Identifying Barriers to Recruiting Low-Income Students into Engineering Master's Programs

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Abstract: The purpose of this paper is to present lessons learned from a recently established NSF S-STEM program focused on creating pathways to master's degrees for low-income engineering students. This population is particularly interesting, because students from income backgrounds who have earned bachelor's degrees may be eager to enter the engineering workforce. However, in many engineering disciplines, individuals have more earning potential and career trajectory options with a master's degree. In this paper, we identify several categories of barriers and lessons learned to launching an S-STEM focused on graduate students at a large R1 public institution that may be useful to other such programs. These include discussions on recruitment of this specialized population of students into graduate school, especially those from other institutions, can be difficult because i) there are structural and legal barriers to accessing financial information about students to identify low-income students and ii) smaller institutions may not have the student support resources to effectively prepare undergraduate students for future research-based advanced degrees in engineering at large universities. By formalizing the issues facing student-centric graduate education and providing some context for how our program is overcoming these barriers, more stakeholders can be aware of barriers that impede broadening participation in graduate-level engineering education to accelerate progress in similar initiatives.

Introduction and Motivation: A focus on graduate students to support the engineering workforce is guided by the call to action and recommendations from the National Academies of Sciences, Engineering, and Medicine which succinctly notes that "[o]ur graduate schools of science and engineering are therefore important not only as a sources of future leaders in science and engineering, but also as an indispensable underpinning of national strength and prosperity—sustaining the creativity and intellectual vigor needed to address a growing range of social and economic concerns" [1, p. 17]. The National Academies also strongly advised that the ultimate success of graduate STEM education depends on the diversification of access and practices that "create an equitable and inclusive institutional environment" [1, p. 77].

While most literature aggregates "graduate students" together, it is imperative that the research, practice, and student support communities begin to understand the differences between PhD students and master's students, and the roles they fill in meeting this national need. It is also important to delineate between these groups as it relates to equity and broadening participation from a financial perspective: Whereas 90% of STEM PhD students receive institutional funding [2], Master's students are not as likely to receive funding. Half of STEM Master's students rely on borrowing to fund their graduate education, and the "lack of adequate financial support" is one of the top three reasons for dropping out of a STEM Master's program [3]. In addition to a greater societal benefit to the STEM labor force and the students themselves [4], students as individuals also benefit from earning an Engineering Master's degree as it pertains to increasing content knowledge, research skills, technical skills, an entryway to a doctoral program, expanding job opportunities, and a wage premium that contributes to social mobility [1, 5, 6].

Context: NSF S-STEM at Penn State University and the Advancing Master's Program (AMP) Scholars Program. Our funded S-STEM project contributes to the national need for well-educated scientists, mathematicians, engineers, and technicians by supporting the retention into

graduate school and subsequent graduation of high-achieving, low-income students with demonstrated financial need at Penn State. The S-STEM project is known locally as the Advancing Master's Program (AMP) with funding started 10/2021. Over its 6-year duration, the S-STEM will attract and fund scholarships for up to 45 full-time students who are pursuing master's degrees across engineering disciplines at Penn State. Students will receive 2-year scholarships and participate in programming designed to impact academic and social success. Project activities will include intentional strategies to increase interest, applications, and enrollment in engineering master's programs. In addition, retention activities such as mentoring (group and individual), and professional development programming will be offered for the two years of the scholars' programs of study. Finally, the project plans to build skills in inclusive mentoring for 54 faculty members that will have an impact beyond the duration of this project.

A primary goal for the first years of funding has been to further develop intra- and inter-institutional partnerships to recruit students to apply to a MS program at Penn State to be supported by the S-STEM. While the S-STEM does not admit students, our team works with the individual departments as they recruit and admit students who may be good fits for the S-STEM funding, which include the requirements that they be incoming master's students, have demonstrated financial need, and will be completing a master's degree that requires a thesis. It has been enlightening to realize the extent to which the departments at our single institution differ in terms of admissions procedures, timelines, student funding expectations, and how and to what extent they recruit and communicate with potential incoming master's and PhD students.

Identification of and Working to Overcome Barriers in Launching an S-STEM focused on Low-Income Graduate Students. Through the initial years of the S-STEM program focused on graduate students, we have identified two main barriers. It is our goal through this paper that articulating these barriers will start conversations, or accelerate conversations and solutions, for other institutions planning similar interventions.

Barrier 1: Identification of "Low Income" Graduate Student Status. While deciphering undergraduate calculation of need is relatively easy, with FAFSA being a typical way of documenting parental income, graduate admissions do not require FAFSA such that there is not a centralized tracking of graduate student need. Further, definitions of FAFSA-based need rely on parent dependency, which is a murky area for graduate students, some of whom are claimed by their parents and some of whom are fully independent financially. We have found multiple obstacles to being able to use a low income status as a recruitment/participant identification approach. Ultimately, to be able to apply to the AMP program with S-STEM funding, students need to submit a FAFSA to prove calculation of need, but at times this does not occur first or during the graduate school application process, and instead may happen retrospectively after we have identified students that may be good fits for the program.

Unfortunately, this barrier requires a multipronged and very flexible approach to the "order of operations" in which students are recruited and apply to the disciplinary master's program and then apply to the S-STEM for funding, and we are always looking for alternative ways for individual graduate programs to help to identify potential graduate students. One method is simply recruiting everyone to the program by sending out email blasts to incoming or admitted students, messaging at graduate visit days, and similar methods, with the hope that students who need

funding will explore the program and self-select into applying for AMP. However, this passive strategy for recruitment is not necessarily the best person-centered approach for recruitment.

Another solution has been to request that graduate admissions committees be cognizant of our funding schema during admission and recruitment season. Again, there is no easy "tell" on applications whether a student may fall into the low-income category, but there are proxy categories that can sometimes indicate (but not guarantee) that a student may fall into a low-income status, especially participation in federal TRIO programs or undergraduate-focused S-STEMs. Mining applications for these aspects is not a digitized activity, though, and requires the graduate admissions committees to be thinking about our programs at the same time as making their admissions decisions. We try to be as communicative as possible with the departments in order to facilitate these conversations, and volunteer to reach out to any potentially eligible students on behalf of the program if need be. We also seek to communicate with departments and faculty members about how the student's S-STEM funding can pair with Research Assistantships in order to be a net value for the department, in addition to the extra mentoring a student involved in the S-STEM program will receive.

Barrier 2: Recruiting undergraduate students from non-R1 institutions. As our S-STEM focuses on broadening participation at the graduate level for students who may not already be considering a master's program, we aim to recruit mainly from smaller schools, who often do not have strongly developed pipelines into undergraduate research or to frequently send students to graduate school, and as such do not have a strong ability to prepare students for potential graduate study. This is a function of being undergraduate level universities without graduate programs of their own (on-campus research is not common), and institutional missions of preparing undergraduates to enter the workforce rather than academia. However, we see smaller institutions as a missed opportunity for recruiting talented future graduate students especially with the goal of resolving representation issues at the graduate level for low-income students.

As we work to recruit from smaller institutions, it is at times difficult to message graduate school because the students have not been prepared to think about higher education, especially in engineering where the bachelor's is a professional degree itself. We surmise that our unique S-STEM focus on low-income students also requires very careful messaging and student preparation on the part of student support services (e.g., academic counselors) to propose the potential value a master's program at the same time students have been planning for immediate employment. If student services offices are not familiar with the pathways into and through graduate school and the value of a master's degree in engineering, then they may not be able to identify or prepare students for future study. While some institutions may have some familiarity with preparing students for graduate school (e.g., via a McNair program or similar), others may not be familiar with the ways in which undergraduate students should be prepared for graduate school or be aware of opportunities like REUs or our S-STEM early enough to prepare students effectively to be competitive graduate school applicants (the first step before achieving S-STEM funding from us).

Prior literature backs the emphasis on considering a student preparation bent to our future work with respect to recruitment: Studies show that students who have undergraduate research experience [7] and have had preparation (either through formal programming or through faculty mentorship) to be able to "see [themselves] as a graduate engineering student" and know they will

be successful, and have had positive interactions with graduate students, and feel their undergraduate education has "prepared [them] to make a decision about attending graduate school," "what is expected of [them] in graduate school" and "what is involved in applying to graduate school" are significantly better prepared for graduate school [8]. It is plausible then, that if students from smaller universities have no access to what graduate school or grad students "look like" then it is difficult to develop these predictive attitudes about graduate school to consider applying, especially if student services offices are not prepared to message and guide students in these conversations.

Ongoing Initiatives to Continue Progress. We are continuously humbled with the realization that if our own institutional norms and expectations are so difficult to navigate even for us as faculty, how much more confusing might the process be for the students we seek to support, who may not have the time, social capital, and/or mentorship to navigate the graduate admissions and funding processes. Unfortunately, the research and practice communities know very little about the transition of low-income students from smaller institutions to graduate study at R1 institutions.

To answer these questions and to build inter-organizational partnerships with other S-STEMs, we are planning to host a virtual summit, called the Supporting S-STEM Graduate Trajectories Summit with S-STEM leaders and relevant stakeholders supporting undergraduate students in their engineering formation to identify pinch points for universities and student support offices in helping students prepare, apply, and be competitive for acceptance into graduate school, with support of an S-STEM Hub accelerator initiative funded by NSF. It is likely that our team, situated in our own context, is not fully aware of how undergraduate engineering students at other universities, particularly those that do not share many characteristics with Penn State, are prepared if they indicate they would like to pursue graduate study. Rather than making blanket assumptions, we plan to host a summit with leaders of S-STEMs that are housed at non-R1 contexts across the United States. This half-day, virtual summit planned for the Spring 2023 semester will launch discussions of student preparation as it pertains to future graduate study. The goal for this summit is to listen and collect practices, wisdom, barriers, "pinch points" from undergrad-focused S-STEM leaders, to ascertain what potential misassumptions and misalignments about the transition to graduate school may lurk of which we and other graduate programs may not be aware. We anticipate that the data generated will highlight unforeseen barriers in student preparation from the faculty/administration point of view because of the differing organizational cultures and contexts between smaller undergraduate-focused institutions and larger universities with a large research presence. Triangulated with master's S-STEM student data generated from our funded S-STEM project we expect to highlight impactful areas for future attention for stakeholders on "both sides" of the graduate pipeline.

Concluding Thoughts for Similar Programs. It is expected that other programs with similar missions likely have the same sorts of barriers in identifying and recruiting incoming graduate students, and these issues are compounded when funded by programs that traditionally serve undergraduate students, because the reporting mechanisms, funding models, and resource distribution is much different at the graduate level than at the undergraduate level. As such, since there are only a few S-STEMs that serve low-income graduate students, the purpose of this paper was to document some of these challenges so that other teams wishing to meet the needs of this specialized stakeholder group can begin to envision the solutions to these problems before even

beginning, rather than needing to be blindsided or forced to take a reactionary approach. In sum, we have discussed two main barriers for our S-STEM focused on low-income graduate students: First, the identification of low-income status and what that actually means/how it can be identified for graduate students, and second, the recruitment of students from smaller institutions to graduate programs at a large R1 institution, considering the differences in educational context and student services preparation across contexts. We hope this work will spur productive and beneficial conversation in the graduate admissions, enrollment, and student support communities and those faculty who care about these issues.

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