Supporting Graduate Women in Engineering: The Approach and Findings of a Year-Long Program at UIUC

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Supporting graduate women in engineering: approach and findings of a year-long program at UIUC

Abstract

This paper summarizes the approach and findings of a targeted, year-long orientation program in the first year of graduate school for minority genders in engineering, implemented in the Fall 2022 - Spring 2023 academic year. The program aimed to enhance the first-year graduate experience of gender minorities in engineering through several interventions: professional networking, community building, advice for finding financial support, supporting the undergraduate-to-graduate transition, and sharing strategies for navigating academia. The program achieved these interventions through a series of events and measured their impact through surveys. Findings from the programmatic effort and lessons learned are provided in this paper.

Introduction

Significant challenges have been identified in recruiting and retaining women and gender minorities in science and engineering fields for decades [1]. As of Spring of 2023, women and other gender minorities make up only 13% of Master's students, 16% of Ph.D. students, and 18% of undergraduate students in the Aerospace Engineering department at the University of Illinois at Urbana-Champaign, for example [2]. Recruitment and retention efforts for gender minorities are ongoing at every level for K-12, undergraduate, graduate, and faculty positions across academia and STEM. The efforts of the current initiative focus on the transition from undergraduate to graduate education, which was identified as one of three critical points in a woman's engineering career, defined as a time when significant numbers of women leave the field [3, 4]. The transition from undergraduate to graduate education can be a difficult transition regardless of gender. Significant differences exist between undergraduate and graduate engineering education in terms of the levels of technical expertise and independence expected of students. While it is part of most undergraduate curricula to impart fundamental knowledge, teach problem-solving skills, and develop critical thinking, as soon as one enters a graduate program, these are assumed. First-year graduate students are expected to use their technical expertise and independence in advanced-level courses and projects/scientific research, alongside older graduate students, with little mentoring or training to ease this transition. As a result, most students struggle to smoothly transition to graduate school [5, 6]. This is disproportionately worse, however, for gender (as well as other) minorities in engineering, i.e., those who identify as women, non-binary, transgender, etc., as this population must continue to simultaneously deal with barriers associated with being a minority gender (MG) in STEM [7, 8, 9, 10]. These barriers include needing to work harder to overcome or disprove gender stereotype biases while also feeling the stereotype threat, experiencing instances of microaggressions at the workplace, dealing with imposter syndrome, and experiencing both hyper-visibility (increased scrutiny) and invisibility at the same time. MGs being even more underrepresented in graduate school than at the undergraduate level only exacerbates these issues.

Orientation events, including departmental orientations and sessions for international students, are common at the start of an academic year. But studies have shown that such programs can be major sources for feelings of self-doubt and invisibility in MGs early on [10]. The present work hypothesizes that a targeted, year-long orientation program in the first year of graduate education can improve the success of MGs in engineering graduate school, where success is defined both emotionally and professionally, through three main intervention strategies. The orientation program should provide opportunities to build a cohort or feeling of community within MGs, to directly learn strategies from older graduate students for success in graduate school, and to provide exposure to resources for professional development. The details of such a program implemented at the University of Illinois Urbana-Champaign and findings on its impact are discussed in this work.

Program Overview

The program spanning the Fall 2022 - Spring 2023 academic year was titled 'GrOW: Graduate Orientation for Women and minority genders in engineering' and included 7 events, one welcome event followed by three events per semester, specifically catered to MGs in the Grainger College of Engineering at UIUC. Participants were recruited from all 12 engineering departments on campus. People of minority genders who were newly admitted to the Grainger College of Engineering (with admission in Fall 2022 or Spring 2022) were specifically invited to participate in the events, though all people were welcome. Invitations for the events were sent out 1-3 weeks before each event through graduate college newsletters and with the help of staff graduate coordinators and student volunteers from each department. Flyers were also put up on notice boards in the engineering buildings. Three surveys were conducted throughout the program: one just after the first event in the series, one at the end of the Fall 2022 semester, and the last one at the end of the Spring 2023 semester.

The program targeted three categories of intervention: belonging (B), advice and support (A), and skills and opportunities (S). The belonging intervention sought to promote a feeling of belonging in the participants through the creation of a cohort and through active and enthusiastic interaction with more senior members of the community. The advice and support intervention focused on giving more experienced members of the community opportunities to specifically give insight into common challenges in the Grainger College of Engineering and gave participants opportunities to ask specific questions and seek targeted help navigating their new environment. The skills and opportunities intervention focused on networking, securing funding, and other practical skills for academic and professional success. Each event in the series is described in Table. 1, with more details provided in the text.

1. **Welcome Orientation Day**: The welcome orientation day was a full-day event held before the beginning of the Fall 2022 semester. MGs who were newly admitted to the Grainger College of Engineering (with admission that Fall or the previous Spring semester) were invited to attend. Icebreakers, games, and socialization opportunities were built-in between talks. The day consisted of several consecutive events that were designed to target all three intervention categories: an opening welcome from the Dean of Engineering, lessons learned in graduate school from a young female faculty member, funding and fellowships workshops from the Director of Fellowships, resources from the Women's Resource Center,

Name of event	Outcomes targeted	Date held	Number of attendees
Welcome orientation day	B, A, S	08/20/2022	65
Meet the faculty	B, A, S	09/30/2022	25
Lessons learned in graduate school	A	10/28/2022	22
Navigating academia as a minority gender	A	11/30/2022	17
Implicit bias and microaggressions workshop	A, S	02/27/2023	20
Speed networking with Research Park	S	03/29/2023	20
End of year social	B	04/20/2023	30

Table 1: Events held in the program. The categories of outcomes are belonging (B), advice and support (A), and skills and opportunities (S).

resources from the Gender and Sexuality Resource Center, resources from the Graduate Employees Organization, resources from the Office of Graduate Diversity, Equity, and Inclusion, and an open-ended graduate student panel.

2. **Meet the Faculty**: This event was a 2-hour faculty-graduate student meet and greet, where female faculty members from different engineering departments were introduced to the graduate students, targeting all three interventions. Attendees interacted in a casual setting over lunch, where different aspects of graduate life were discussed including academics, research, work-life balance, professional opportunities, and funding opportunities.
3. **Lessons Learned in Graduate School**: Four senior graduate students were invited as panelists for an interactive discussion on what they wish they knew earlier in graduate school. Over lunch, students got to hear tips to succeed in their programs and unfiltered stories about life as a graduate student. This event was a collaboration with another student-led initiative on-campus for MGs in the ECE department, called the HUG (Historically Underrepresented Genders) Initiative. This event targeted the 'advice and support' intervention.
4. **Navigating Academia as a Minority Gender**: A seminar featuring a faculty member from the Grainger College of Engineering, and one of the first female faculty to be hired in her department, was held. Students were invited to have cookies and coffee while they learned about the trials and tribulations of navigating academia as a woman. This was an opportunity for graduate students to visualize their own careers as future academics and scientists. Attendees also received engineering seminar credit for the event. This event targeted the 'advice and support' intervention.
5. **Implicit Bias and Microaggressions Workshop**: A workshop on implicit bias and how to recognize and respond to microaggressions in the workplace was conducted by trained professionals from the Diversity and Social Justice Education office, targeting the 'belonging' and 'advice and support' interventions.
6. **Speed Networking with Research Park**: Students were invited to a networking event that

was exclusive to MGs in the Grainger College of Engineering, attended by representatives from companies at the Research Park at UIUC. This was an opportunity for students to secure internships and full-time jobs, as well as build long-term connections. This event fell under the 'skills and opportunities' intervention.

7. **End of Year Social**: Graduate students and faculty members who identify as one of the MGs were invited to an end-of-year social. The 'belonging' intervention was targeted.

Data Collection Methods

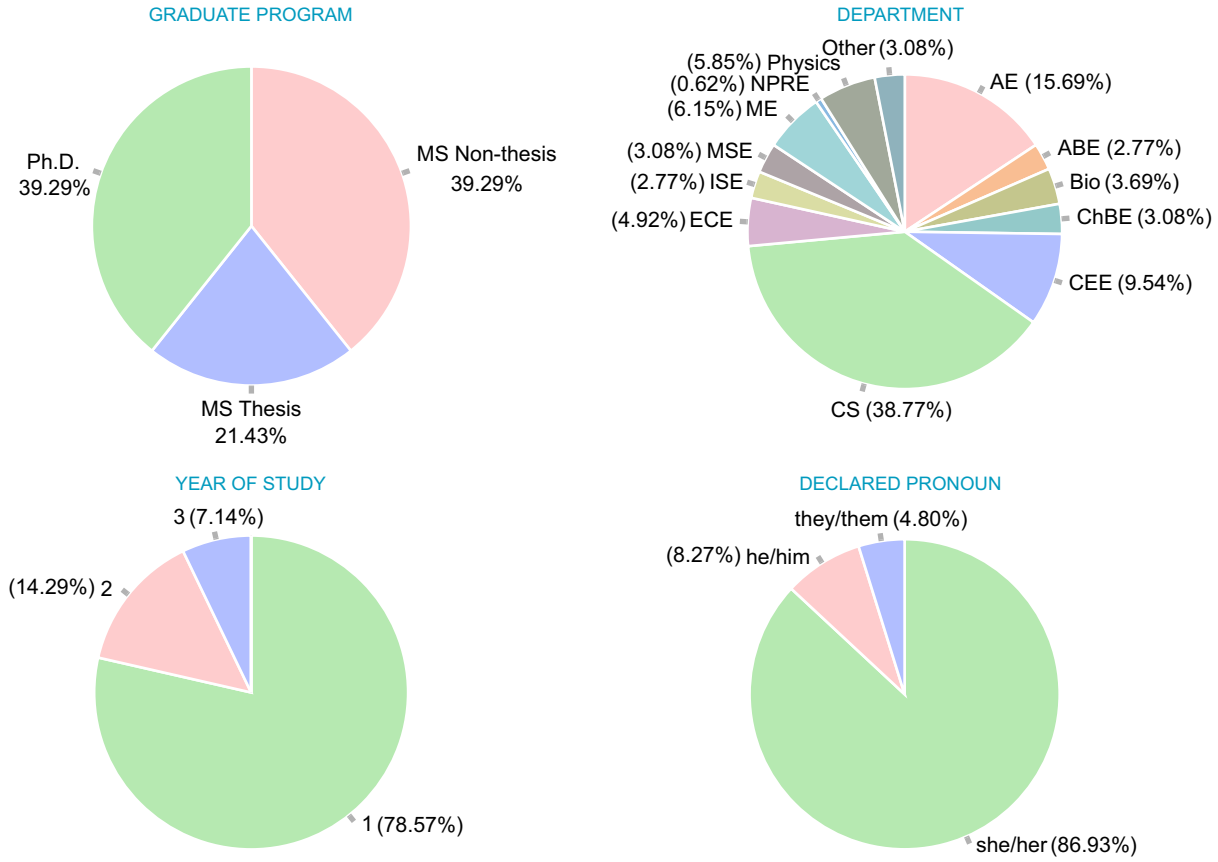

Figure 1: Demographics of survey participants.

Results from a total of three anonymous surveys are used in this study to judge the impact of GrOW. The surveys contain both self-reflection questions and quantitative questions to evaluate "success". The self-reflection questions judge adjustment to graduate school and feelings of belonging and self-worth using a 5-point Likert scale. The quantitative questions gather metrics such as GPA, number of publications, and fellowships earned. The surveys are attached in the appendix for reference.

Survey 1 was distributed in August 2022, after the first event of the GrOW program. Twenty-three attendees participated in the survey. Survey 2 was distributed in December 2022, after the fourth event. First-year MG graduate students who had not attended any of the GrOW events were also

invited to take the survey and they formed the control group. Thirty-three students took the second survey, out of which six formed the control group. Survey 3 was distributed in April 2023, after the final event. Twenty-eight students took this survey, out of which four formed the control group. Demographics of the survey participants are shown in Fig. 1. Respondents were compensated for their time with a gift card worth $5.

Outcomes

Results from the three surveys are grouped and presented in separate figures for each targeted intervention: questions that judge the program's impact on students' belonging in Fig. 2, advice-related questions in Fig. 3, and skills-related questions in Fig. 4. Survey 1 is the 'orientation survey', Survey 2, is the 'end of Fall survey', and Survey 3, is the 'end of year survey'.

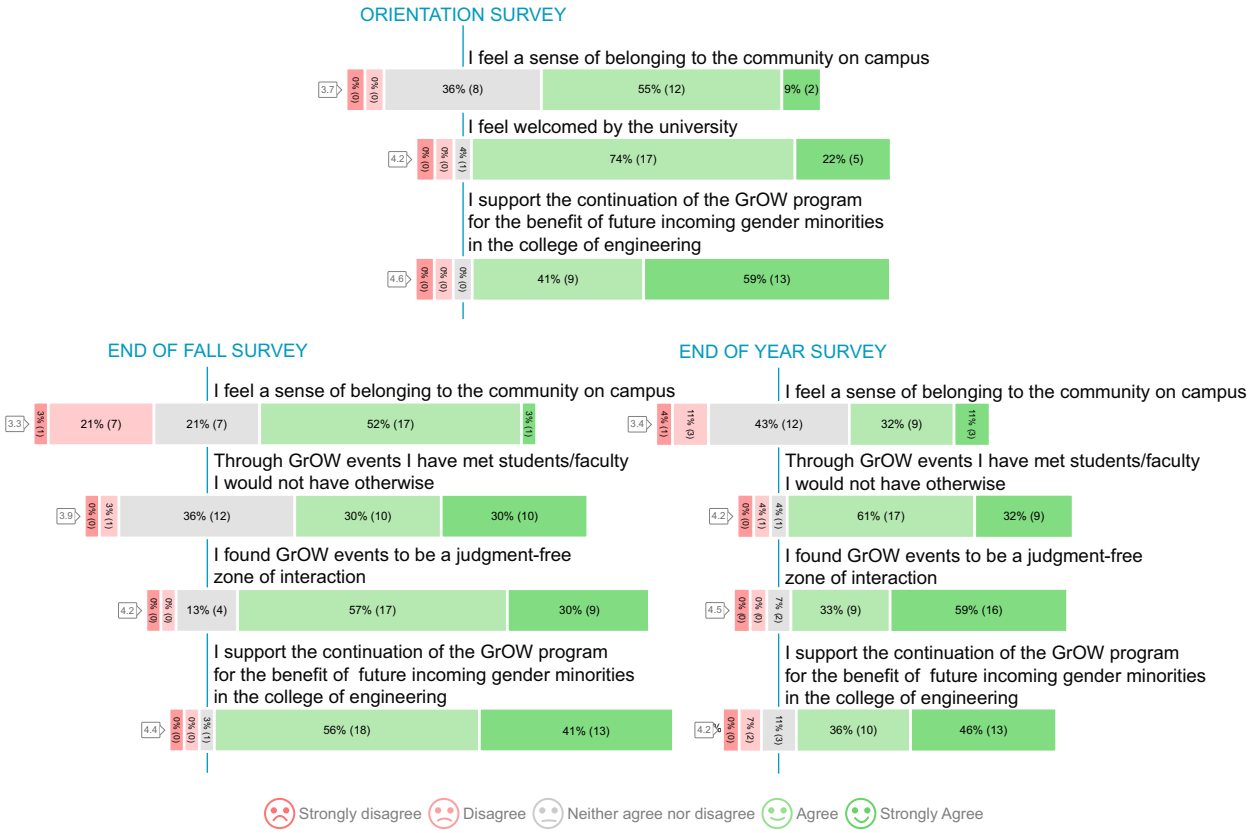

Figure 2: Belonging-related questions answered on a 5-point Likert scale.

The welcome orientation day at the beginning of the Fall semester was the longest and best-attended event in the GrOW series with 65 participants. 23 students responded to the follow-up survey. The responses suggest that participants were able to connect with other students and felt welcomed by the college. As one of the objectives of the orientation day was to provide early opportunities for peer connections, participants were also asked about the number of friends they made that day. 39% and 61%, respectively, reported to have made 1-2 and 3-7 friends that day. While Fig. 3 suggests that the program had a limited impact on the participants' confidence

and anxiety, many other factors may have influenced this result and the effects of the GrOW program cannot be isolated. It does show, however, that the start of school is indeed a time of high anxiety for most graduate MGs. Fig. 4 shows that the majority of survey respondents were able to learn significant and new information from the event and felt that their questions had been answered, suggesting that a major goal of the orientation program was fulfilled. Finally, the results strongly indicate that participants found the event worthwhile, as they unanimously agreed it should be continued in the coming years.

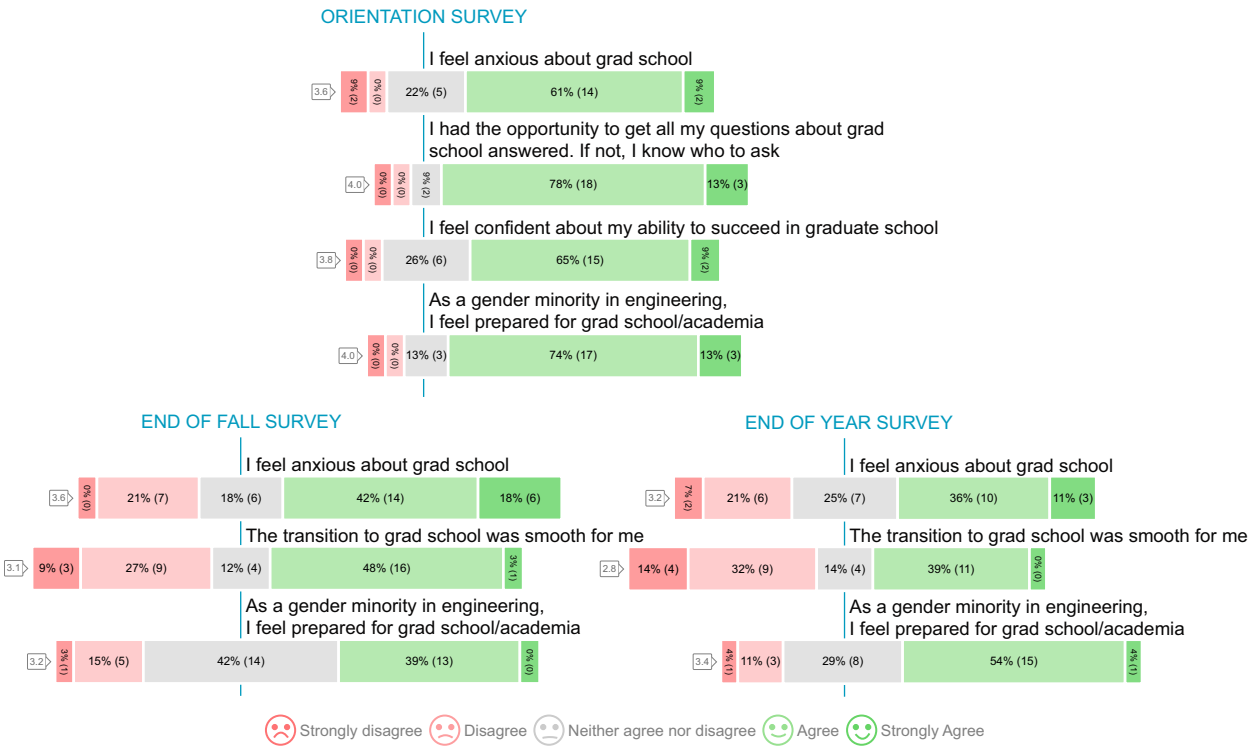

Figure 3: Advice and emotional support-related questions answered on a 5-point Likert scale.

Surveys at the end of the Fall semester and at the end of the year contained the same core questions. The results were positive overall but showed some interesting trends. Students simultaneously exhibited a reduction in anxiety about graduate school and a reduction in feelings of preparedness to succeed in graduate school. From the start to the end of the year, a considerable progression could be seen in students' anxiety about graduate school (Fig. 3): 70% initially reported feeling anxious, which dropped to 60% at the end of the first semester and to 47% at the end of the year. The control group, however, showed no significant changes. First, this supports the current hypothesis that the transition to graduate school is a stressful time, and second, that providing students with resources and advice catered specifically for them can help ease some of the uncertainties and feelings of anxiety. On the other hand, a loss of confidence in their ability to succeed in graduate school was observed (Fig. 3), with 87% responding agree/strongly agree at the beginning of the year and that reducing to 47% on an average as the year progressed. Many factors contribute to one's perception of their ability to succeed in a program, including their previous academic background and their classroom or lab environment. Based on observations of the participants and personal experiences, the authors speculate that

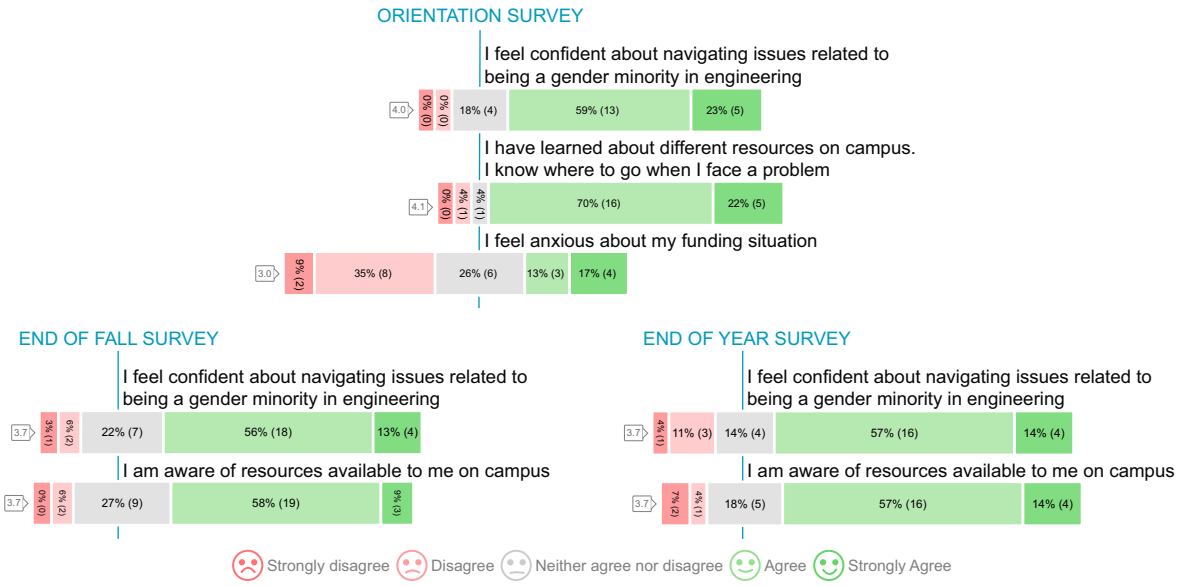

Figure 4: Skills and opportunity-related questions answered on a 5-point Likert scale.

students generally start their first year with more optimism, which gets adjusted as they gain a better understanding of the realities of graduate school. It is also difficult to judge if this is a gender-related issue: for example, increased inhibition due to stereotype threat. But it is worth noting that most survey participants (63%) disagreed or strongly disagreed when asked if they experienced microaggressions when interacting with peers or faculty. Nevertheless, continued engagement with students through such programs and more frequent technical/professional development activities are recommended to have a better impact along these lines. Programs that cater to the full engineering college, such as GrOW, are slightly limited in this regard because of the wide range of technical/professional needs of the different engineering streams.

Another fairly striking result was the loss of feelings of belonging to the community on campus (Fig. 4). While 82% agreed or strongly agreed that they felt a sense of belonging immediately after the orientation, only 55% said the same after the first semester and 43% after the second semester of the program. While the authors acknowledge that the surveys do not necessarily track the same set of students, the results do suggest a general loss in students' feelings of belonging as the year progressed. In contrast, participants also said that they made friends they would not have outside of GrOW events and that they were able to interact without fear of judgement within the space created as part of GrOW (Fig. 2). The students also continued to unanimously agree that the program should continue for the benefit of future first-years (93% agreed or strongly agreed to it). While not required in the forms and surveys distributed, many respondents provided comments that implied the success of a primary goal of the GrOW program, to bring graduate MG students together in the same room: "I learnt that I am not the only person suffering in grad school" and "[Would like to see] similar events, it's just useful to be in a place where everyone unconsciously supports you". Similar sentiments were also expressed verbally to the authors at the end of each event. Potential event attendees expressed their excitement and interest: "So excited to attend!" and "Very cool event! Thanks for putting it together." Given that the program was indeed successful in bringing students together, creating a safe space, and being a support structure, the

decrease in the sense of belonging with time reported by the survey participants demonstrates the challenging nature of the problem and the required continuous, frequent, systematic effort.

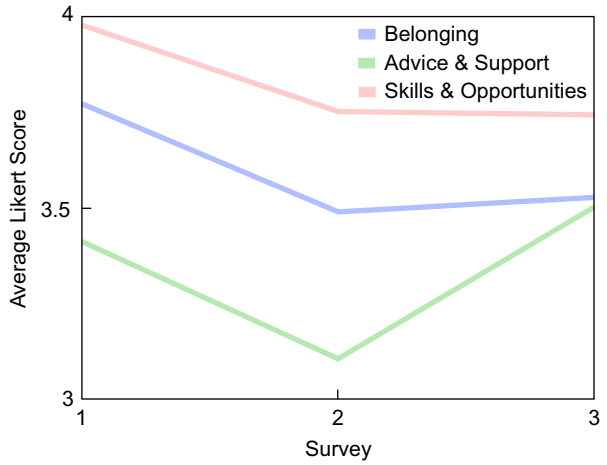

Figure 5: Average of responses to questions related to each intervention category, tracked across the surveys as the year progressed. This metric captures how much students perceived their need for each type of intervention support was being fulfilled.

The reduction in anxiety about graduate school, reduction in confidence to succeed in graduate school, and decrease in feeling a sense of belonging to the community on campus are also reflected in part in Fig. 5. This graph depicts the average response on a Likert scale to the questions asked in every survey for each intervention. Overall, responses show a decrease in positive perception of the 'belonging' and 'skills and opportunities' interventions, whereas although there was an initial decrease for the 'advice and support' intervention, by the end of the year sentiment was back up. While the results and trends across the three surveys are concerning, it is important to keep in mind that the effects of the GrOW initiative cannot be isolated. Most participants attended only 1-3 events in the series. Other factors, such as societal and institutional biases and discrimination, may also be contributing to the participants' decreasing feelings of belonging, anxiety, confidence, and preparedness. Despite these challenges, the program's efforts to support and empower gender minority students in engineering were widely well-received, as shown through direct testimonials. By providing a space for these students to connect with one another and offering resources to navigate the unique challenges they may face, the program has undoubtedly had a positive impact. It is essential to use these survey results to inform and improve future efforts to support MG students in engineering. The trends depicted in Fig. 5 emphasize the need for multi-faceted support across all identified intervention categories throughout the entire academic year. Through continued advocacy and support, a more inclusive and diverse academic environment that benefits all students can be created.

Lessons Learned and Recommendations

Throughout the execution of the year-long program, additional lessons were learned along the lines of what worked and did not work when engaging with graduate students. It was consistently observed that only $50-60\%$ of those who registered to attend an event actually attended an

event. When asked what the barriers were in attending GrOW events, 91% of respondents reported schedule conflicts, 21% hurdle due to transportation, and 21% not knowing other attendees. The issues of schedule conflict and not knowing other attendees are judged to be more prominent for graduate students than undergraduates (whom such programs typically cater to). This is because graduate students tend less to prioritize attending events over multiple research or academic deadlines they may be working on. Additionally, finding someone to go to events with who is also willing and able to take the time is harder when MGs make up low percentages of the population in most engineering departments. In support of this argument, it was observed that most participants in GrOW events belonged to the Computer Science department (which is a large department with 24.4% of graduate students being women) and they attended in groups. To understand students' motivation to attend similar events, a relevant question was introduced in the surveys. 82% reported that they were motivated to attend events where professional benefits could be gained, 80% showed interest in socializing/networking with peers, 48% in learning from eminent/distinguished presenters, and 71% reported being motivated by free food (which was provided in all the current events). Social events that had peer advising built in (the first, second, and last events) were the best-attended events.

The authors believe that the full potential of such programs can be achieved if students were incentivized to attend (almost) every event in a series, for example, by structuring the program into a for-credit course that meets regularly. A unique aspect of the GrOW program was that it was led by (senior) graduate students (authors), who first-hand understood the needs of first-year graduate students, which yielded relatable and useful events. Therefore, the authors also suggest that there be some involvement of students (for example, from registered graduate student organizations) in the planning and execution of such programs in the future.

Summary

A year-long orientation program for gender minorities in the first year of graduate engineering at UIUC was developed and consisted of 7 events spread throughout the academic year. This program had three themes of supporting the students: providing opportunities that promoted feelings of belonging within the community, closely interacting with more experienced members of the community to gain their insights and strategies for success in graduate school, and creating opportunities to learn skills that are important to succeed in graduate school. These intervention themes were chosen based on suggestions from literature and the authors' experiences as members of the community. The impact of the program was judged by three anonymous surveys. Overall, the students highly appreciated the initiative and reported to have found benefits that were unique to the program. 93% of survey respondents (N = 84) agreed or strongly agreed that the program should continue for future first-years. Interesting trends that emerged in their levels of confidence and feelings of belonging as the year progressed were also rationalized and discussed. Lessons learned during the execution of the program and recommendations for initiatives in the future that are to focus on graduate students are also provided.

Acknowledgements

This work was funded by the Institute for Inclusion, Diversity, Equity, and Access in the Grainger College of Engineering, University of Illinois (Grant #: 2022-04) and the IBM-Illinois Discovery Accelerator Institute. This study received IRB approval from the University of Illinois at Urbana-Champaign Office for the Protection of Research Subjects (IRB #: 23254). The authors thank the Grainger College, the engineering departments, graduate coordinators, and student volunteers for supporting GrOW.

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Appendix

A: Orientation survey

1. I feel anxious about grad school.
   Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree
2. I have learned about different resources on campus. I know where to go when I face a problem.
   Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree
3. I had the opportunity to get all my questions about grad school answered. If not, I know who to ask.
   Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree
4. As a gender minority in engineering, I feel prepared to succeed in grad school.
   Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree
5. I feel welcomed by the university.
   Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree
6. The number of friends I made during the GrOW orientation day is in the range
   0, 1-2, 3-7, More than 7
7. I feel a sense of belonging to the community on campus.
   Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree
8. I feel confident about my ability to succeed in graduate school.
   Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree
9. I have realistic expectations for myself, the people I will interact with in the graduate program, and the college/department.
   Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree
10. I feel anxious about my funding situation.
    Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree
11. I support the continuation of the GrOW program for the benefit of future incoming gender minorities in the college of engineering.
    Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree
12. I learned something (information, tips) new during GrOW orientation day that was not covered in departmental e-mails / other orientations I attended
    Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree
13. I feel confident about navigating issues related to being a gender minority in engineering.
    Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree
14. I intend on participating in the social and professional development events planned for the semester as part of GrOW.
    Yes, No, Maybe

15. What would motivate you to participate in the events planned as part of GrOW?
    Professional benefits, Opportunities for socialization/networking, Eminent/distinguished presenters, Food

B: End of Fall and end of year surveys

1. I feel anxious about grad school.
   Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree
2. As a gender minority in engineering, I feel prepared to succeed in grad school.
   Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree
3. I feel a sense of belonging to the community on campus.
   Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree
4. The transition to grad school was smooth for me.
   Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree
5. I am experiencing academic difficulties with the following number of courses
   0, 1, 2, 3+, N/A
6. I experience microaggressions when interacting with my peers and/or supervisors.
   Never, Rarely, Sometimes, Often, Always
7. Through GrOW events I have met students/faculty I would not have otherwise.
   Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree
8. I am aware of resources available to me on campus.
   Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree
9. I found GrOW events to be a judgment-free zone of interaction.
   Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree
10. Which of the following GrOW events have you attended? Fall orientation day, Meet the Faculty social, Things I wish I'd known earlier panel, What I've learned in academia seminar, None of the above
11. I support the continuation of the GrOW program for the benefit of future incoming gender minorities in the college of engineering.
    Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree
12. I feel confident about navigating issues related to being a gender minority in engineering.
    Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree
13. I have at least one mentor on campus I can go to for grad school-related advice.
    Yes, No
14. I have received an internship/job offer.
    Yes, No, N/A
15. The number of fellowship awards I have received is
    N/A, 0, 1, 2, 3, 4+

16. The number of publications I am listed as an author on since starting grad school is
    N/A, 0, 1, 2, 3, 4+
17. What would motivate you to participate in the events planned as part of GrOW?
    Professional benefits, Opportunities for socialization/networking, Eminent/distinguished presenters, Food
18. What are the potential barriers to your participation in such events?
    Location/transportation, Schedule conflict, Not knowing other attendees, Lack of interest, Other