2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
ASEE
Paper ID #40198

Work In Progress: Exploring the Impact of a Mentoring Structure on Female Persistence in Engineering

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Work in Progress: Exploring the Persistence of Female Students in Engineering through Structured Mentorship

Abstract

This Work in Progress paper describes a mentorship structure to support the professional formation of engineers that advance the science of mentorship, retention, diversity, and inclusive (DI) perspectives in engineering. According to the National Student Clearinghouse Research Center, the overall persistence rate improved as first-time in college (FTIC) students declined sharply by 9.9% in 2021. The National Center for Science and Engineering Statistics (NCSES) 2023 diversity and STEM reports show the representation of women reached 35% in 2021, a 3% increase from 2011 data. Though successes have been made in the past decade to increase the number of female students in STEM, their persistence rate is still low due to factors like lack of confidence, self-efficacy, and their definition of success. Mentoring plays an important role in college success depending on the mentor's level of self-efficacy, cultural responsiveness, and the process for matching mentors to mentees (surface or deep-level similarities). An effective mentorship structure supports the mentee's growth and development by using multiple mentors for academic, career, and psychosocial support functions.

For the mentees, a buy-in on the mentor's credibility is necessary to understand the mentor's motivation for sharing information and experiences. Could similar social and cultural identities promote trustworthiness in female engineering students? For mentees from underrepresented and underserved populations, the social-psychological concept of a mentor's credibility might be critical to hone from the onset of each mentoring relationship to foster a sense of expectancy and candidness that promotes retention. The FTIC population, especially women, experience culture shock and lack of mentorship. They struggle with their engineering identities, and most lack how to navigate higher education bureaucracy. This study investigates the impact of a guided mentoring relationship on female students' academic progression in the college of engineering at the University of South Florida. FTIC female undergraduates are paired with third-year female peer mentors and are provided with structured discussions and modules that impact mentees learning and sociocultural awareness. It is anticipated that the study would reveal a possible pathway for increased persistence of females in STEM and DI practices and potentially help create a national systemic mentoring program that addresses academic disparities in STEM education for FTIC students alongside historically underrepresented and underserved populations.

Introduction

The persistence rate of undergraduate females in STEM consistently ranks higher than their male counterparts [1, 2]. Since the 1950s, the engineering curriculum involved foundational mathematics and science gateway courses that led to student attrition [1-5]. Some broad factors

for student attrition across multiple universities include academic climate, self-efficacy, self-perception, ineffective study skills, cultural background, ethnicity, race, and gender [1, 2, 5-14]. Students' inability to persist in their engineering majors leads to a lack of motivation, self-doubt, and loss of self-confidence [14]. The notion of "weed out" courses promoted by faculty and their attitudes is a major factor in student attrition rates [5, 15, 16]. The attrition rates are even higher for first-time in college (FTIC) female students who struggle to navigate college success and have a different definition of academic success [9, 17]. In contrast, the underrepresented minorities (URM) population among the FTIC students encounter additional barriers like stereotype threat, microaggressions, impostor syndrome, and lack of social connectedness [18].

Mentoring practices play an important role in students' academic success and retention, especially females [7]. In academic settings, the mentoring approach involves applying standards and experiences to professionally and academically inspire individual growth and development. [17, 19]. Mentorship is only effective if the mentees' experience achievement, engagement, and motivation [8]. Studies have correlated effective mentoring to the employed mentoring structures, the shared common interests between the mentor and mentee, and their self-efficacy levels [8, 20-24]. The mentor's self-efficacy can determine the success of the mentoring relationship and how the mentee views themselves. Alternatively, ineffective mentoring occurs through a lack of trained mentors, culturally irresponsive mentors, identity interference, or mixed-match pairing, all of which can lead to psychosocial consequences [22, 25-27].

Mentorship structures could take the form of a dyad or triad structure involving peers, faculty, staff, alums, industry partners, and professional mentors [22, 28]. Effective mentoring is observed in mentoring structures that synergistically pair mentors with a mentee with similar social and cultural identities. Mentees' self-efficacy improved, and their STEM identities were impacted positively [8, 24, 29, 30]. The dichotomy of mentoring models to perceived outcomes is an area this proposed research seeks to explore. Can the desired outcome of improving female persistence data in STEM be facilitated by investigating mentorship best practices? What mentorship model needs to be implemented and how? The answers to these questions are critical to understanding the correlations between mentorship and persistence.

Effective mentorship models are multifaceted in practice. A mentorship triad structure involving hierarchical mentors can bring out mentees' full potential, leading to a holistic outcome [19, 28, 31]. Likewise, mentees paired with peer mentors a few semesters ahead can realize a nascent realistic psychosocial support and acquire close perspectives into their respective STEM fields [7, 19, 20, 32-35]. On the other hand, faculty mentors can provide a holistic service of support from the perspective of their position to guide students' career plans and development. A mentorship ecosystem is what students need to thrive in academia. All these influential guides can provide

mentees with increased self-efficacy levels in STEM and entrance into a realistic pathway to accomplish their academic engineering goals.

Consequentially, the structural design of mentoring processes and implementation do not go without imperceptibly unknowns. In pairing, there are seldomly suitable identifiable matches based on social and cultural identities. This sociocultural factor inevitably provides salient connections and psychosocial support, helps strengthen STEM identity, commitment, and overall guide the mentee's interpersonal development [36-40]. However, the correlation of this sociocultural responsiveness to the persistence of FTIC students in STEM is understudied. Can mentorship alone, role modeling, and emotional support be the sole solution to improve female STEM persistence? No. However, the institutional process will need to be situated with other entities that can build and foster an inclusive environment through intentional student success practices and curriculum development or modifications.

Given the promising outcomes of mentoring, its success relies on its implementation, structure, and stakeholders [17]. Mentors should be formally trained to recognize students' potential, be stewards of change and be capacity builders through intentionality [22, 25, 27, 41]. Likewise, the mentees' ability to receive support should be a prerequisite to mentoring. Extremal effects are avoidable, so mentees do not need to exhibit the "extra-scientific effect." A condition where underrepresented students minimize their identities (race or gender) to conform to the STEM community [42].

This study investigates the relationship between mentorship and the corresponding effects on engineering persistence for FTIC female students. The existing mentorship process in engineering accounts for surface-level similarities and rarely deep-level similarities in shared values, beliefs, and interests [17, 43]; however, the underlying mechanism by which the practice of mentorship affects female persistence in engineering remains an unmet challenge. We investigate differing mentorship structures and examine their impact on multiple female FTIC populations across seven engineering disciplines at the University of South Florida (USF).

Methods

Focus group study

In the spring of 2022, seven female undergraduate student assistants from Computer Science (3), Biomedical Engineering (2), and Industrial Engineering (2) majors were interviewed. These students held a student assistant position in the first-year engineering program at USF.

I.	Why Study Engineering or Computer Science ?
II.	What has been your experience in the college of engineering with respect to academic progression?
III.	Share your successful academic experience strategies.
IV.	Discuss recommendations for staff, faculty and administrators with regards to female students in

Figure 1: Focus Group Questionaire

Their academic classifications ranged from upper freshmen (1) to juniors (3) and graduating seniors (3). Each student took turns verbalizing their responses to the questions in Figure 1.

Research Questions and Strategies

The lessons learned from conducting a focus group led to the two research questions below. This paper focuses on question #1, while #2 is underway.

1) Can we reduce the FITC female attrition rates by mentoring students on how to be successful in engineering disciplines?
    a. First-year female undergraduate FTIC students are paired with third-year academically thriving students for mentoring activities.
    b. Mentees participate in weekly mentoring sessions and monthly workshops to learn how to navigate the academic system and manage their academic responsibilities and expectations.
2) Will the development and use of integrative and engaging modules that are high-impact practices for introductory STEM courses decrease the persistence rate in the college of engineering?
    a. Supplementary modules are being developed for Calculus, Physics, and Chemistry.
    b. Students will use supporting STEM modules to augment course lectures and prepare for quizzes and exams.

Recruitment of Mentees and Mentors and Activities

Five mentors in their third year majoring in four engineering disciplines (biomedical, mechanical, electrical, and chemical engineering) with a GPA above 3.5 were recruited. The first cohort of mentees was eight students from four engineering disciplines. These students were selected from the pool of FTIC incoming first-year students who had the potential to persist as predicted by the University's student success Learning Analytics software. The second cohort of mentees utilized an application process with the listed questions in Figure 2. Both non-FTIC and FTIC female students applied, and 81 % of the second cohort were FTIC students, comprising 20 students in the program (16 students from the second cohort).

I.	Identification and background questions
II.	What do you want to gain from the mentorship program?
III.	What would you like your prospective mentor to

Figure 2: Mentee Questionaire

Mentees are required to meet with their peer mentors at least once a week for academic support and tutoring as necessary. Monthly, mentees meet in groups with other mentees, mentors, and a female faculty. Students (mentees and mentors) selected for this study were required to document their experiences using journal entries, hold weekly meetings, share academic goals, and participate in reflection exercises and program activities. Monthly workshops covered professional

and academic goal-setting topics, vision boarding, scholarship, study abroad, internship, and research information sessions.

Mentees Feedback: Mentees share their experiences about feeling safe and confident as they journey through the rigor of academic life.

***Mentoring Structure, Relationship, and Mentors Feedback*:** The mentors serve two roles, mentoring and tutoring their mentees. The vision boarding session was well attended; students bonded with their mentors and freely shared their academic and personal goals. Mentors help students with course registration, advising, proofreading essays, building a project, finding jobs, researching labs, or applying for scholarships. During exams, mentors held office hours and shared study skills and their best practices. All mentees and mentors have access to each other through the GroupMe App. Mentors are coached by faculty monthly on how to support their mentees.

Discussion and Results

Lessons Learned from the Focus Group. The focus group session revealed strategies that could help female students persist and thrive in the college of engineering. All participants provided two recommendations. The first was to foster study groups to better prepare for courses and expand resources. The second was to create a peer mentoring community for female students in engineering and computing. These students want female role models in their fields as their mentors. Sadly, students (80%) in this group did not feel a sense of belonging due to their classroom experiences with their male counterparts, professors, and TAs. Unanimous, these students suggested DEI training for all TAs and faculty. The discussion suggests that female FTICs can benefit from intentional mentoring activities from their peers, academic staff, faculty, and industry mentors with cross-sectional sociocultural identities.

Summary of Mentees Application entries. Over 57 mentees (first-year students) responded with a need for mentors. Notably, the students wanted a guide on navigating their academic responsibilities, acquiring professional experiences, and developing interpersonal skills. In the responses to the part III question of Figure 2, students shared their hobbies, personality type, jobs, goals, and ethnicities. Below are selected responses from students to the part II question in Figure 2:

“As a student of Mechanical Engineering, I would be thrilled to have the opportunity to participate in the Women Engineer Mentorship Program. This program provides a unique and valuable opportunity for me to develop professionally, academically, and personally as a woman in a predominantly male-dominated field. My primary objectives for this program are to receive guidance and support from an experienced mentor in Mechanical Engineering. I am eager to learn from their experiences, challenges, and successes, particularly as a woman in this field.”

“I’m looking for the guidance and advices in my classes because I feel a bit confused and having some hardships with them.”

“I want to build connections with an upperclassmen that can give me advice on classes, preferred professors, applying to internships/co-ops. Having someone to consistently look to for help, will help me organize my life and not feel super in the dark and overwhelmed with difficult classes and summer responsibilities.”

“I want to learn about other girls experiences and tips to succeed in the engineering field as a woman.”

Outlook. This research is still in its infancy, so rubrics and coding are being developed to support quantitative and qualitative assessments. The impact of the mentoring structure and program will be analyzed in year two after a second cohort of students has entered the program.

Acknowledgment
This work is supported by funds from the Alfred P. Sloan Scholars Mentoring Network (SSMN) career award and the Women Leadership & Philanthropic Dr. Kathleen Moore Faculty Excellence award.

Conclusion
The mentorship structure for first-time college women at USF has allowed students to acquire core competencies and skills development needed to thrive academically and prepare for engineering careers. Students’ self-efficacy for engineering aspirations is increasing with the strategic engagement with mentors from similar social and cultural perspectives. Thus this new mentorship structure seems promising for establishing a pathway for a culture of inclusive excellence for women in STEM entering the workforce.

Future work includes examining the persistence data after year one of the first cohorts of students in the program. And building a mentoring circle structure that consists of peer mentors, engineering faculty, academic staff mentors/coaches, and industry members who identify as females. Survey instruments that investigate students’ perceived impact on their mentoring relationship and sense of belonging in engineering will be evaluated along with the desire to continue pursuing engineering. An increase in the number of FTIC female students and pairing with a mentor, faculty, staff, and industry mentor will be evaluated at a 5:1 pairing ratio (mentees to mentor) for the duration of the study.

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