Understanding Participant Engagement in a Large-Scale Mentoring Program for Women Undergraduate Engineering Students

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Abstract

There is a lack of representation of women in engineering throughout all academic levels, with less than 30% of women earning bachelor's degrees, and in the workforce, where less than 20% of working engineers identify as women. Commonly identified reasons for the disparity between men and women in the field include gender stereotyping, the lack of representation, and the absence of same-gendered mentorship opportunities.

The Purdue University Women in Engineering Program has been offering mentoring opportunities for women undergraduate students since 1993. The first cohort consisted of 50 participants in paired peer mentoring relationships, where First-Year students were paired with upperclass students. Now, three decades later, the program offers support, affirmation, and strategies to more than 1,000 participants through a network mentoring model where all participants (undergraduate women engineering students) can learn from one another.

This research paper analyzed the data for the 2022-2023 cohort and used the MUSIC (eMpowerment, Usefulness, Success, Interest, and Caring) model of motivation as a basis to understand 93 participants' external motivation for engagement with the mentoring activities based on academic classification (First-Year, Sophomore, Junior, Senior) and type of mentoring relationship.

Introduction and Background

Women in STEM (Science, Technology, Engineering, and Mathematics) fields face negative stereotypes that cast doubt on their abilities, leading to a decreased sense of self-efficacy that negatively affects the retention and success of women [1]. This decreased sense of self-efficacy is exacerbated by both the lack of similar peers and role models, which creates a reduced sense of belonging that discourages the participation of underrepresented groups, like women, in STEM [2]. Therefore, prioritizing effective retention strategies is essential for transforming the current environment for women in STEM fields. A particularly effective retention strategy is to expose women to positive role models through mentoring programs especially when women first enter the university [1]. Career planning, enhanced engagement activities, and elevated academic support have also been shown to be effective retention strategies [3]. The current study reports on the impact of a formal peer mentoring program that supports women undergraduates from the College of Engineering.

Mentoring Undergraduate Students

In this work, we define mentoring as a dynamic relationship in which a more skilled or experienced individual (mentor) offers guidance and support to a less experienced individual (mentee) [4, 5]. At the undergraduate level, mentorship often encompasses several active support roles: psycho-social-emotional support (such as counseling and guidance), instrumental support (including skill development and opportunities for advancement), and collaborative experiences (such as coauthoring publications) [6]. The 2019 National Academy of Sciences, Engineering, and Medicine report supported the efficacy of mentoring programs at the undergraduate level, showing that students with a mentor are more likely to succeed in their major. Moreover, they found that women mentees who were paired with women mentors had a higher chance of a positive experience in the workplace due to the shared relational struggles faced [7]. These positive impacts can be explained by the stereotype inoculation model, according to which interactions with role models combat the negative stereotypes causing women to undermine their abilities [8].

While different types of mentoring approaches exist, this work focuses on peer mentoring. In this type of approach, participants have similar ages, experiences, and ranks. This fosters a more relaxed and supportive mentor-mentee relationship built on mutual understanding [9]. Cho and Lee [10] studied participant satisfaction with a peer mentoring program and evaluated its appropriateness, outcomes, and benefits. Satisfaction scores ranged from 3.5 to 3.9 on a 5-point scale, with no significant difference between mentors and mentees. Overall, participants were satisfied, citing academic and non-academic benefits, such as emotional support and improved relationships. Fox and Stevenson [11] reported similar results when examining the effectiveness of peer mentoring among accounting and finance students, where third-year mentors assisted First-Year mentees. The Fox and Stevenson [11] program aimed to enhance academic performance and develop transferable skills through semi-formal tutorials and meetings. Results indicated that mentoring positively impacted academic performance, with mentors and mentees reporting significant benefits. Bhatia and Amati [12]'s study of a peer mentoring program for women graduate students in science and engineering shows that the benefits of peer mentoring can also be applied beyond the undergraduate level, where there is a lack of role models available due to the progressive decrease in the representation of women at higher levels of engineering education. However, it is important to emphasize that the choice of mentor in peer mentoring relationships plays a crucial role in positively impacting STEM retention. As Dennehy and Dasgupta [13] reported in their study comparing different mentors for women engineering students, women mentors—unlike their male counterparts—had a positive impact on fostering and maintaining a sense of belonging in engineering, enhancing self-efficacy, motivation, and desire to pursue higher education.

The Mentoring Program

The Mentees & Mentors Mentoring Program (M&M) was developed in 1993 to foster community and improve retention among women undergraduate engineering students through peer mentoring. Over the past 30+ years, the program has gone through several iterations in the way it offers mentoring to the participants. Originally, the program created mentoring pairs by matching First-Year students with upperclass students in the same major (called a pair program). As participation increased, a second mentoring program was created around a network mentoring model (called a group program). The network mentoring model is based on the philosophy that participants can choose to act as a mentor or mentee in a given situation based on their comfort

level and lived experiences. Beginning in Fall 2021, these two individual programs were merged (see Figure 1 that shows the participation since Fall 2006). All participants are in the network mentoring (group) program and can choose to participate in the one-to-one (paired) program, where First-Year students are paired with upperclass students in the same major.

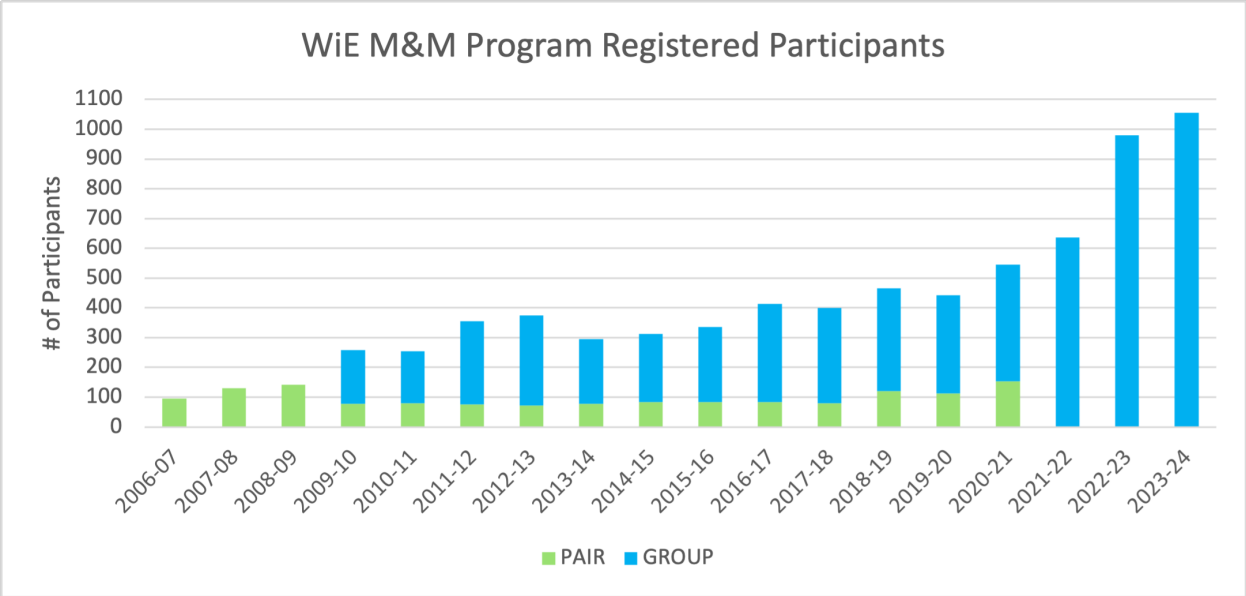

Figure 1: Number of registered participants in the pair and group programs over time.

Students enrolled in M&M can participate in intentionally designed events and programs for professional and personal development and community building. The program's core is the Monthly Meeting, where participants are encouraged to engage in discussions and activities around a common topic to learn strategies for success, build confidence through affirmation, and enhance personal support through community building. Monthly Meeting topics focus on professional and personal development and are determined annually. Examples of past meeting topics include interviewing skills, negotiating job offers, career pathways after graduation, personal finance, and mental wellness. These evening meetings are held in person for 1.5 hours. In addition, social events are offered monthly for participants to continue to expand their networks while providing a break from classes and coursework.

All registered participants can choose to also participate in the one-to-one paired program. First-Year students are mentees, and they are paired with an upperclass student in the same major who acts as their mentor. All one-to-one participants are required to attend training and orientation at the beginning of the academic year, and mentoring resources are provided using the institution's course management software. Additionally, organized social activities are offered to one-to-one participants to encourage pair bonding and growth. Finally, all pairs are encouraged to meet weekly to develop their mentoring relationship. For more information about the program organization, see Appendix A and the website visit https://engineering.purdue.edu/WIE/.

Methods

Research Question

The following research questions guided this work:

- How does academic classification (First-Year, Sophomore, Junior, Senior) influence motivation factors (specifically, usefulness and empowerment) for participation in mentoring activities?
- Do one-to-one mentoring relationships offer additional motivation to participants compared to network-mentoring?

Participants

This study used the data obtained from the 2022-2023 cohort, which consisted of 743 students in the network mentoring program that participated in at least one activity during the academic year. A total of 93 (12.5%) completed the End-of-Year programmatic survey with 56 of those also choosing to participate in the one-to-one portion of the program. Within the one-to-one respondents, 14 self-identified as mentors, 41 as mentees, and one did not provide information. The remaining 37 surveyed participants were only part of the network mentoring (group) program. Participant distribution is based on academic classification, with 57 First-Year and 36 upperclass undergraduate students (Figure 2).

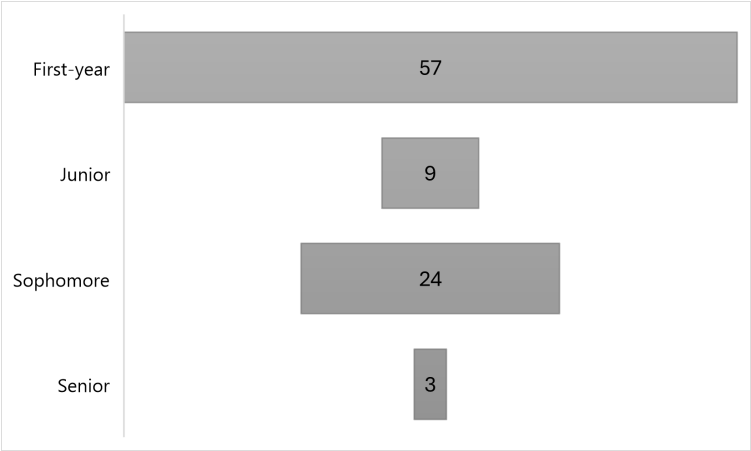

Figure 2: Participant's distribution based on academic classification.

Data Collection and Assessment Tool

The assessment tool was designed using the MUSIC (eMpowerment, Usefulness, Success, Interest, and Caring) Model of Motivation variables. This model is based on research that explains the factors that intervene in people's motivation to engage in activities [14]. In this work, motivation is defined as an individual intention to engage in an activity [15]. This model uses five perceptions (eMpowerment, Usefulness, Success, Interest, and Caring) that work together to create a positive motivation climate for an individual [14, 15].

For program improvement purposes, data has been collected from participants since 2007. Over the years, the assessment tool has evolved based on evaluation metrics. To that end, the Music Model

was introduced in 2020 to assess motivation. The current instrument had 13 programmatic-relevant questions: seven open-ended and six close-ended. This study explores two of these questions (Table 1) that cover two perceptions of the Music Model (Usefulness and Empowerment). The analysis of the remaining perceptions required a qualitative approach, which falls beyond the scope of this study.

Data collection occurred at the end of the spring semester of 2023.

Table 1: Data collection instrument, questions under study.

	Question			
1	The goals of the program are to provide strategies, affirmation, and support to the participants. Please rate these three goals below.	1a	Strategies: Have you learned strategies to help you thrive in college, successfully complete your engineering degree, and prepare for your future endeavors?	Usefulness
		1b	Affirmation: Have you gained confidence in your skills?	Usefulness
		1c	Support: Have you found personal support through female role models (including peers, alumni, and industry partners), and the interactive, mutually-beneficial peer mentoring program?	Usefulness
2	How would you rate your contributions to the program in the following areas:	2a	Taking initiative to meet new people	Empowerment
		2b	Participation in discussions	Empowerment
		2c	Actively listening to others	Empowerment
		2d	Engagement in activities	Empowerment
		2e	Putting effort into maintaining connections	Empowerment
		2f	Attending Monthly Meetings	Empowerment
		2g	Networking or de-stressing at Socials	Empowerment
		2h	Networking at programmatic alum-featured events	Empowerment

Data Analysis

Data was collected anonymously, and before starting the data analysis, each entry received a five-digit random code for internal identification of individuals.

The descriptive statistical analysis phase calculated frequencies, mean, median, mode, standard deviation (SD), minimum, and maximum for the variables of Usefulness and Empowerment. The Usefulness (1a + 1b + 1c) subquestions and the Empowerment (2a + 2b + 2c + 2d + 2e + 2f + 2g + 2h) subquestions were each consolidated to generate a unique measurement for both variable, as seen in Table 1. Individuals could rate each of the subquestions on a 5-points scale thereby generating a maximum score of 15 points for Usefulness and 40 points for Empowerment. The inferential analysis included ANOVA tests and Fisher's Least Significant Difference test using α = 0.05.

Results

Descriptive Statistics

The descriptive statistics of Usefulness by academic classification showed that Senior students rated the mentoring activities most useful, followed by Sophomore, then Junior, and finally First-Year students. These results are shown in Table 2.

Table 2: Descriptive Statistics for Usefulness by academic classification

Academic Classification	Frequency	Mean	Median	Mode	SD	Minimum	Maximum
First-Year	57	11.86	12	15	2.64	3	15
Sophomore	24	12.50	13	15	2.09	9	15
Junior	9	12.22	12	12	1.86	9	15
Senior	3	13.33	13	12	1.53	12	15

The descriptive statistics of Empowerment by academic classification showed that activities were self-reported as more empowering for Sophomore students, followed by Junior and then First-Year students. Senior students reported the activities as less empowering compared to other academic classification categories. These results are shown in Table 3.

Table 3: Descriptive Statistics for Empowerment by academic classification

Academic Classification	Frequency	Mean	Median	Mode	SD	Minimum	Maximum
First-Year	57	28.93	29	30	4.97	15	40
Sophomore	24	30.83	31	27	5.06	21	40
Junior	9	30.78	32	32	4.76	22	37
Senior	3	26.00	24	24	3.46	24	30

When analyzing Usefulness by the type of mentoring program they participated in, the one-to-one Mentors found the activities the more useful than the one-to-one Mentees. Network mentoring participants self-reported the activities as less useful. These results are summarized in Table 4.

Table 4: Descriptive Statistics for Usefulness by Mentoring Type

Mentoring Type	Frequency	Mean	Median	Mode	SD	Minimum	Maximum
one-to-one Mentee	41	12.17	12	15	2.44	3	15
Network	36	11.83	12	12	2.56	3	15
one-to-one Mentor	15	12.57	13	15	2.02	9	15

For Empowerment by the type of mentoring program, the students that participated as one-to-one Mentors found the activities more useful than the one-to-one Mentees. Network mentoring participants self-report the activities as less useful. These results are shown in Table 5.

Table 5: Descriptive Statistics for Empowerment by Mentoring Type

Mentoring Type	Frequency	Mean	Median	Mode	SD	Minimum	Maximum
one-to-one Mentee	41	29.90	30	35	5.27	15	40
Network	36	28.31	29.5	32	4.33	20	35
one-to-one Mentor	15	31.20	31	27	5.48	22	40

One-way ANOVA

- There was not a significant effect of Academic Classification on Usefulness at the $p < 0.05$ level for the four conditions [F(3, 89) = 0.67, p = 0.571].
- There was not a significant effect of Academic Classification on Empowerment at the $p < 0.05$ level for the four conditions [F(3, 89) = 1.53, p = 0.5211].
- There was not a significant effect of Mentoring Type on Usefulness at the $p < 0.05$ level for the four conditions [F(3, 89) = 0.64, p = 0.529].
- There was not a significant effect of Mentoring Type on Empowerment at the $p < 0.05$ level for the four conditions [F(3, 89) = 0.64, p = 0.529].

Discussion and Conclusions

Similar to Cho and Lee [10], participants' satisfaction levels in terms of Usefulness and Empowerment were not significantly different among one-to-one mentors, one-to-one mentees, and network mentoring participants.

Upon reviewing the results, the following conclusions were formulated:

- Among the four academic classifications, First-Year students rated the activities as the least useful. Additionally, self-reported perceptions of activity usefulness increase as students advance in their careers. This trend may be influenced by the long-term impact of the activities' topics as their significance becomes more apparent to students with more experience.
- Among the four categories of academic classification, Senior students scored the activities as less empowering. Senior students may have attended numerous program events throughout their academic journey at the institution. Moreover, as they transition into the workforce or pursue higher education, the topics may no longer align with their evolving needs.

- Similar to Fox and Stevenson [11], our results show that mentors and mentees in the one-to-one program have a positive outlook on the program's usefulness and empowerment capabilities. Participants of the network mentoring program self-reported activities as less useful and less empowering when compared to one-to-one participants. However, differences between groups were not statistically significant. This outcome may be attributed to the fewer number of activities available in the network mentoring program compared to one-on-one mentoring.

In terms of practice, the study results emphasize the importance of maintaining both types of mentoring relationships within the current program structure. Since the difference between the network mentoring participants and the one-to-one participants is not statistically significant, one-to-one mentoring should remain an optional component of the program. Additionally, the activity topics should be evaluated annually to ensure they continue to meet students' evolving needs.

Future Work

Longitudinal analysis of data will be conducted in the future. Additionally, qualitative analysis of the data collected will be conducted for the perceptual areas not analyzed in this work. Finally, pre- and post-assessments would be helpful to determine the impact of the individual activities.

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Appendix

Mentoring Program Administrative Details

The program is led by two full-time staff members and a 15-student Leadership Team (LT). The staff sets the vision, mission, and goals for the program. They also secure alumnae speakers and ensures that their talk aligns with the objectives of each meeting. The staff also oversees logistics such as securing rooms, arranging food, and ordering supplies. The student LT is comprised of five sophomores, five juniors, and five seniors. Each sophomore is paired with a senior for on-boarding and mentoring throughout their first year on the LT.

Weekly LT meetings are held to ensure that programmatic planning is on schedule. Twice-yearly retreats are held to conduct a programmatic review and discuss large-scale planning, changes, and initiatives.

To successfully execute a Monthly Meeting, the LT duties have been categorized into six areas (given below). Two LT members are assigned to each area each month, and the assignments rotate over the course of the year so that all LT members are assigned each area at least once a year.

Monthly Meeting task areas:

- Facilitator - oversees all aspects of the Monthly Meeting, including acting as the main contact for the guest speaker and planning and executing the meeting agenda
- Mentoring Minute - designs and leads the mentoring activity at the Monthly Meeting to ensure that participants have the opportunity to gain mentoring in small groups (usually in pairs or trios)
- Networking Activity - designs and leads the networking activity at the Monthly Meeting and ensures the activity follows the meeting theme, engages participants, and creates opportunities for community building
- Seating, Icebreaker, and Photos - designs the participant icebreaker, arranges seating at the meeting, and takes photos
- Evaluation and Data Analysis - updates the monthly meeting evaluation and analyzes the results post-meeting
- Food - oversees the food details and distribution at the meeting
- Floater - fills in on other roles where needed and intentionally engages with participants during meetings

Each LT member is also assigned a Special Role that they hold throughout the year that focuses on overarching programmatic issues. These are Attendance (one LT member), Program Analyst (two LT members), Communications (three LT members), Teambuilding (one LT member), Work Time (one LT member), Socials (three LT members), and One-to-One program (four LT members).

- Attendance - Prepares RSVP survey, coordinate check-in at events, and update attendance records
- Program Analyst - monitors the program data and reports conclusions from a longitudinal examination of Monthly Meeting evaluations. Prepare, execute and analyze Mid-Year and Year-End participant surveys.
- Communications - Sends weekly emails to participants announcing monthly meetings, socials, etc., manage any social media accounts, monitor program email accounts, and make regular postings to BrightSpace.
- Teambuilding - plans and facilitates monthly teambuilding activities for the LT
- Worktime - organizes work time meetings for the LT to effectively and efficiently move forward on action items.
- Socials - plans, executes, and facilitates monthly socials
- One-to-One - Organizes, executes, and facilitates mentor training and socials for the one-to-one participants, oversees engagement, and implements improvements