) lack of women in the work place and in academic programs in STEM and engineering fields, 2) lack of confidence of women in STEM academic programs, and 3) existing mentoring programs, their success and design.

Lack of Women in the Work Place and in Academic Programs:

One study focused broadly on women in the workplace by LeanIn.Org and McKinsey & Company which explored how women move into management positions at lower rates than men [3]. On average, women are promoted and hired at lower rates than men, so there are far fewer women in the pool to become senior leaders. At more senior levels, we see women shift from line to staff roles, so very few end up on the path to becoming CEO or in C-suite positions that lead the organizations (Chief Executive Officer (CEO), Chief Financial Officer (CFO), Chief Operating Officer (COO), etc.). Women remain underrepresented in the corporate pipeline, mainly at progressively higher levels of management. Although this study was not specific to engineering disciplines, it represents the challenges that women face in the work place.

In academia, in 2014, women received 19.9% of undergraduate engineering degrees, which was an increase from 17.8% in 2009. Women earned 24.2% of the engineering master's degrees in 2014, an increase of 1.5% from 2005. The percent of women receiving doctoral degrees in engineering decreased slightly in 2014 to 22.2%. In the workplace, only 12% of the engineers are women, as of 2013. So even though women are receiving almost 20% of the bachelor's degrees in engineering, they are dropping out in the workplace. [4]

There is a need for more women in STEM to increase diversity and fill the workforce needed to sustain current and future technology. Women are consumers, not just men, and their opinion should matter for products and services developed by engineers, scientists, mathematicians, etc. Women make up about 50% of university students across the United States and only 13 to 33% of those students hold a bachelor's or master's degree in STEM, with the lowest percentage in engineering degrees [2].

Lack of Confidence of Women in STEM Academic Programs:

Since many female students struggle with lack of confidence in STEM, studies have been completed analyzing female's perspectives on their courses and experiences compared to their male counterparts. A study revealed that women showed lower perceived ability, self-efficacy, performance approach, and mastery approach than men, along with a higher performance avoidance and mastery avoidance than men. However, the research concluded that women demonstrate a lack of confidence and self-efficacy in engineering, they are still able to learn the material just as well as men. However, building confidence is crucial to building the female community in STEM fields. [5] Ro and Loya found that men tended to rate themselves higher on engineering-focused skills, while women scored higher on self-assessments of professional skills in the workplace. Other studies found that developing a community that unites those with similar minority statuses can provide a buffer against the effects of a "chilly climate". Good well-designed mentoring can help. [6]

Walton, et al [7] tested two interventions that had positive effects on women's GPAs and improved women's confidence for succeeding in engineering, they are: 1) An intervention of providing the idea that encountering adversities and being worried were typical and dissipate over time helped women feel more valued in engineering and facilitated friendships with male engineers; and 2) A second intervention incorporated values and aspects of identify important to women into stress-management strategies. It helped women to place greater value on their gender identify and to strengthen ties to women outside of engineering.

Existing Mentoring Programs, Their Success and Design.

Mentoring programs are growing across the United States by building peer and professional mentoring programs. Kloos and Furterer analyzed a study aimed at increasing sense of belonging by female students in STEM. Trained mentors met with females in STEM to make the females feel welcomed and motivated. The study concluded that all the female students felt more confident and a sense of belonging in engineering since they had a female mentor [2]. In addition, those with a male mentor had a lower retention rate than those with a female mentor (89% compared to 100%) [8].

An additional article discovered that mentoring groups found "slight improvement in metacognitive strategies, goal orientation, resource management and academic performance" [9]. A study completed at the University of Toledo revealed that a mentoring program focused on STEM provided opportunities to see fellow women as role models and balance academic work with greater community [10].

Two studies show that periodic meetings with advanced students and first-year STEM students provide encouragement and support as they learn how to be successful in college and STEM courses [11], [12]. In a study by Albion College faculty, they implemented a peer mentoring program in math courses to improve retention in physics and engineering courses. They developed group mentoring, and assigned mentors from students who had completed two years of math and physics courses and had mastery of the material, had appropriate personality (were outgoing, approachable and patient), and had a willingness to help other students succeed. The mentoring program helped improve retention in the courses, and the students' attitudes toward physics and math courses did not appear to deteriorate over the semester and 80% of the

students planned to take the next course in the physics sequence. Additionally, more than half of the students could see themselves as an engineer or scientist. [13]

In another peer mentoring program, the Women in Science and Engineering (WISE) program at Syracuse University implemented a mentoring program focused on helping women graduate students in engineering and computer science and Arts and Sciences, designed to address the drop-off of women in engineering at the graduate level. The program helped address barriers of isolation and the lack of successful women role models at the graduate level. [14]

Another graduate peer mentoring program was implemented in a research-oriented university with master's students majoring in science or engineering in Taiwan. This program helped reduce anxiety, enhanced the mentees' professional knowledge, helped them adapt to lab teams and accomplish lab research. [15]

Another study found that mentors reported the process of role modeling to be the most beneficial yet challenging component of a mentoring program. [16]

3. Methodology

The University has about 10,000 undergraduates and about 3,000 graduate students. They have a very large School of Engineering, where 1 out of 6 students is in the school. They have large science, technology and math programs as well. The Women in Science and Engineering (WISE) program is a university program where students in science and engineering can interact with faculty, upper level students, and professionals in these fields. The WISE program includes an Integrated Learning and Living Community ILLC). The WISE program is designed to provide support and community to women in engineering and science programs at the university [17].

The Women in Engineering coordinator, the first author of this paper, who is an engineering graduate student, designed the mentoring pilot program based on the two prior Lean Six Sigma projects [1], and the investigated research. She developed a one-on-one mentorship and a group-mentoring component for the program. The details of the program that was piloted will be discussed in the following sections.

3.1 One-on-one Mentorship

The primary form of mentorship in the pilot program is one-on-one interactions between mentors and mentees, where they foster deeper relationships and provide personalized guidance and advice. Ideally, the pairing creates a safe space to foster open conversations ranging from classes to roommate conflicts to life paths.

For the first year of the program, mentors were recruited by contacting previous WISE members, various clubs such as the engineering sorority and Society of Women Engineers, and by word of mouth. A survey was sent to the interested mentors asking for their major and minors, campus involvement, off-campus interests, and description or personality in three words. The survey asked interested mentors to reflect on previous mentoring experiences and impacts of mentors on

their life, and why they wanted to mentor a freshman. Forty-seven (47) upper-class women completed the survey, where approximately 50% were sophomores, with a wide range of majors, minors, involvements, and hobbies. Sophomores in the WISE program were selected to be mentors because they were closest to the freshmen experience of the women students that they would mentor, and they were still part of the WISE program.

Only freshman in the WISE program were recruited for the mentoring program, though in the future all freshman females in STEM can be engaged. The freshmen were asked their major, interests on and off campus, and describing their personality in three words. In addition, they were asked what they hoped to get involved in, and their goals for their college experience. Forty-five (45) freshmen responded (50% of the women in the WISE program).

The program coordinator sorted mentors and mentees first according to majors and then interests and involvements. Personality was considered into the pairings as well. Not all matches were perfect, but pairing was optimized as best as possible. Overall, there are 40 active pairings.

The program coordinator notified the mentors of their mentees and instructed them to meet with their mentee once a month in a setting that suited their personalities and schedules. Suggestions for meetings included coffee, lunch, walk, or a similar activity. Emails offered suggestions of topics to cover such as:

- October: introductions, classes and scheduling, professors
- November: roommates, clubs and campus involvement, Thanksgiving
- December: tackling finals week stress, transitioning living back home after living in college, Christmas break

The goal of one-on-one mentoring is to create an organic, natural, comfortable setting. To encourage involvement, the pairings were incentivized to take a picture together and to enter a contest of which three pairings took the most creative, silliest, or interesting pictures to win prizes. The prizes were giant matching Dayton cups from the bookstore, chosen due to their practicality, fun colors, and having a matching partner.

3.2 Group-Mentorship

The pilot program emphasizes group mentoring along with one-on-one mentoring. Group mentoring fosters collaboration and communication among a wide range of ages, majors, and involvements. Group mentoring provides a space for mentors to assist other mentees and share their story. In addition, it allows mentees to get other advice from other mentors, especially in areas their mentor may not intersect. Overall, group mentoring creates community and nurtures the sense of belonging among females in STEM. Members feel like they are a part of something larger than just themselves and recognize they are not alone.

The group mentoring participants are the same students engaged in the one-on-one mentoring. The first group mentoring event kicked off in September to provide information and social opportunities. Mentors arrived a half hour before and were briefed on their expectations for participating in the program. When the freshmen arrived, everyone was shown a 20-minute

overview of the program, which emphasized the importance of mentorship, inclusivity, and expectations of engagement. Overall, members were forced to recognize their commitment to their mentee or mentor for the year and realize the value they receive from the program will be equivalent to the amount of effort they put in. Then, members ate pizza and engaged with other members of various ages on how the start of the semester was going. The purpose was to introduce the program and create an inclusive, social environment to foster the sense of community and belonging. Approximately 50 students attended, including the mentors and mentees, and the energy of the event was positive, engaged and excited for the program.

The second group mentoring event occurred in November and focused on Imposter Syndrome. Two professors spoke and provided a 40-minute lecture on the Imposter Syndrome and ways to overcome it. Imposter syndrome is where one feels inadequate or incompetent despite obvious success in their field. This is common among females in male-dominated fields. The speakers emphasized the importance of recognizing imposter syndrome and ways to boost confidence, such as confiding with fellow female peers and recognizing you are not alone. Approximately 40 students attended, and verbal feedback was positive and stimulated productive conversations.

The third group mentoring event occurs in February and will be a breakfast with the women faculty in STEM. Students can attend whenever to eat breakfast and interact with other mentors and mentees, along with professors and staff. The goal is to provide students the opportunity to network and converse with female faculty, giving the ability to visualize life beyond college. In addition, it provides students the opportunity to interact with their peers of all ages, fostering the sense of belonging and community.

The fourth group mentoring event will be on fostering passions in career paths and how to start building a resume and other professional tips.

The success of the pilot program will be assessed in three ways: 1) number of mentor/mentee pairs starting the program, compared to the initial number interested; 2) through mentor and mentee reflections 3) mentor/mentee engagement.

4. Results

There were 44 matches of mentor/mentees matches at the start of the program, for a total of 89 females involved. A survey was sent out at the end of the first semester to gage program success. The survey inquired how the match was going, frequency of meetings, topics wanted to cover in group events, and other feedback for the program. Out of the original pairings, about 40 are actively engaged in the program, determined by survey responses.

The feedback was overwhelmingly positive and contained constructive critique. In the three months of the program, 45% of the people have met one-on-one more than twice, 36.7% met once, and only 2% had not met yet. When asked how the partnership was going, 51% replied “good”, 30.6% replied “perfect”, and only 6% replied unsatisfactory, as shown in the Figure 2.

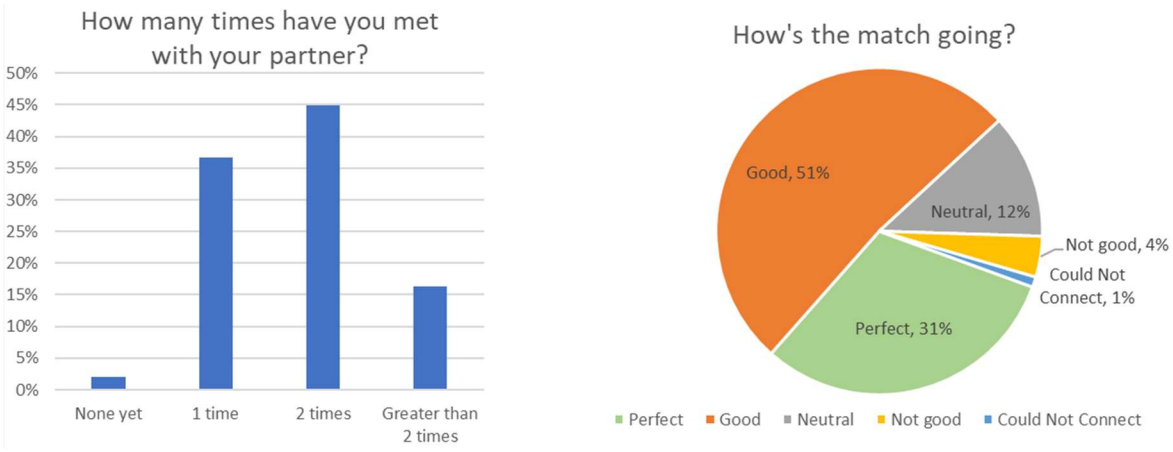

Figure 2: Results of After Semester Survey

Overall, responses to the survey were positive and encouraging, expressing enthusiasm and a desire for the program to continue, as shown below:

- *"It's nice to be able to talk to a peer that can provide me answers as she was in my shoes last year."*
- *"I think this is a great program that should continue!"*
- *"I really appreciate this program reaching out to me. It has helped me in many ways, with hearing advice about certain classes or professors."*

In addition to providing mentorship and guidance, many reported common connections with their partner and positive relationships forming. This emphasizes community building and sense of inclusivity and belonging. Examples of feedback is shown below:

- *"I think you matched it very well! We both have similar majors, interests, and even from the same hometown"*
- *"We're a bit different and are both introverted but we've definitely found ways to connect"*
- *"I love my mentee! We've met up to bake fall treats and studied for finals together".*
- *"We both have pretty busy schedules, so it is hard to meet up, but it is good to keep in contact"*
- *"She is super helpful and sweet!"*
- *"We're a good fit! I like my mentor a lot, she is interested in the same things as me and it is nice to know someone who can help you decide what classes to take"*
- *"We are literally twins! I love her so much as I'm so so happy she's my partner! I love meeting with her/seeing her/ hanging with her"*

Despite overall positivity, some reported difficulties in scheduling meetings with their busy schedules or awkwardness in connecting. This is determined to be natural since friendships and relationships happen organically and scheduling times to meet can frequently be difficult. Examples of feedback is shown below:

- *"Between both of our schedules it is just hard to find time"*

- *"We met and conversation just felt really forced. I don't think our personalities mashed well"*
- *"I feel like with both of our busy schedules it makes it hard to visit just one on one."*

Many expressed a desire for more group mentoring events and opportunities to interact with the other mentor and mentee pairs.

- *"I like the program so far. I think we should do more group events/all get together and know other mentor/mentees better."*

For future group events, many reported interests in covering topics like finding passions, career options, college survival tips, handling stress, and job skills (like networking and work attire). Many expressed interest in female strengths and how to use them, stemming from the Impostor Syndrome workshop. One noteworthy mentor stated, "I would love some advice about how to be a good mentor, and not just a nice, older friend. I definitely want to make sure that my relationship is valuable for my mentee".

Based on the semester, the program coordinator believes the pilot program has been overwhelmingly successful and will continue to grow and develop in subsequent years. Building off of the pilot year, efforts can focus on recruitment, involvement, and planning group mentoring events.

5. Conclusions

The first semester of the mentoring program provided female students in STEM to create community, belongingness, and share experiences. Following research conducted in a previous study, students desire direct access, a community, and someone who understands their struggles when adjusting to school. By providing mentors to first year students, the first-year students gain direct access to a friend to help provide guidance and community. With 40 active pairings and positive feedback, the pilot program is determined to be a success. The 89 participants responded with mostly positive feedback and eagerness for the program to continue. Members also provided feedback to help foster future work as the program becomes more established. Overall, the pilot program was determined to be a success and efforts can be focused to develop trainings, recruitment, and group events in the following years.

6. Future Work

This paper described the methodology of piloting a mentoring program for women in STEM. Future work entails analyzing the retention rate of members of the program and establishing future group mentoring events. As the first year of the program, many improvements will be made to the methodology, identified by the coordinators and participants. First, recruitment will be expanded to other clubs and departments outside of the WISE program and female engineering groups. This will help to ensure that the program reaches all of those qualified to participate. In addition, coordinators will recruit members more heavily to increase involvement.

The program will be started faster and earlier in the semester to retain interest and enthusiasm of the program. More group mentoring events will be provided for more opportunities for mentors and mentees to get to know each other rather than just four in a year. Mentors will be provided an in-depth mentoring training to help them be a good mentor and not just a nice older friend. Such training may consist of a longer workshop or retreat exploring characteristics of effective mentors. In addition, the program will explore professional partnerships for mentoring in industry as well. As a first-year pilot program, there is much room for growth. Other areas for future research include incorporating a reference or control group to assess the program's effect on gender diversity using quantitative statistical analysis. Additionally, it is important to understand the GPA differences in mentored versus non-mentored students. Retention is also worthwhile to investigate, although at the University, the women who start in engineering do tend to remain in engineering, so recruitment of additional women could also be an area of interest. Some additional qualitative measures would be to assess whether the mentoring program increased the mentee's confidence in STEM and a sense of belonging.

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