

Capturing First- and Second-Year Master's Engineering Students' Perceptions of Support in Their Transitions to Graduate School

Dr. Catherine G. P. Berdanier, Pennsylvania State University

Catherine G.P. Berdanier is an Associate Professor of Mechanical Engineering at Pennsylvania State University. She earned her B.S. in Chemistry from The University of South Dakota, her M.S. in Aeronautical and Astronautical Engineering and her PhD in Engineering Education from Purdue University. Her research expertise lies in characterizing graduate-level attrition, persistence, and career trajectories; engineering writing and communication; and methodological development.

Dr. Julio Urbina, Pennsylvania State University

JULIO V. URBINA, Ph.D. is a Professor in the School of Electrical Engineering and Computer Science at The Pennsylvania State University. Dr. Julio Urbina received his BSEE degree from Universidad Nacional de Ingeniería, Lima, Peru, in 1990, and his M.S. and Ph.D. degrees in electrical engineering from the University of Illinois at Urbana-Champaign in 1996 and 2002, respectively. He has worked at Jicamarca Radio Observatory, Arecibo Observatory, and University of Arkansas. Dr. Urbina's research has used radio and radar technologies to study the Earth's middle and upper atmosphere. He conducts research in RF and Microwaves, digital systems and space instrumentation, cognitive radars, software-defined radio and radars, sensors, acquisition, drones, UAVs, harmonic radars, reconfigurable instrumentation, meteor radio science, radio wave propagation, space engineering, remote sensing, and radar studies of the ionosphere. In 2011, Dr. Urbina received the National Science Foundation CAREER award for his research on Cognitive Radar systems to study plasma instabilities. Dr. Urbina has received numerous federal grants for studies related to mentoring low-income undergraduate and graduate students, radar remote sensing of the Earth, satellite systems, wirelessly networks, ground and space instrumentation and observations, and tracking pollinators. His educational research interests include effective teaching techniques for enhancing engineering education, global engineering and international perspectives, thinking and working in multi-, inter-, and transdisciplinary ways, cyberlearning and cyber-environments, service and experiential learning, mentoring, peer-mentoring, teaming and collaborative learning.

Prof. Reginald F. Hamilton, Pennsylvania State University

Dr. Catherine L. Cohan, Pennsylvania State University

Catherine Cohan, Ph.D. has been a research psychologist for over 20 years. Her areas of expertise include engineering education, retention of underrepresented students, measurement, and assessment. She is currently an Assistant Research Professor and coor

Dr. Tonya L. Peebles, Pennsylvania State University

Professor Tonya Peebles joined the Penn State College of Engineering in August of 2018, as the Inaugural Associate Dean for Equity and Inclusion and Professor of Chemical Engineering. Prior to joining Penn State she worked at the University of Iowa and i

Dr. Cynthia Howard Reed, Pennsylvania State University

Cindy Howard Reed is the Director of Graduate and Postdoc Equity and an Assistant Teaching Professor in the College of Engineering at Penn State. She has a MS in Environmental Health Engineering and PhD in Civil Engineering from The Un

Capturing first- and second-year master's engineering students' perceptions of support in their transitions to graduate school

The purpose of this research full paper is to investigate issues facing very early-stage master's students as they transition into a degree program at a large research-intensive university. While there is an increasing focus on graduate and doctoral engineering education, few studies have sought to focus specifically on master's students, treating them from a research perspective as miniature doctoral students, though it is documented that MS students in engineering have different goals and motivations for pursuing graduate study than PhD students, as well as different anticipated career trajectories. To further compound these gaps in the literature, most studies assume that doctoral students in engineering come from historically privileged socioeconomic backgrounds. National conversations are clear that to broaden participation in engineering, the educational community must attend to the specific needs of students from low-income backgrounds. These students may also not have access to the social and cultural capital required to navigate graduate school, since many are first-generation graduate students and because systems of education are traditionally designed for students from upper class backgrounds. To this end, this study explores the experiences of first-semester graduate students supported in part by funding aimed to support master's students and have demonstrated unmet financial need. Interviews were conducted with six first- and second-year master's students and analyzed using thematic analysis methods employing Posselt's Framework for Doctoral Student Support—here, extended to master's students—to elicit information about surprises, expectations, and unanticipated issues facing this special population of students. Findings indicate that there are several easily implemented structural modifications programs and faculty can take that can facilitate the transition to graduate school for graduate students, low-income and otherwise.

Introduction and Literature Review

Graduate engineering education literature is still scarce, but becoming more common, with common streams of attention focused on retention of graduate students, particularly given tragic trends in underrepresentation and attrition of students of color[1], [2]; graduate identity development[3], [4], [5], [6]; graduate competencies[7], [8], [9], [10], [11], [12]; and graduate well-being to counteract common causes of attrition[13], [14]. To date, however, most literature considers “graduate students” holistically while prioritizing the experiences of doctoral students, who have several years in which to acculturate into the academic norms of their departments, match with an advisor, and learn to conduct research. Engineering disciplines are unique from other disciplines in higher education in that most doctoral students and even many master's students are fully funded on research assistantships (RAs) or teaching assistantships (Tas), and the research assistantships are tied tightly to the lines of funding an advisor has won. The research group plays an important part in the development of belongingness in academia; literature has shown how research groups of various sizes accommodate differently to be able to support sometimes very large numbers of students[15], often employing ‘deputy’ status to postdoctoral scholars, research staff, and senior graduate students to be able to support more novice students as they enculturate into the research group.

Literature is clear that there are several factors critical to success and retention in engineering graduate school, including quality of life and work (of which mental health and well-being are part); advisor relationship; social support structures in graduate school and beyond; and goals for graduate programs[16]. As these factors may shift, the student can begin considering the “costs” of persisting in their program, as has been described in recent work[17]. Ultimately, the stressful nature of graduate school is evident, with literature noting myriad coping mechanisms engineering students use to navigate various stressors in graduate school[18], [19], [20]. The studies on which these findings are based are high-quality, employing stratified sampling to achieve diversity in participant demographics as well as stage of graduate study and engineering discipline. However, to date, there has been little focus specifically on the transition into graduate school in timeframes very close to the beginning of graduate school: The retrospective nature of

interviews with later stage students may mean that some of the salient factors and stressors of early stages of graduate school were forgotten or lost their poignancy over time as the issues were resolved.

Further, there is a need to separate the experiences and socialization processes of Master's students from those of Doctoral students, as noted previously by Sallai et al[21]. Although that paper discussed the reasons for pursuing graduate study and staying in their programs differing between the two populations, we also highlight here that all the prior literature on socialization that focuses on graduate students inherently assumes that there is substantial time in order to make these advisor matches and to ensure that these socialization processes occur. However, for master's students in engineering—many of which are pursuing thesis/research-based degrees requiring research credits, substantial progress, and a resulting thesis—this “time” to acculturate is difficult to accommodate. For a two year degree program, assumptions are that students are able to jump into research nearly immediately to make progress. To that end: The purpose of this paper is to investigate the transition into graduate school for beginning-stage master's students in engineering programs at a large research institution, answering the following research questions:

1. How do early stage engineering Master's students seek support and make sense of challenges through their transitions into a Master's program in engineering?
2. How if at all, did financial issues manifest within the transition to the Master's degree?

Theoretical Orientations

This study employs Posselt's Framework for Doctoral Student Support[22] as a conceptual framework for the study. Developed through a study of STEM doctoral students, the framework presents mechanisms by which faculty can and should support graduate students through the academic, psychosocial, and sociocultural aspects of graduate school. The framework lays out four categories of faculty behaviors that are crucial to support: Visibility, responsiveness, downplaying status, and cultivating trust. Through the faculty behaviors, they can help students overcome the common thematic challenges in graduate school, broadly categorized into subject matter learning, scholarly development, conflicting norms of challenge and support, conflicting academic and personal values, impostorism and belonging, and identity threats. In this study, we employ this conceptual framework as an *a priori* coding schema to help us understand how these elements may manifest, or manifest differently, for very early-career graduate students, as a way to interpret students' perceptions on their transitions into and through graduate school. In this study, we are particularly interested in how the challenges emerge in these first semesters, and how faculty (and by extension, departmental programming/support structures) may or may not be meeting those challenges.

Methods

Context: This research was conducted at a single large research intensive (RH-VH) public university located in the mid-Atlantic region of the United States, as part of an NSF Funded S-STEM program. S-STEM programs are intended to support low-income students in their trajectories to and through school. While most funded SSTEM programs in the United States are aimed at undergraduate student support, this SSTEM is unique in that it supports low income Master's students to obtain thesis-based MS degrees. Students in the program are supported financially, have substantial professional development programming, regular mentorship meetings with faculty affiliated with the program, and peer/near-peer mentoring. At the time of data collection, the program was in its second year of funding. Students are enrolled in a variety of different engineering departments; one of the consistent challenges is working within the individualized structures, processes, and norms of different departments as we support students: For example, research advisor matching processes look very different across departments; some students attended this same university for undergraduate and already had made connections with faculty; and other variance means that not all students encounter the exact same issues at the same times.

Participants and Recruitment: All participants in this study are first- or second-year Master's students enrolled in an engineering field at the institution of focus in this study. While the different disciplines of

engineering at the university differ slightly in application requirements and timelines, all Master's students at are required to do research and write a Master's paper or thesis (i.e., there is no coursework-only/non-thesis option.) All participants for this study recruited were part of the SSTEM, although participation in this particular study was optional. IRB approval was obtained for the entire project and all data collection; the interviews collected and analyzed in this study are part of the broader engineering education research plan in the funded SSTEM project. All 11 current SSTEM students were recruited for participation in the study; 6 students scheduled interviews in the timeframe for collecting data for this paper. Of those six, two were second-year MS students, and four were first-year students that were just finishing their first semester of their engineering Master's program. Five participants were men and one was a woman. Three of the participants had previously attended Penn State for their undergraduate degree, and the others transitioned for their graduate work from a variety of institutions. The disciplines of these students in who participated in the interviews reported here included aerospace, nuclear, and electrical engineering.

Data Collection and Analysis: Semi-structured interviews[23] were conducted via Zoom with the study participants, recorded, and transcribed. The basis for the interview protocol borrowed interview protocols from past research by the research team investigating graduate engineering student development, goal setting, and asked questions that prior research have found to be important for students' success. Even though these questions were similar to those asked of participants in previous work, we were not sure how populations of very early stage graduate students would answer these questions. The interview protocol also asked about the transition into graduate school and what things surprised them about graduate study, or what things had differed from their expectations. Interview transcripts were transcribed by secure auto-transcription service, and cleaned by a member of the research team for accuracy by listening to the original audio recording and modifying the transcript. Then, the written transcriptions were coded using and abductive approach[24], employing Posselt's Framework for Doctoral Student Support[22] to understand the transition experiences of very early-stage engineering Masters students were navigating their graduate environments. Of note, it is the aim of the SSTEM program to alleviate some of these issues, particularly surrounding mentorship, professional development, community, and career trajectory support, but the data analyzed for this paper attended to how the students were encountering these issues in their own departmental domains.

Limitations of the Study: While the goal of qualitative research is not to be generalizable, we offer the following findings as a sending context, by which readers of the paper can consider which aspects of the qualitative experiences reported in this study might translate to their own contexts, and how. The participant population for this study are all at a large R1 public institution and are part of a funded program intended for students with demonstrated financial need. One caveat to this selection criteria is that for graduate students, it is very difficult to ascertain whether demonstrated financial need is a function of being independent from parents on FAFSA, or whether the financial need is a result of low socio-economic status in childhood (e.g., Pell eligible.) To be eligible for the SSTEM funding, all that is required is a FAFSA with demonstrated financial need, and acceptance into a thesis-based master's program at this university. However, we must be clear that the 'demonstrated financial need' may or may not correspond with family financial status, and it is probable, given the literature on low-SES students[25], [26], that there may be additional significant barriers to pursuing a graduate degree in engineering for these students, especially if they are first-generation college students. Some of our participants discussed their statuses, if relevant.

Findings

The final codebook is shown in Table 1. Adapting the themes from Posselt's[22] framework, through the abductive coding processes, we developed subthemes to better capture how these aspects manifested in the perspectives of the early-career graduate students. All these codes are new, emergent from our data through the abductive coding process; the only addition to the larger categories is extending the definition of "Faculty behaviors" to also include departmental behaviors, since many new Master's students did not yet

have a research advisor. Throughout the data, students took a very agentic view of their own development, often attributing their issues to things they “could have done differently” or things they “wished they would have known” rather than more directly articulating which entity could have provided that needed support. As such, as data were analyzed, students were not accusing their faculty members or departments of anything, and through this qualitative coding process, the research team was able to ascertain to which of the support/behavior categories either the positive instances or the lack of support instances mapped.

Table 1: Codebook and Definitions, Adapted from Posselt (2018). All themes were present in original framework; all codes were new from this work.

	Theme	Codes: Ways in Which Theme Manifests in Master's Engineering Students
Faculty Behaviors and Departmental Support*	Visibility: Faculty are visible to students including regular meetings with students	Regular research group meetings Access to faculty before and during graduate study
	Responsiveness: Attentiveness to student needs and concerns, with timely feedback	Quality of Feedback Access to answers (faculty or other students) Attentiveness to Prospective Student Research Interest
	Downplaying Status: Actively reducing power dynamics where appropriate in student interactions	<i>Not observed in this dataset</i>
	Cultivating Trust: Ways in which the student perceives that the department or their faculty supervisor will support them	Clarity of expectations around working hours and graduation requirements Financial support and backing; advocacy Clarity and transparency in research advisor matching processes
Dimensions and Expressions of Support	Academic: Normalizing Struggle	Overselling graduate programs Perceptions of “helpful hints” toward research progress Shifting expectations week to week Ambiguity in department structures, policies, procedures
	Psychosocial: Validating Competence and Potential	Departmental and faculty offers of funding validate student self-perception of competence and potential Encourage social support in group and department
	Sociocultural: Keeping it Real about Race and Gender	Access to affinity groups for specialized support Willingness to attend/utilize resources for specialized support
Student Challenges	Subject Matter Learning	Coursework selection and preparation Role of coursework in graduate study
	Scholarly Development	Professional skills Balancing time Assuming more responsibility in a research team How to find a research advisor How funding mechanisms and expectations work
	Conflicting norms of Challenge and Support	When to ask for help in independent research Academic advisor versus research advisor
	Conflicting academic and personal values	Establishing life balance
	Impostorism and Belonging	Built community inside research group/among grad students Established support network outside graduate school Involvement in graduate student organizations Worth and belongingness linked with funding
	Identity threats	<i>Not observed in this dataset</i>

Many of the experiences of the graduate students were not new to literature—issues with advisor matching process; issues in re-learning to balance graduate coursework along with teaching or research responsibilities; and development of support networks dominated the conversation. However, many of these topics manifested in very specific ways for these very early career students, which we highlight in the following sections. The following sections will be presented first in terms of student challenges, then dimensions and expressions of student support; then faculty and departmental behaviors before offering our discussion and implications. In these sections, we will not cover each and every one of the subthemes, but will present the theme as whole, discussing the most interesting parts of how these facets emerged in this population.

Student Challenges.

Likely due to the novice status of these graduate students—some with 1.5 years of their masters' program done, some with only four months completed at the time of the interview—the ways in which student challenges manifest for Master's students is different than reported in literature for doctoral students. Often, these challenges were reported by students as being somewhat expected, but that there were unexpected surprises related to these challenges that caused them duress during their transition into graduate school. Experiences with subject matter learning, for example, were discussed from two points of view: Students who had switched disciplines for their master's degree noted a “learning curve” but by and large, students felt surprised by the shift that graduate students in engineering only take a few classes, and those classes are typically, in the experiences of these students, meant to be useful and reasonable rather than exams being “soul-sucking” (in the words of one participant.)

“It was a very big change, in my opinion, from what undergrad is to what graduate school is like. So it was different at first, but once I got in a groove, I’m kind of going through that now, I’m good now. In grad school [...] I feel like it’s primarily research-focused, which was very different for me. And while you do have classes and things like that, it’s difference... It’s not so much worried about ‘getting an A on this exam.’”—Henry

Students from small undergraduate programs also struggled through the transition in both coursework and research, feeling and felt that there were too many choices, and a lack of structure in procedures. For example, Edith noted the challenges of moving to a large university:

“I’m obviously at a disadvantage because I didn’t go to [this University] for undergrad and it’s difficult, because this university is ten times the size of [undergrad institution]. So there’s a lot more choice. There’s things like... I don’t know what a professor is going to be like. As an undergrad, like, you could easily ask someone and they’d be like ‘Oh, well, the professor is like this, this professor is great, but he does this [...] And the admissions process for grad school for engineering, was not very clear. Like, it wasn’t just me, I remember talking to another student who was also confused, he was like, ‘Do we have an academic advisor? Are we supposed to?’ And I think there needed to be more clarity at the beginning of expectations, even in the orientation, there could have been more.” --Edith

Other students navigated this with the help of a department mentors or advisors who suggested them to take some senior-level undergraduate coursework to help bridge into a new domain of learning, but sometimes only after some duress in the first semester, rather than proactively. However, all participants assumed that the subject matter learning challenges were to be expected, noting that the specialization and deep learning was essentially the reason they had decided to pursue a graduate degree. Challenges related to scholarly development also related to establishing new routines to balance coursework with teaching and research obligations, or conversely, in the absence of research, how to manage time to accomplish coursework while finding a research advisor.

Many students expressed apprehension at the opaque nature of “how” to write a thesis, wishing there were a timeline or protocol for when they should be writing which section. Henry noted having apprehension

about the writing and research timeline, with most of his knowledge coming from word-of-mouth from other students:

"I found out from another student that if you don't start early in terms of research and don't start right away, you may not get to where you need to be. You may, you may not...after two years, you may not be where you should be in terms of research, and you may not be able to finish within two years. [...] Theres' not really a...someone or a thing that shows you how to go about writing your thesis or where you should be...kind of like a timeline. I know it's different for everyone, but maybe like a timeline to kind of help guide where you are throughout the process."—Henry

Quotes like these indicate that students are not getting enough professional development in how to collect, read, interpret, and use literature in their research processes. Given that literature has captured these facets for doctoral students for decades, this research shows that the problem is perpetual that graduate students seem to be needing to reinvent the wheel for themselves rather than being prepared effectively with the information they need to thrive.

The other big challenges students noted related to the unclear procedures in which research matching occurs. Given that in engineering programs, student funding flows through each faculty member's funded projects, there is often a tension where students interested in one research area cannot find an advisor who works in their area of interest with available funding that can support a two-year project. Especially in smaller departments, the process of identifying and courting research advisors is very individualized, [Participant] discusses how he felt like he stumbled onto doing things the "right" way and how he notes that if he would have left the process until the academic year, he may have been at a disadvantage.

"So, I emailed [current research advisor] right away and that's kind of how I got into it, but I actually reached out to him before I got to grad school, before I started. So I feel like [...] that's kind of one of the big things that I didn't know, but kind of lucked into by reaching out early and starting early. I feel like that's one thing that, me personally, I didn't know coming in, but I lucked out by reaching out early."—Henry

Approximately half the students in this participant pool had a research advisor; half were still searching. Roger discusses the uncertainty for how advisor matching operates on an *ad hoc* basis, which causes lots of "awkward conversations" with faculty that leave students feeling like outsiders and unsupported.

"I don't know how it's usually done, but it's very individual. At least in [my department] right now, there's not money, so I've been, you know, nagging some professors about their proposals and trying to keep up to date with them. It kind of feels like I have friends in terms of I can complain about the problem, but I can't really get anybody to help my out with finding an advisor. You know, obviously I can talk to my temporary advisor, but they can only help me out so much because I have to come to an agreement with a professor. [...] I'm like, very timid. I feel like it's hard for me to approach professors, so I'm trying to over come that. But I feel like if there were some easier way to, you know... it feels award getting in contact basically, and you know, trying to tell them about your interests."—Roger

Edith's noted a similar feeling of being "left behind", as she discussed how she had no idea how the research process was supposed to commence, feeling upset that it seemed like other students had some additional hidden knowledge.

"...Understanding enough to know who to talk to for research is one thing where I'm, like, I am still figuring out...I'm behind, there. Like, how do people know they're ready for research? Like, how does happen? [...] When I came to orientation day, and there were some people I was talking to, and they, like—they'd gone to undergrad [here] and they're like, 'Well I'm going to work with this exact professor.' And I'm just like, 'Huh?'"—Edith

While Edith, later in the interview, attributed these skills to having done their undergraduate work at the same university, there are also other elements of social and academic cultural capital at play in these hidden competencies and norms of graduate school that could be structured more thoroughly for students.

Dimensions and Expressions of Support (by Faculty and Departments)

We saw evidence of all the three dimensions of student support (or unsupport) in participants' interviews. Academic support, including normalizing academic struggle, manifested in participants interviews through several themes, most of which related to how often they felt they could meet with their advisors (for those in research groups) and how comfortable they felt asking questions. For the students who were not in research groups yet, this (lack of) support was acutely felt in the ambiguity of selecting appropriate coursework. Although students who come into graduate programs who don't yet have a research advisor were typically assigned to the Graduate Program Director or another faculty member as a temporary advisor, typically there is little guidance about what courses "have to be" taken in graduate programs. This open-ended freedom resulted in some students selecting courses that sounded appropriate but ended up being extremely specialized, such that students felt over their head. Students expressed some consternation that they didn't realize there was no one to help them select appropriate courses, and that the freedom to select any courses in the department actually was the cause of struggle.

Programs and faculty also influenced these Master's students' perceptions of self-confidence and competence in ways that may not be immediately visible. For example, students who were offered a departmental TA to support their first year in school, or students who were offered a research assistantship by a faculty member felt like, even if they were still unsure, another entity wanted them there as an external form of validation that helped to carry them even in hard weeks. Alternatively, students for whom no departmental/faculty support was available immediately, who were also struggling to find a research advisor, worried not just about making satisfactory research progress and how they would manage to complete a thesis in a relatively short time, but also struggled with self-perceptions of competence. Edith, who expressed uncertainty around how other students had known to contact professors ahead of time, continued, saying

"I at some point did try to reach out to a professor, but they were like, 'Hey, you need to be able to do this thing, and if you learn it in this time, you can do it. I did not. So I went back to square one and I think it's like figuring out who has active research projects has been the biggest thing for me. Because I don't want to just pull the 'Email people until I find something' and I'm still trying to figure out how to find out how I'm supposed to get [research...] I don't know how to figure out what all the projects are and what can take on new students." -Edith

We did explicitly ask about departmental and university support for graduate students and whether the participants were involved in any other affinity groups or student groups. Some students reported being vaguely aware that there were graduate student support groups or programming intended to increase the community of the department, but most also said that they chose not to attend these events.

"Yeah, we do have events, like we have a fall party and a cookie party, just yesterday, I didn't attend...but they do offer events like that. One time, the head staff member of the department hosted a hike and ice cream and icecream truck. I also didn't go to that, but there are events that the department is holding, like, for leisure." --Pete

Another student, who was very involved in his department as an undergraduate student and continued this leadership as a graduate student, expressed consternation that graduate students rarely attend the events.

"The one annoying thing is, I'm really involved with our [professional society] orgs, with three of them. [...] Grad students don't participate! I don't know why. I mean, we do a ton of outreach things and social things, and professional development, but they don't really jump in that because I guess they don't see the benefit in it, which is like, 'Okay...?'" --Arlo

The rationale for not getting involved with social, professional, or support groups between students. Some discussed that they felt they already had sufficient social support in their research laboratory groups; and others noted that they know they "should" go but when events come up they just don't attend. Worryingly, some students expressed the sentiment that because they're only there for two years, its not "worth it" to build a new friend base, seeing these "extra" things as purely social and not part of their technical progress and success.

Faculty Behaviors and Departmental Support.

This theme is potentially the most valuable theme from the paper, pulling together how the challenges and the types of support can be enacted by faculty. The four categories of behaviors from Posselt's framework are: Visibility, Responsiveness, Downplaying Status, and Cultivating Trust. We did not see explicit instances of "Downplaying status" from the students in our population, but we do note that the students who reported feeling that they were thriving in their programs discussed feeling comfortable bringing their issues (both research and personal) to their advisors, indicating that the lessening of the power dynamic is likely present, even though it wasn't explicitly addressed here. All the participants discussed how the visibility and responsiveness of faculty members (and staff) was essential to their transition into graduate school. Some were happily surprised with how welcoming the faculty members were and willing to talk with them about their research, even if funding was not available. Other students were happily surprised with how easily faculty members introduced the incoming students to their research group; promoting the importance of the research group as a pseudo-family in engineering departments. On the flip side, some students struggled with this, and when faculty were not responsive, or not visible in the form of regular meetings, the lack of support impacted sense of self and they found themselves questioning whether they belonged in graduate schools, recalling Edith's quote about trying to find advisors, and responsiveness, above.

Most interesting to us was the role that finances and financial support as evidence of championship, selection, and support meant to these master's students, as a form of cultivating trust. The students, without being armed with a deep understanding of how funding works in academia or research institutions, perceive that the offer of funding either by a department or a faculty member as a process of selection, that they are "worth" supporting and have been "chosen."

"Honestly, it was not until I began grad school, like, as I said, my advisor kept, like, suggesting he could offer me a research assistantship! I didn't understand that he had just received a huge grant to basically support students on a [...] project, and I didn't understand that, like, I was basically the person who was going to be the flagship of this program!"-Pete

While we don't diminish the importance of funding in student support, literature has typically treated financial support as a means to an end, such that students don't have to worry about paying bills or taking second jobs. Here, we note that the financial support—from the point of view of these participants is, to them, evidence that they belong in the program and are supposed to be here. Without knowledge of intradepartmental politics around research assistantships, teaching assistantships, budget models, etc., these students take the offer of financial support as external recognition that not only were they accepted but they have the skills to be able to do a master's program. This is even more poignant when a faculty member picks them up on a research project—being "claimed" by an advisor financially is the first step to belonging.

"Downstream" of the funding and advisor matching decisions, however, there are also faculty behaviors that either promote or erode trust. Arlo discussed the uncertainty of expectations and a seeming shift in expectations from week to week that made him feel like he was unable to assess his progress:

"That's another kind of questionable side of grad school. At least with my advisor, [expectations] can be kind of unclear because sometimes it's like, I'll discuss something with them that I think isn't really that substantial and it's like, "Oh Wow! That's awesome!" There are other times I present my stuff and it's not ...it might not be enough. It's a little difficult [...] it depends what mood he's in."—Arlo

"My current advisor [...] was the one I actually wanted to work with originally, but when we met during my senior year he said he didn't have room for students. So it kind of worked out, but at the same time I kind of got thrust on his schedule and he's already pretty stretched thin, so [...] We also have weekly meetings just between the students so that it's less harrowing, which is also really helpful to get other people's perspectives in that way too. It's kind of hard to read them [advisors] sometimes. [First Advisor] was a hard guy to decipher in terms of, like, what he wanted, how exactly he wanted it done. Not a lot of hints directing me towards where I should be thinking, which , I mean, that's

something expected from grad school, and [...] has definitely played out in the way I expected it to. My current advisor, like I said, he's stretched thin that I can't always reach him, but when I can, he gives good hints. He's very direct in terms of being like, 'This is what you need to kind of gear yourself toward [progress.]' —Frank

These quotes show how “Cultivating Trust” also manifested downstream, in how a research advisor fosters community in the research team, and whether and how the students felt they could depend on their advisor to offer “good hints” on their research or not change their expectations but the financial trust as an “upstream” trust was an interesting and important finding in this work.

Discussion and Implications

There are three main discussion points that we would like to highlight from this work. Although a small sample, a focus on very new graduate students transitioning into their programs, and particularly students that have demonstrated financial need, is of high utility to the research and practice engineering education community. We offer these three main discussion points combined with their implications in the following section.

Master's Students may not be able to rely on the Research Advisor as a sole source of trust. Prior literature, including Posselt's framework, prioritizes the research advisor as one of the sole sources of information and support. This is not untrue, especially for doctoral students, and certainly literature supports the essential elements of a strong and healthy advisor relationship[27], [28], [29], [30], [31], [32]. However, most of this literature explores the role of the advisor after that relationship has been established. For master's students, the advisor matching process is tenuous, because of ambiguity of matching process, time limitations on the master's degree, the priority in funding PhD students who are already on the research teams, and a tension in research interest vs. faculty with available funding. All of these issues are things that are not apparent to master's students when they are incoming, and are more acute for Master's students. As such, this work highlights the importance of clear departmental structures and protocols that incoming Master's students can follow to select appropriate courses, find advisors (given relevant departmental norms), and some preparation in basic “grad school hacks” so that master's students don't need to reinvent the wheel in their short duration of time. In other words, Master's students need to have full trust in the department to support them until that trust can be transferred or extended to a research advisor, ideally one that similarly is trustworthy from the point of view of the student.

Confidence and competence cues are developed through several external and internal mechanisms. Because we focused on very early stage Master's students, we highlight some of the emergent issues related to how students take in cues and information that affect their confidence, perceptions of competence and value, and, from literature, plausibly have downstream effects on belongingness. Master's students in this study were constantly comparing themselves with others—who has an advisor already, how many still don't have an advisor, who has what types of funding—in ways that immediately influence their worth. Especially for students attending graduate school at a new institution (different from their undergraduate degree) and moving from a small undergraduate institution to a very large research institution, these cues are strong and not mitigated by a strong support network at the beginning when students are starting their programs. The implications of this finding are that to the extent possible, departments should build in true community-building to orientation and onboarding meetings in the department; advisors and grad chairs should strongly encourage students to join graduate student groups (also highlighting their leadership development opportunities and professional development assets); and, again, ensure that students have a high level of trust in how they are to select classes or begin conversations with research advisors.

Finances are a key element in developing and establishing trust. Particularly for Master's students and particularly for graduate students with demonstrated financial need, we found that finances operate in a more nuanced and sophisticated way than just avoiding student loans or being able to focus on research rather than having a second job. For Master's students who were offered departmental funding or a research

assistantship, the financial support indicated to them an external form of recognition and competence that was able to bolster them through some of the other challenges they faced in terms of coursework. In the absence of a research advisor at the beginning of a program, having financial support from the departmental (for example, from a Teaching Assistant position) boosts confidence and gives them a job to do in the department, building belongingness. Students without funding feel they are worth less than students who do have funding, and this stress compounds the rote financial pressures of graduate school. Funding opportunities also innately have social components—Teaching Assistants work with other TAs or faculty members, thereby socializing into departmental norms, and Research Assistants are part of a laboratory family, that, if facilitated, can serve to develop belongingness over time[15], [33]. As a recommendation, to the extent that it is possible, equitably distributing funding to unfunded students will be a consistent best practice, but if there are students who cannot be funded, it would be a suggestion that the department strongly message opportunities to be involved in the department, and explicitly note how these processes work such that students do not take the lack of funding as a measure of their worth right off the bat as they transition to graduate school. Graduate offices and graduate program directors should be acutely aware that students are comparing themselves with other students, and making assessments about themselves based on their limited data and understanding of policies: Thinking proactively about how to message the funding landscape in different departments would likely go a long way in helping students reconceptualize their belongingness as beginning master's students.

Conclusions

In conclusion, this qualitative study investigated the experiences of beginning-stage Master's students who had demonstrated financial need, in engineering programs at a large research-intensive university. Viewed from the conceptual framework of Posselt's Framework for Doctoral Support adapted to this audience, this study showed that the issues of challenges and support manifest differently for master's students and especially novice Master's students because of their limited time in the program and the ways in which they were making sense of their experiences. In particular, we used this framework to analyze the ways in which students felt supported or not supported by their research advisors (if they had one) and/or the department. Adding value to prior literature, this extension of the framework shows how impressionable these early-stage students are to external cues on their competence, affecting their self-confidence, and the role that funding plays in establishing the foundations of trust in a department and in faculty members. Being financially "chosen" by a graduate program or a faculty member helps to provide external recognition that can help overcome challenges; conversely, students who don't have any funding and who are struggling to find a research advisor conceptualize this struggle as a direct reflection on their competence and worth.

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