Preparing Female Engineering Doctoral Students for the Academic Job Market through a Training Program Inspired by Peer Review

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Rohit Bhargava is Bliss Faculty Scholar of Engineering and Professor at the University of Illinois at Urbana-Champaign. He is a faculty member with affiliations in several departments across campus (Primary – Bioengineering: Affiliated - Electrical and Computer Engineering, Mechanical Science and Engineering, Chemical and Biomolecular Engineering and Chemistry) as well as the Beckman Institute for Advanced Science and Technology. Rohit received dual B.Tech. degrees (in Chemical Engineering and Polymer Science and Engineering) from the Indian Institute of Technology, New Delhi in 1996 and his doctoral thesis work at Case Western Reserve University (Department of Macromolecular Science and Engineering) was in the area of polymer spectroscopy. He then worked as a Research Fellow at the National Institutes of Health (2000-2005) in the area of biomedical vibrational spectroscopy. Rohit has been at Illinois since as Assistant Professor (2005-2011), Associate Professor (2011-2012) and Professor (2012-). Rohit was the first assistant professor hired into the new Bioengineering department and played a key role in the development of its curriculum and activities. He later founded and serves as the coordinator of the Cancer Community@Illinois, a group dedicated to advancing cancer-related research and scholarship on campus. Research in the Bhargava laboratories focuses on fundamental theory and simulation for vibrational spectroscopic imaging, developing new instrumentation and developing chemical imaging for molecular pathology. Using 3D printing and engineered tumor models, recent research seeks to elucidate hetero-cellular interactions in cancer progression. Rohit's work has been recognized with several research awards nationally. Among recent honors are the Meggers Award (Society for applied spectroscopy, 2014), Craver Award (Coblentz Society, 2013) and the FACSS Innovation Award (2012). Rohit has also been recognized for his dedication to teaching in the College of Engineering (Rose and Everitt awards) and he is routinely nominated to the list of teachers ranked excellent at Illinois.

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Introduction

The existence of a gender gap in the STEM fields is very prevalent across universities in the United States[1]. According to data collected by the National Science Foundation, from 2002-2012 roughly 40% of doctoral degrees in STEM fields were conferred to women, yet in 2010, women accounted for only 27% of tenure-track assistant professorships in engineering.[2] This lowered representation of women in upper divisions of academia is not due to a lack of interest. The Royal Society of Chemistry in London found in a 2006 survey that 70% of first year female students planned to be in a research career, yet only 37% had that goal by their third year[3]. This 'leaky pipeline' of women in STEM fields remains an ongoing discussion[1,4-7] and several potential causes have been identified including a lack of role models in the upper divisions of academia[1], low self-confidence[8], and student impressions of work-life balance in academia[2].

At the University of Illinois, there exist many resources for the graduate community to learn about the academic job application process. In addition to seminars and workshops, these resources include the Mavis Future Faculty Fellowship Program, which focuses on developing participants' research, teaching, and mentorship experiences[9]. Other universities also host programs and classes similar to those at the University of Illinois[10-12]. While these programs are effective at disseminating information, they do little to target female engineering students or to encourage their sustained interest toward academic career paths.

The Graduate Committee of the Society of Women Engineers (GradSWE) at the University of Illinois has launched a program to specifically target the gender gap in engineering. This program aims to improve the strength of faculty position applications from female doctoral students while targeting the potential sources of the leaky pipeline. The Illinois Female Engineers in Academic Training (iFEAT) program is a multi-month program designed to strengthen the applications of female faculty candidates by providing a structured schedule for preparing their application packages while encouraging community growth. iFEAT provides informational resources for prospective faculty candidates through seminars and panel discussions, followed by peer-review groups for students to share and review application materials. iFEAT aims to not only disseminate information but also to provide positive role models, increase participant self-confidence, and change student perceptions of academic life. iFEAT also aims to foster a supportive community through increased participant interactions with faculty and peers. The peer-review groups also provide opportunities for participants to learn from each other, find mentors, and establish future relationships. *The goal of this work is to analyze the impact of the iFEAT program on its participants to determine its effectiveness in addressing the 'leaky pipeline'. We will analyze the participants' perceived self-confidence level, career outlook, and sense of community.*

iFEAT Program Structure

The iFEAT program is a five-month program consisting of a seminar or panel approximately every three weeks from October of 2014 to March 2015. Participants were assigned peer-review groups at the beginning of the program, and peer-review groups self-scheduled meetings in between major programming events.

All seminars are delivered by faculty and staff at the University of Illinois who have experience in the topic of choice. Panels consist of faculty members from various departments and academic ranks, ranging from Dean to Assistant Professor. The seminar and panel topics include cover letters, application package materials, grant proposals, recommendations, interviews, and negotiations (**Table 1**). The peer-review groups were encouraged to meet throughout the program to discuss their cover letters, teaching statements, and research statements. They are also given the opportunity to have a tenured faculty member review their entire application package at the conclusion of the program.

A case study of the iFEAT program will be performed to explore the success of the program goals in order to gain a holistic portrayal of the participants' experience in the iFEAT program[13]. This method has proven helpful in other instances of education-related program development[14-16]. Surveys were administered at the beginning, mid-point, and conclusion of the program. The program was evaluated on the success of its structure[2] and an analysis of student outcomes, including any changes in participant mentality, career outlook, and career goals. The program effectiveness was determined based on trends from survey answers as given by participants.

Table 1: iFEAT Schedule and Topics

Week	Seminar Topic	Peer Review Topic	Additional Notes
Weeks 1 - 3	Cover Letters	Cover Letters	Pre-Survey
Weeks 4 - 6	Teaching Statements	Teaching Statements	
Weeks 7- 9	Research Statements	Research Statements	
Weeks 10 - 11	Holiday Break		
Week 12	Grant Proposals		Mid-Survey
Week 15	Recommendations		
Week 18	Interviews		
Week 20	Negotiations		Post-Survey Interviews

Methods

Participant Selection

Out of twenty-four applicants to the iFEAT program, thirteen students were selected to participate based on their academic record, current standing in their graduate program, and demonstrated commitment to academia. Each applicant answered several questions to evaluate

their commitment to academia and submitted a current curriculum vitae (CV). The application materials were then scored from one to one hundred by iFEAT program coordinators and three faculty members. Specific selection criteria included the applicant's academic record, previous involvement in GradSWE, availability during program events, and indicated timeline for job application. Candidates with scores above seventy were selected for the program and further divided into four peer-review groups. The peer-review groups were assigned based on participants' academic achievements and intended timeline for job applications, as indicated in their program applications. For example, one particular group demonstrated higher academic achievements (more publications and conference presentations) in their CV and indicated initiation of their job search within one and a half years, whereas another group demonstrated comparatively fewer academic achievements and indicated initiation of their job search in more than three years.

Surveys

iFEAT was evaluated based on three surveys administered at the beginning, mid-point, and end of the program. Survey questions requested trainees to self-report on their aspirations and intentions for the academic job search, the progress of their application materials, and their confidence level in the application process. We seek to quantify any changes in the trainees' goals, perceived preparation levels, and confidence levels throughout the program. As trainees progressed through iFEAT and gained information about the application process, we noted shifts in perception of the most challenging and most important components of the application process. We also monitored any changes in trainee career aspirations, including candidates' preferred type(s) of institutions and academic positions, plans to conduct postdoctoral research, and anticipated application timeline.

Data analysis involved looking at trends across survey questions. All questions had either a numbered rating system or distinct multiples choices for participants to select. Trends were determined via either an average of all participant ratings or a percentage of participants who chose that answer. For some questions, participants chose more than one answer; in these cases, each choice was compared to the total number of participants who took the survey.

Interviews

Participants were given the option to participate in a post-program interview intended to uncover the reasoning behind major changes in (or confirmation of) career plans and perceptions of academia. Interview questions were approved by the Institutional Review Board at the University of Illinois based on regulations by the federal Office for Human Research Protections. Interviews consisted of audio recording of participants with their consent. Ultimately, we seek to track student outcomes from the program and uncover factors that may contribute to or prevent the 'leaky pipeline' of female engineers in academia.

Results and Discussion

Participant Confidence and Preparedness

Survey questions were administered at the beginning, mid-point, and conclusion of the program. When participants were asked to rank their familiarity with the faculty application process (1-not familiar to 5-very familiar), participants indicated an increase in familiarity from 2.5 ± 1.2 (beginning) to 3.4 ± 0.5 (mid-point) to 4.2 ± 0.4 (post). In contrast, participant evaluation of how prepared they felt indicated no significant difference from the beginning to mid-point of the program, however there was a slight increase from 2.4 ± 1.0 at the mid-point of the program to 3.2 ± 1.1 at the conclusion of the program (**Figure 1**). The reduction in standard deviation of students' familiarity with the job search process could be a result of iFEAT's programming content. As iFEAT programming proceeded, all participants are normalized to the same amount of information and familiarity with the job application process, thus resulting in a decrease in variance. The slight increase in preparedness at the end of the program could be a result of participants receiving information regarding all aspects of the application process, thus eliminating uncertainly regarding topics which were not discussed yet at the mid-point of the program. We also noted that the participants who actively engaged in peer-review sessions reported higher levels of preparedness compared to other participants at the mid-point of the program (3.5 ± 0.7 versus 2.0 ± 0.6, respectively). When asked whether they felt more confident, one interviewee commented "Yes. Mainly because … it was helpful to get some other eyes for the proofreading." This result suggested that peer-review sessions positively impact participants' perception of preparedness.

Figure 1: Participant familiarity with and preparedness for the academic job search.
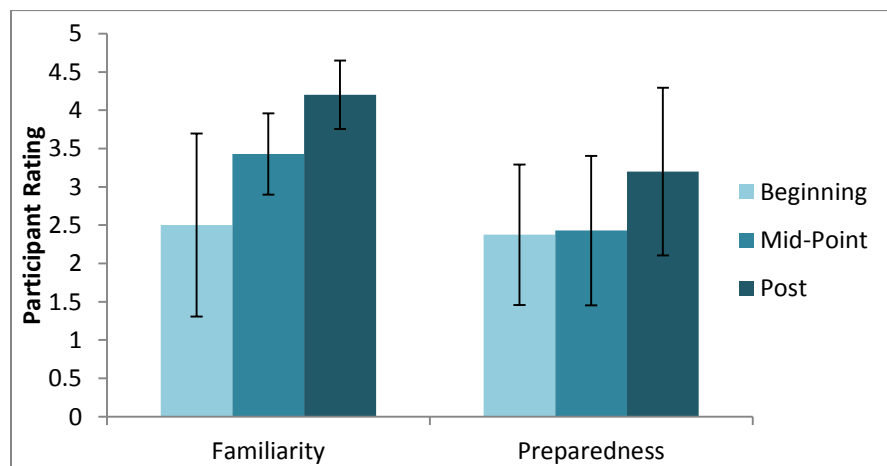
Participants were also asked to indicate what they regarded as the most and least important and the most and least challenging components of their application package (**Figure 2**). From the beginning to the end of the program, we observed a decrease in how challenging recommendations are perceived. We also noticed an increase in how important the research and teaching statements were perceived. Despite this finding, participants reported an overall shift in interest from research-oriented positions to teaching-oriented positions from the beginning to

post surveys (**Figure 3**). Overall changes in perception could indicate that participants improved their understanding of the demands of an academic job search and the way search committees function.

When participants were asked when they plan to apply for academic job positions, 37.5% of participants indicated within one year, 62.5% answered with two years, and none answered within three years at the beginning of the program. At the mid-point of the program, 71.4% answered within one year, none answered within two years, and 28.6% answered within three years. At the end of the program, 50%, 33.3%, and 16.67% of participants answered within one, two, and three years, respectively (**Figure 4**). We note that some time has elapsed between the surveys, which may correspond to changes in some responses from two years (beginning) to one year (post). Despite the elapsed time, we observed an increase in the number of participants indicating that they would apply for positions in 3 years. This shift may be a result of an increased awareness of participant preparedness and the effort required for the application process. A delay in a faculty candidate's job search may enable them to apply for jobs with a better sense of confidence and preparedness. Overall, participants indicated that they would recommend iFEAT to others, indicating a program rating of 4.3 ± 0.9 on a scale from 1-would not recommend to 5-would recommend.

Figure 2: Perceived (a) most and (b) least important components of an application package, as well as (c) most and (d) least challenging materials to prepare. Materials included Cover Letter (C.L.), Research Statement, Teaching Statement, Recommendations, and Curriculum vitae (CV)

Figure 3: Career aspirations of iFEAT participants. (a) Type of academic institutions and (b) type of academic positions iFEAT participants are interested in applying to.
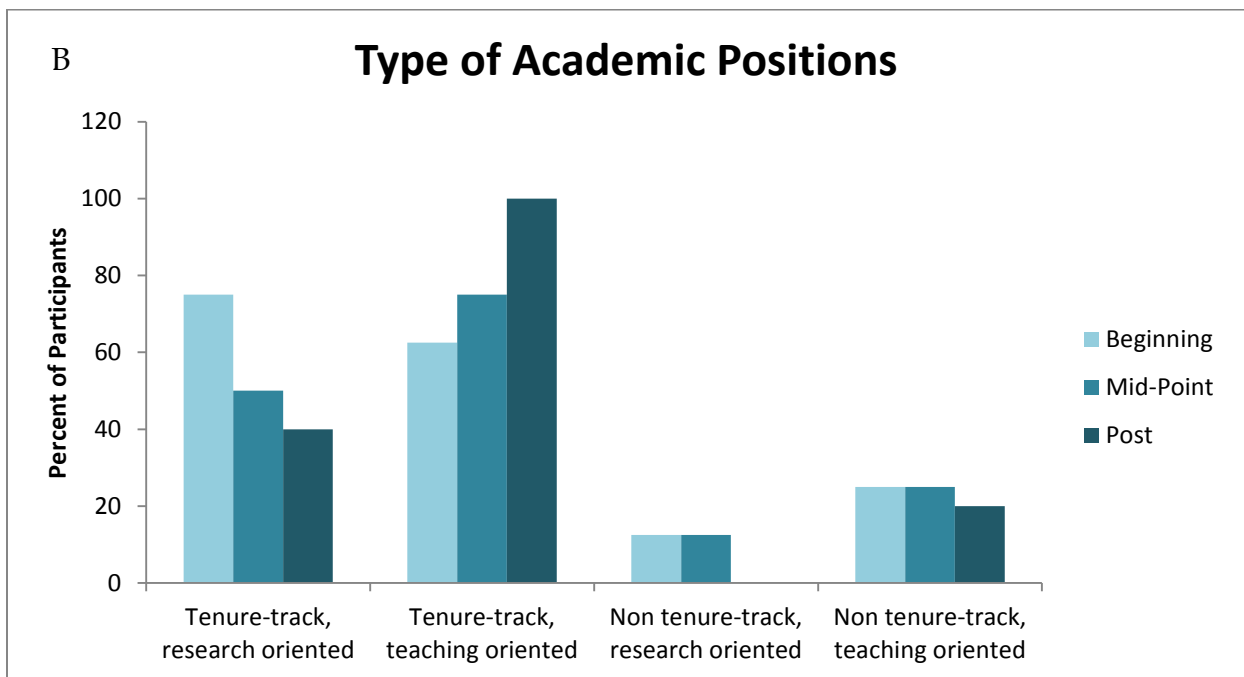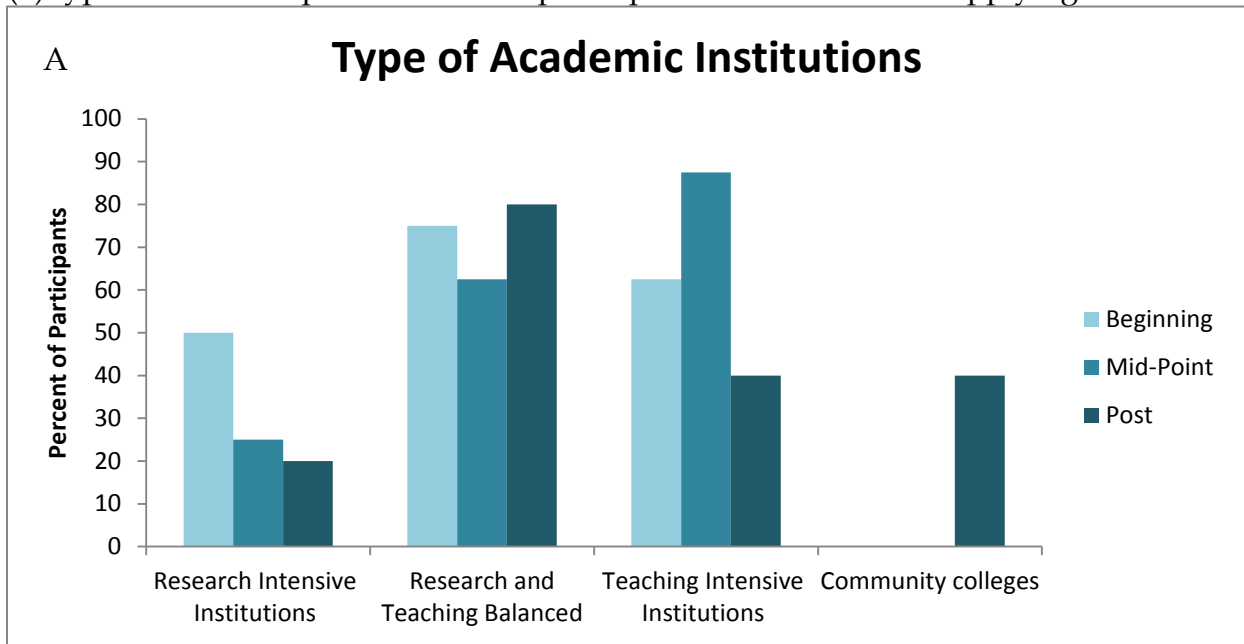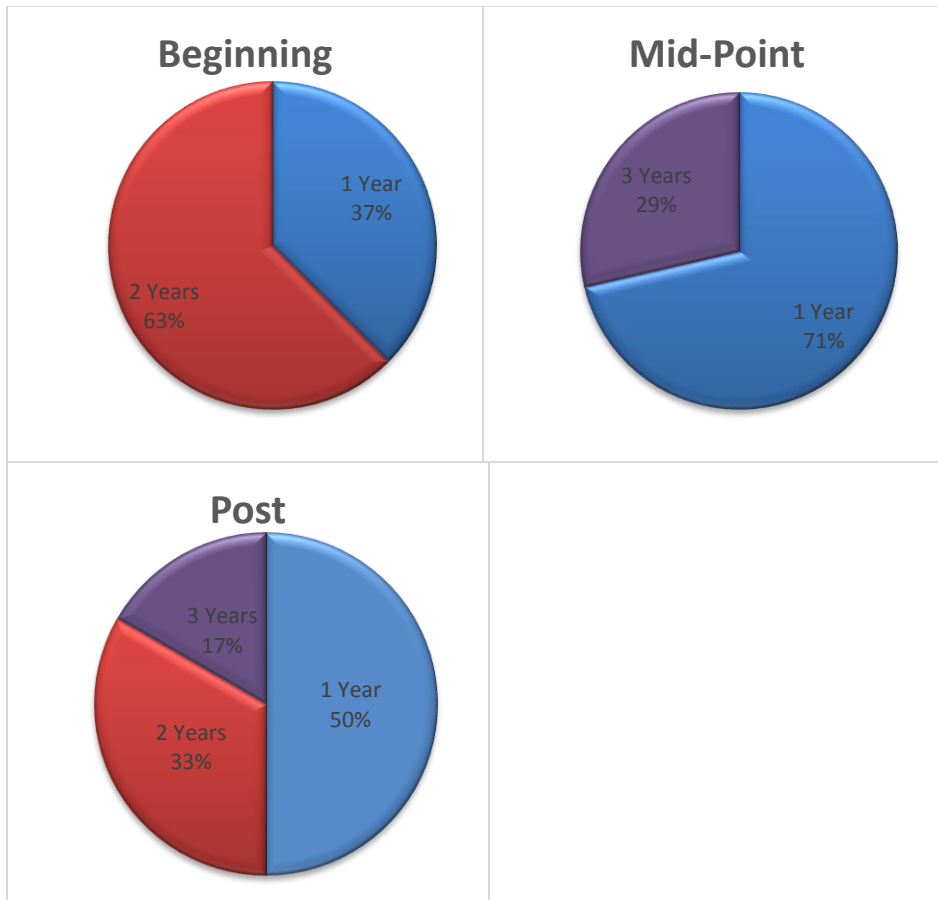

Type of Academic Institutions

Percent of Participants (y-axis, 0 to 100)

Categories (x-axis): Research Intensive Institutions, Research and Teaching Balanced, Teaching Intensive Institutions, Community colleges

Legend: Beginning, Mid-Point, Post

B

Type of Academic Positions

Percent of Participants (y-axis, 0 to 120)

Categories (x-axis): Tenure-track, research oriented; Tenure-track, teaching oriented; Non tenure-track, research oriented; Non tenure-track, teaching oriented

Legend: Beginning, Mid-Point, Post

Figure 4: Participants' anticipated academic job search timelines

Participant Sense of Community

One goal of the program is to build a sense of community by establishing relationships between students. The success of this aim is evaluated using several criteria including networking, accountability, and comfort. The survey results for these factors are shown in **Table 2**.

Table 2: Survey data indicating participants' sense of community

Survey question	Description of ratings		Response (average ± s.d.)		
	1	5	Beginning	Mid-point	Post
Would other iFEAT participants be a useful resource for networking?	Not a good resource	A great resource	4.3 ± 1.0	3.6 ± 0.8	2.4 ± 1.1
How committed to iFEAT do you feel compared to the members of your peer review group?	Not committed	Very committed	N/A	3.5 ± 0.8	3.6 ± 0.9
How accountable do you feel for preparing materials?	Not accountable	Very accountable	N/A	3.2 ± 1.2	2.8 ± 1.1

Collectively, these results indicated that the program has not yet fostered a sense of community amongst participants. A potential contributor to this result was the lack of structure imposed on the peer-review groups. Peer-review groups were given the responsibility to schedule their own meetings to allow flexibility in timing and location. In this system, many review groups were unable establish a fixed meeting schedule, thus rendering the peer-review process less effective than expected. These factors likely decreased individual participants' accountability and prevented participants from reaching an increased comfort level with their iFEAT peers.

An anomaly in this trend arose from one particular group that succeeded in meeting regularly as planned. The participants of this group rated the peer-review sessions favorably and considered peer review to be the most valuable aspect of iFEAT. One member commented "I think iFEAT set itself apart because of the feedback that we were held to in between meetings". She also mentioned that the diversity in the group was helpful in her application materials preparations. In comparison, members of groups that did not meet regularly rated seminars as the most valuable component of iFEAT. This disparity suggested that a successfully implemented peer-review schedule could be very helpful for participants, and a more structured approach to the peer-review process could strengthen the sense of community within iFEAT.

While a sense of community between peers has proven to be challenging to facilitate, the goal of improving student-faculty interactions was successfully achieved. One participant stated "I found iFEAT to be more personal, and so the difference between iFEAT and other career-type seminars was that it was a personal interaction with a panel or with a speaker…We were actually able to get an understanding for our situation specifically." Another participant agreed that the small group setting was important because "I had an opportunity to get my questions asked and answered, whereas the Grad College [workshop] was a couple hundred [people] in the room, and I didn't have a chance to do that." These responses indicated that the small group setting was successful in increasing the interaction between students and faculty members, which could lead to further develop a sense of community for graduate women in engineering at the University of Illinois. A participant also commented that "having all the participants being female meant that we could bring up…women's specific concerns without the same kind of judgment that I feel when I bring them up in other spaces." This indicated that iFEAT was successful in the establishment of a female-friendly environment where female faculty candidates can have their questions answered and addressed.

Conclusions and Future Directions

The iFEAT program aims to strengthen the applications of female engineering graduate students interested in academic positions and to combat the 'leaky pipeline' of female engineers in academia. iFEAT utilizes a multi-faceted approach by disseminating information, increasing participant confidence, changing student perceptions, and building a sense of community. At the conclusion of the program, many participants indicated an increase in familiarity with the job search process, even though they do not yet feel prepared. Due to this increased familiarity, some participant perceptions have changed, including importance of various application documents, participants' perceived readiness to begin applying for faculty positions, and the types of institutions and positions they would like to apply to. Building a sense of community amongst

participants has proven challenging, potentially due to limited input from program organizers on the peer-review group meetings.

There still remain shortcomings to iFEAT, which will be addressed in future programming cycles. Changes will focus on the program's goal of fostering a supportive community of graduate students seeking academic careers. First, we will implement more interactive components to increase participant engagement and communication. This includes designated time in the first program meeting to allow peer-review groups to meet and begin sharing experiences, as well as a culminating event at the end of the program with participants, engineering faculty, and prospective iFEAT applicants. It is our hope that increased social interactions throughout the program will facilitate the establishment of a community. We propose to address existing flaws with accountability through further integration of the peer-review sessions, seminars, and panels. This includes more structured scheduling and increased peer-review group interactions during major programming events (seminars and panels). One participant mentioned that the peer review groups were difficult to maintain due to early-stage application materials that are not ready to review. In future iterations of the program, participation in peer review groups could be restricted to participants who are in the later stages of their graduate career and/or the postdoctoral community.

We also aim to provide a more varied perspective in the program. One participant mentioned that the perspective of a small school "is the perspective I struggle to get." By inviting faculty from various types of institutions, from teaching intensive universities to community colleges, to present at the program, we hope to address this problem and ultimately strengthen the program. Overall, iFEAT has proven to be a great resource for female engineering candidates preparing for the academic job search and poses a potential framework for institutions to address the gender gap in academia.

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