Brewing Change: A Forum for Women in Engineering and the Sciences

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Abstract:

A recent focus in engineering education has been gender disparity within engineering. Students are more apt to continue with the discipline if we engage them early and in innovative ways. This paper details a weekly discussion group for women in the sciences and engineering on the small campus of a major university (Penn State Greater Allegheny). Participants were invited to the discussion group to talk about their experiences as women in these traditionally underrepresented areas. The group was provided with journals for recording their experiences as well a weekly prompt for discussion. The goal of this discussion area was to provide a friendly and open forum for discussion about gender issues. Participants valued the forum as a place to speak and hear about the experiences of female faculty who may have faced similar issues as well as way to connect with their peers in the discipline.

Introduction:

Gender disparity in education has been an important topic in recent years, particularly in STEM education. Women in STEM fields make up only about 30% of the workforce, and data has shown that a disproportionate number of women leave the field after only a few years[1]. Other studies have presented data that supports the hypothesis that girls lose interest in mathematics and science between grades 6 through 8, due to a lack of support and available female role models [2]. Young women entering these fields at college have been shown to benefit from mentoring and collaboration efforts, which help them become strong problem solvers and gain the confidence needed to succeed and remain in the workforce.

This paper details the initial observations of a weekly discussion group of young women in the sciences and engineering. Participants were from a single small campus affiliated with a major university (Penn State Greater Allegheny). Student participation in the group was entirely voluntary. Our student pool is primarily first year, first generation college students. As it is a small campus, the total number of students involved in the project is not large (~20), and students are primarily freshman and sophomore level.

Each meeting, participants were given a discussion prompt which related to a current topic in engineering. Some were specific to the female experience in engineering, such as how to approach a superior with a problem, while others were more broad, such as how to give an effective presentation. Topics were determined from a wide variety of sources, such as the Society of Women Engineers, American Association of University Women, and Association for Women in Mathematics. The campus is fortunate to be well represented with women in the sciences and engineering; professors from all disciplines serve as facilitators for the group.

Background:

There are initiatives on other campuses and with other groups to increase the involvement and retention of women in the sciences and engineering, including OXIDE (Open Chemistry

Collaborative in Diversity Equity), a diversity equity initiative cofounded by the National Science Foundation, the National Institutes of Health, and the Department of Energy [3]. In addition to OXIDE, other initiatives aimed at addressing the gender gap include the NSF ADVANCE grants to increase the participation and advancement of women in academic science and engineering careers, and COACh, a grassroots organization offering career building workshops and other programs to help women succeed[3]. Similar discussion groups to support young women in STEM career paths exist as well. WSTEM at UC Merced brings together undergraduate and graduate students, postdoctoral researchers, professors and staff members of both genders [4]. Formed in 2015, the organization sponsors monthly events such as panel discussions and workshops, and also offers mentoring opportunities to help improve the representation of women in STEM disciplines [4]. At Penn State there is a large and active chapter of the Association for Women in Science (AWIS) which matches undergraduates with mentors and helps those involved apply for scholarships and internships. In addition to AWIS, Penn State also offers housing in the Women in the Sciences and Engineering (WISE) house. WISE House is a female only special living option for undergraduate students who are majoring in science, technology, engineering, and mathematics (STEM)[5]. WISE House is designed to provide students with an opportunity to network with experienced professionals, receive mentoring, develop and build leadership skills, and engage in outreach within the State College community while developing relationships with fellow female classmates[5]. As part of residency in WISE House, students are invited to attend professional conferences that are designed to help women discover how professional women in the sciences balance their education, careers, and personal lives. Another program, BRAID (Building, Recruiting and Inclusion for Diversity), started by Harvey Mudd College in Claremont, California focuses on promoting women and minorities in computer science at other institutions. Fifteen universities, from Arizona State to the University of Vermont, are taking part and receiving funding from the tech industry to send female students to women-in-computing conferences [6].

Women earned 57.3% of bachelor's degrees in all fields in 2013 and 50.3% of science and engineering bachelor's degrees. However, women's participation in science and engineering at the undergraduate level significantly differs by specific field of study. While women receive over half of bachelor's degrees awarded in the biological sciences, they receive far fewer in the computer sciences (17.9%), engineering (19.3%), physical sciences (39%) and mathematics (43.1%) [1]. Other data from the Census Bureau's 2009 American Community Survey (ACS), says that women comprise 48 percent of the U.S. workforce but just 24 percent of STEM workers [1]. In other words, half as many women are working in STEM jobs as one might expect if gender representation in STEM professions mirrored the overall workforce. There were 2.5 million college-educated working women with STEM degrees in 2009 compared with 6.7 million men. What makes this disparity even more alarming is that, in the overall labor force, there are 21.4 million women (49 percent of the total) and 22.2 million men who are employed and have bachelor's degrees [1].

More than twice as many men than women attend graduate school for computer science fields, and more than four times as many men are enrolled in engineering, according to the 2016 NSF Science and Engineering Indicators report. All of these factors together make up a gender gap between women and men in STEM [7].

Retention is another area where the gender disparity in STEM is evident. Jennifer Hunt of Rutgers has studied women who exit the science and engineering fields. In most fields of science, she found, the exit rate for female engineers is much higher than in other scientific fields[8]. And the more male the field, the more women are likely to leave, her data shows [8]. A lack of female mentors, subtle discrimination or work conditions in which men talk in a way that women found disrespectful were also common factors [8]. The requirements for doing well in certain scientific fields don't fit with the attributes women are considered to have, another researcher, Madeline Heilman said. "And if they do get in, they're ostracized, sidelined and seen as unlikeable, and that makes it unpleasant to stay.[9]"

Females are equally qualified as males in STEM; study has shown that female students participate in high level mathematics and science courses at similar rates as their male peers, with the exception of computer science and engineering[7]. The rates of science and engineering course taking for girls/women shift at the undergraduate level and gender disparities begin to emerge, especially for minority women [7]. Programs to level the playing field can help combat those disparities. For instance, inclusion of service learning has also been shown to increase retention of women and underrepresented minorities in engineering [10,11]. Other approaches such as pairing female students with mentors and creating discussion groups that explore diversity and inclusion have also been shown to help, as was done in this study.

Methodology:

Participants shared experiences during weekly discussion and through journaling about how gender norms in engineering and the sciences tend to reflect masculine values, experiences and life situations. Through these discussions, participants learned to address underlying assumptions, norms, and practices to change the culture for all members, men and women. The initiative was assessed by participant engagement with the topics and qualitative journal responses to the discussion prompts.
Our effort for this project consists of two main goals:

Goal 1: To encourage female students to remain in STEM fields through supportive dialogue.

Goal 2: To promote collaboration, self-efficacy and leadership while providing strategies for females to change the culture.

Each of these goals are in line with new ABET criteria focused on educating the "whole engineer." To measure our progress toward these goals, we have begun to capture student engagement via qualitative journal responses. In the future, we plan an additional survey and a limited number of interviews about the project. Journal data is derived from written comments to a series of statements reflecting on the project. Figure 1 shows an example journal topic.

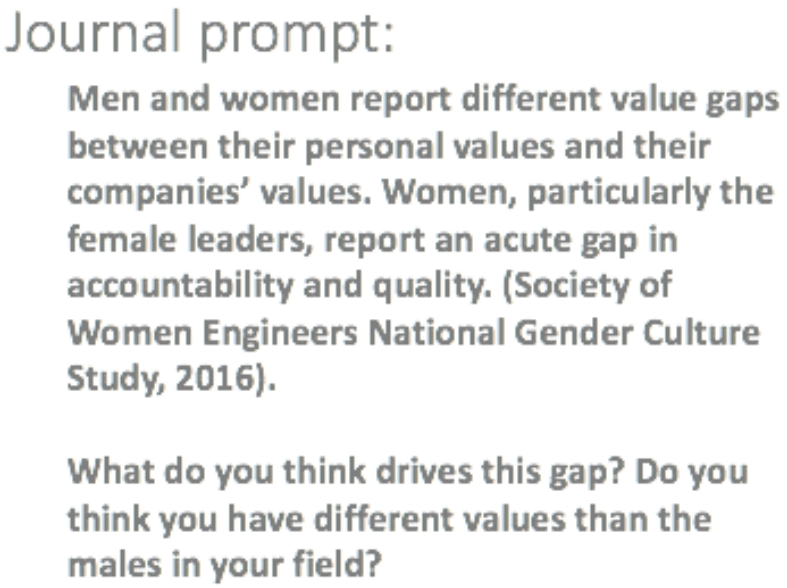

Figure 1: Example journal prompt

Participants were gathered from both engineering and science students in the first or second year of undergraduate education. As the campus is small, the target audience for the group was broadened beyond engineering to include all of the disciplines in STEM. For this project, our goals for student experience primarily encompass Goals 1 and 2. Specifically, we hope to provide students with a support for progression in STEM fields by providing a platform for addressing assumptions and experience in those fields. We are fortunate in that the goals expressed above are also reflected in the goals embraced by the greatest university community with respect to engagement and student retention. At the conclusion of the project we will compile the data generated along with student reflections to determine if our goals have been achieved.

As part of Goal #1, we plan to track those students involved in the group to determine if they remain in STEM through graduation. As this project is in beginning phases, we do not yet have data for this Goal. For Goal #2, we have provided students with tools and techniques to support their efforts to change the culture for females in engineering and science. During discussion, students identified several techniques which they thought would be most useful to accomplish Goal #2. Avenues selected included pairing female students with a female mentor, providing collaboration space to work on homework, and promoting leadership roles in student organizations. To expand on the idea of female lead organizations, it was also suggested the students hold workshops prior to meetings discussing elements of leadership. The students identified several topics for leadership including networking, public speaking, and management. Following these workshops, participants will be surveyed and asked to reflect in order to identify shifts in attitude, thinking and efficacy of training. Findings from all assessments and reflections will be compiled into a document detailing the impact of this project at its conclusion.

Themes that emanated from the data (both written and discussed informally) were varied. Students identified several factors that lead them into the discipline. Some ideas delineated were a feeling that engineering is a positive profession, liking math and science from an early age, having experiences of attending math and science camps or learning and practicing engineering at a young age. As two example priorities for success, the group identified taking advantage of opportunities for training and education such as internships as being important to further their success, and the importance of mentoring in developing networks and supporting one another. Finally, the women involved in this cohort expressed intentions to persist in their majors while pursuing expertise and experience in their individual engineering fields.

Continuing work:

This project is the launch pad for tackling gender disparity in engineering and science through support and education on our campus. It will provide a knowledge base useful to other educators and directions of future educational development. This project will also build links for future projects while empowering underrepresented groups in both engineering and other disciplines. Initial take-aways from the project are that students felt more engaged with other females in their discipline than through traditional avenues such as classes, benefited from positive experiences with those outside their social sphere, and felt that the project enhanced their understanding of gender disparity in an innovative manner. At the conclusion of the project all survey data and material from reflections will be compiled to determine the effectiveness of this project in reaching the expressed goals.

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