Engineering practitioners in PhD programs: Who are they and why do they return?

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I. Introduction

Future economic development and security in our knowledge-driven global community relies on engineers in industry, academia, and government who have the technical skill, knowledge, vision, and expertise to identify and solve real-world problems and connect scientific knowledge and theory to technological advances[1]. These qualities are learned and developed through education and real-world professional experiences and consist of a strong theoretical background as well as rigorous research and problem solving skills. Engineering students who have spent time working as engineering practitioners prior to pursuing a PhD, a group we refer to as returners, can bring this combination of experiences and expertise to their work, potentially placing them in a unique position to identify practical needs and apply their skills to developing innovative solutions.

While returners may have the potential to play a critical role in addressing the advanced engineering needs of the 21st century, very little is known about engineering returners, particularly at the graduate level. Our team developed a three phase study in order to better understand returners' past experiences and how their experiences may be better leveraged in academia, government, and industry to advance engineering innovation. The first of these phases is the Graduate Student Experiences and Motivations Survey (GSEMS), a national survey aimed at characterizing the population of PhD-level returners in engineering and developing a better understanding of their experiences and motivations as compared to direct-pathway students, those students who begin a PhD shortly after completing their undergraduate degree. This paper focuses on the findings of this first survey phase, specifically findings related to describing returners' past work and education experiences, their processes for deciding to pursue a PhD and selecting an institution, information about their PhD programs, and their plans upon completing the degree. We aim to use findings from our study to inform efforts to better recruit graduate returners, support these students throughout their academic careers, and learn more to better utilize their unique skills and perspectives within both academia and beyond.

II. Background

The report "Rising above the Gathering Storm," sponsored by the National Academy of Sciences, National Academy of Engineering, and National Institute of Medicine[1], outlines several investments necessary for the United States to make in order to "compete, prosper, and be secure in the global community of the 21st century." One of the investments highlighted is people, specifically investing in highly-trained engineers across government, industry, and academia who are able to apply technical knowledge to solve problems, anticipate real-world implications, relate theory to technological advances, and have vision and endurance to identify opportunities for innovation and successfully implement them. These engineers require both knowledge of the theoretical foundations of STEM disciplines as well as the skills to conduct rigorous research on which innovations are built. These skills are honed through engineering practice and advanced training like that offered in engineering graduate programs.

Returners are likely to bring a unique perspective to both their graduate work as well as their work upon completing their degree. They have a diverse array of personal as well as professional experiences, which may include work experience in academia, industry, government, or the military, that they can draw on in their academic work[2].The convergence of ideas from multiple contexts can often be the source of innovative outcomes[3].Thus, the intersection of returners' previous experiences as practitioners and their academic training in a PhD program could provide the groundwork for innovative solutions to global engineering challenges.

Due to returners' first-hand experiences as engineering practitioners, their academic work is likely to have more direct and immediate applications in the engineering community, regardless of if they decide to pursue a career in academia or return to a career in industry or government[4]. Returners enter academia with an understanding of real-world engineering problems that they can apply to their research work. In our team's initial case study, one returner explained that her PhD research directly addressed needs she had identified in her industry experience and her plans following her PhD directly related to the outcomes of her research work[2]. For those returners who decide to return to a position outside of academia in industry or government after completing their PhD, their past experience likely enables them to advance in their careers more rapidly to higher positions with greater impact than their direct-pathway peers are able to do. In addition to returners' rich work experience, they represent a largely untapped source of potential engineering graduate students. The National Science Foundation has called for additional pathways to and through advanced engineering programs[5]. Engineers with advanced training are crucial for success in today's global economy but there are currently too few students enrolling in advanced engineering study[6]. In particular, women and traditionally underrepresented minority groups pursue advanced degrees at a disproportionately low rate, limiting the diversity of perspectives of highly trained engineering professionals[6,7,8]. Numerous studies point to the benefits of having diverse teams: diverse teams can increase problem-solving capacity and creativity, demonstrate broader perspectives, and develop innovative solutions[9,10,11,12,13]. Returners represent an additional pathway through advanced engineering and a better understanding of and support for these students may positively contribute to an increase in the diversity of experiences and perspectives of students enrolled in engineering graduate programs.

While the work of returners may have significant impact, very little research has been conducted about returning students at the PhD level, particularly within the field of engineering. There have been several studies on returning graduate or undergraduate students in other disciplines that provide some insight into the experiences of these students. Existing studies within and outside of engineering also point to some differences in the motivations and needs of returners compared to direct-pathway students. Returning students are often more goal-oriented[14,15], more motivated and mature, have stronger teamwork skills[16], and generally display a high work ethic[15]. However, returners have reported struggles with a different work style than many of their peers[17], a lack of mentoring and information about applying to and enrolling in graduate programs, less recent practice with advanced mathematics[15], a reduced chance of receiving fellowships and research and teaching assistantships, and balancing time for family responsibilities[18]. Engineering returners have reported perceiving engineering programs to be unwelcoming and feeling they do not fit in with the traditional graduate population[17].

In an earlier study, we conducted interviews with ten returners to learn more about their decision to return to graduate school and their experiences during their graduate program. The findings of this work suggested several common themes within the experiences of returners and provided a useful starting point for a more broad-scale investigation. These themes were clustered based on different aspects of returners' identity, including their identity as scholars, as individual students, as members of the student community, and as whole people. Themes also emerged that described the transition in identity that took place as returners made and executed the decision to return to school[2]. Further analysis showed that Expectancy Value Theory (EVT) was a suitable framework for interpretation of the data[4]. This interpretation yielded several interesting findings. First, it was found that the returners had a high expectancy of success. While they might question whether a graduate degree was worth the effort required, they generally were confident in their abilities to complete the degree. Their motivation for completing their degrees was primarily driven by Utility, the certain advantages that come with an advanced engineering degree that will help them advance their career goals, with Interest in advanced engineering topics and experiences ranked second and Attainment, or the idea that an advanced engineering degree is fundamentally aligned with their self-perceptions, third. Several types of costs for returners completing their degrees also emerged from the analysis – Financial, Balance, Intellectual, and Cultural & Environmental costs. These findings provided new insights into returners in terms of understanding what kinds of tradeoffs they consider in their decisions to pursue a PhD.

In order to contextualize the experiences of returners, it's helpful to understand what existing work tells us about engineering PhD students as a whole. Information on graduation age data suggests that a majority of PhD students in engineering and other STEM disciplines are direct-pathway students, as the average age of doctoral recipients in engineering upon graduation is 30.5. This is in contrast to other fields that appear to have more returners, such as education, in which the average age upon completion of a PhD is 40.5. Physical, life, and social sciences also appear to have younger graduate students, with average doctoral graduation ages of 30, 31.2, and 32, respectively, whereas students in humanities (average 34.2) and other non- science and engineering fields (36.2) skewed slightly older[19]. While it's likely that this difference in graduation age between fields is due in part to a higher proportion of returning students in non-engineering fields, it may also reflect differences in average time to degree and proportion of part time students in these fields. Of all of the doctoral degrees awarded in engineering in 2012, 22.2 percent were awarded to women[20]. Among 2012 engineering PhD recipients that were US Citizens or permanent residents, 69.8 percent identified as white, 15.7 percent as Asian, 5.4 percent as Hispanic, 4.3 percent as Black or African-American, 2.2 percent as mixed race, and an additional 2.5 percent of students whose ethnicity is other or unknown[21]. The NSF 2012 Survey of Earned Doctorates indicates that the most common primary source of funding for Engineering PhD students are research assistantships or traineeships (60.7 %), followed by fellowships or grants (21.3%), teaching assistantships (8.6%), their own resources (4.1%), and employers (3.5%), with an additional 1.8 percent receiving funding from other sources[21].

Students choose to pursue PhDs for a variety of reasons: to advance their careers, to obtain a high-paying job, a desire to be a teacher or researcher, to complete their education, an intrinsic psychological desire to be an engineer, a desire for more knowledge within their fields, to help others with their work, the lifestyle and regard for scientists, as a means to make a career change, or even a lack of better options[22,23,24]. Upon completing a PhD, graduates pursue a variety of

options. In 2012, 63.6 percent of PhD graduates across all disciplines had definitively committed to either postdoctoral study or employment at the time of graduation. Of those, 41.1 percent of graduates planned to pursue a post-doc. For 2011 engineering graduates who had confirmed employment plans, 71.2 percent were going into industry or business, 13.5 percent planned to pursue an academic career, 11 percent planned to work for the government, 2.7 percent in a non-profit organization, and a remaining 1.7 percent had committed to an other or unknown position[21].

While multiple studies have provided insight into the composition, motivations, plans, and experiences of engineering PhD students as a whole, it cannot be assumed that these findings accurately represent the minority of engineering PhDs who are returners. As graduate returner status is not a demographic that is commonly tracked by engineering colleges nor fully explored within engineering education literature, it is unknown how returning students compare to the engineering graduate student population at large. Our work aims to address this gap in the literature by providing insight into the demographic composition of returning PhD students, their past educational and work experiences, decision process to return to graduate school, experiences and support during graduate school, and plans upon receiving a PhD.

III. Methods

We developed and distributed a national survey to help us better understand the returning student population and how these students compare to direct pathway students. The survey was grounded in theory and literature as well as findings from our earlier smaller-scale investigation and aimed to characterize the characteristics, experiences, and motivations of returners. In the following section we describe the survey contents and its development and distribution. It also further describes the focus for this particular paper and methods of analysis.

A. Survey development

The Graduate Student Experiences and Motivations Survey (GSEMS) was created to better understand the backgrounds, experiences, and motivations of returning and direct pathway students. The results of the initial study, described further by Peters and Daly[4], supported the use of Eccles' Expectancy Value Theory (EVT)[25,26] as a theoretical model for our survey to explain how and why returners make the choices they do, based on the anticipated results of their various options, the costs required of each choice, and their personal interests and values. The EVT model helped to shape our survey, which included questions about students' decision to pursue doctoral study, their anticipated success, what they value about pursuing a PhD, and the challenges faced throughout their degree.

In addition to findings from our initial study and the EVT framework, we used findings from the literature on adult, returning, and PhD students, the experiences of our diverse team, and input from our advisory board, which consisted of experts from academia, government, and industry, to collectively construct an initial draft of our survey. The survey was further refined through several versions and multiple meetings to best reflect our study goals and best practices in survey design as described in literature. We then piloted our survey draft with six current PhD students using the think-aloud approach to cognitive interviewing. In the think-aloud approach

participants are asked to read each question and choices aloud and verbally describe their thought processes as they answer each question, a process that is helpful in identifying questions with confusing wording, those that may be misinterpreted, or questions that may be difficult for participants to accurately answer[27]. During these pilot interviews, we received helpful feedback on the wording of several of our questions as well as aspects of the PhD experience students felt needed more representation in our survey and we revised the survey to reflect these suggestions for the final version.

The final version of the GSEMS contained 11 sections:

- Demographic Information
- Academic Background Information
- Current Academic Information
- Pre-PhD Activities / Career
- Decision to Attend Graduate School
- Expectancy of Success in Graduate School
- Values of the PhD
- Costs of the PhD
- Cost Reduction Strategies
- Advising Relationship
- Post-PhD Plans

For the purposes of this paper, we focused on those sections that helped to characterize returners: basic demographic information, their current and past academic background, and work experiences prior to their PhD. We also looked at their process for deciding to pursue a PhD and their plans upon completing their PhD in effort to further characterize who these students are and their purposes for getting a degree. This type of information may prove helpful in the identification and recruitment of returners, an important first step in supporting these students and better utilizing their unique backgrounds. Future work will examine how the experiences, challenges, and values of returners compare to those of direct pathway students as well as taking a more in-depth look at both groups' process of deciding to pursue a PhD. A more comprehensive overview of the survey development process can be found in Mosyjowski, Daly, Peters, and Skerlos[28].

B. Survey Distribution and Participants

We distributed the GSEMS nationally to both returning and direct-pathway domestic engineering PhD students. We opted to focus only on domestic students due to the variation in "typical" paths to graduate study in other countries, which can be affected by factors such as compulsory military service. The survey was built and distributed using Qualtrics™ survey software, provided by a university-wide license.

Returners are a minority of PhD students and returner status is not yet a tracked demographic, which made survey distribution a challenging process. To attempt to get approximately equal numbers of returning and direct-pathway students, we contacted engineering graduate programs and asked them to distribute a screening survey invitation to their domestic PhD students on their graduate student mailing lists. The email briefly explained our study and invited students to

participate, but had no obligation for them to do so. The screening survey linked to in the email asked for basic information about students' education history that enabled us to determine returner status. The survey was distributed in several rounds; we initially started by contacting several engineering programs in the Midwest and eventually expanded our efforts nationally, contacting over 80 universities, with a total of 31 institutions agreeing to distribute the survey to their students. We also recruited individual participants through the NSF Fellows database as well as suggestions from survey participants.

While the survey was not a random sample and we are unable to draw any conclusions about its representativeness of returning and direct pathway engineering graduate student populations, we were able to sample diverse participants in regard to returner status, gender, race, and university affiliation. The survey yielded 476 usable responses from returning and direct-pathway PhD students attending 61 different universities in 30 states. 179 of the 476 responses were from returners. Approximately 35 percent of the total respondents were female, a rate higher than the 21.8 national percentage of female engineering doctoral students. About 14 percent of survey participants were underrepresented minorities, compared to an estimated 6 to 7 percent of engineering graduate students who are underrepresented minorities nationally[5]. Participant ages ranged from 21 to 64, with an overall average age of 30.4.

C. Analysis of Data

The first step in characterizing the experiences of returners was identifying which students are returners. For the purpose of this study, we defined returners as any student who had a total (though not necessarily continuous) gap of 5 or more years not enrolled full-time in school between completing their undergraduate degree and beginning a PhD. For those students who did not pursue a Master's degree prior to beginning their PhD or pursued a Master's degree only part time, we calculated gap years based on the difference between their PhD start date and completion date for their undergraduate degree. For those students who pursued a Master's full-time at any point prior to beginning their PhD, we subtracted the length of the Master's program from the difference between their undergraduate degree and start of their PhD to determine the total years not enrolled as a full-time student prior to beginning their PhD. Any student whose gap years totaled 5 or more, was classified as a returner. We chose 5 years in order to capture the experiences of those students who have been out of academia long enough to establish a career and develop significant experience within a field, as opposed to those students entering the workforce for 1 or 2 years with the intent to return to school after a short break. We separated out the responses for returners and traditional students, and for this paper, we focus only on the returner group with the goal of understanding characteristics and experiences of this population. Analysis of the survey responses for paper consisted primarily of basic descriptive statistics, calculating means, counts, and percentages to begin to characterize returners' experiences and opinions.

IV. Results

A. Demographic Information

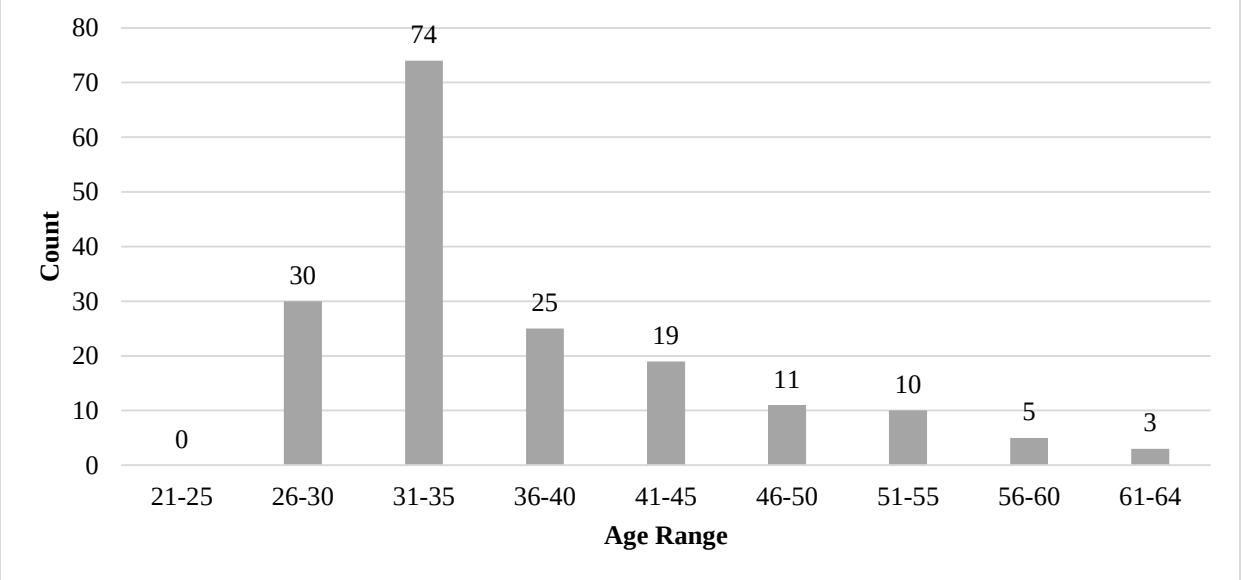
Participants were asked to complete several questions asking about basic demographic information, including:

- What is your gender?
- What is your current age?
- Please select all races that apply to you: (American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Pacific Islander, White, Other)
- Are you Hispanic or Latino/a?
- What was your relationship status when beginning your PhD?
- What is your current relationship status?
- How many children live in your household the majority of the time?

Of the 179 returners who participated in our survey, 59, or about 33 percent, of those were females. 29, or about 16 percent, of the 179 returners were underrepresented minorities (consistent with national and engineering college definitions), which included those students who identified as American Indian or Alaskan Native (1.1%), black (6.1%), Hispanic or Latino (5.0%), Native Hawaiian or Pacific Islander (0.06%), or who identified as more than one race or ethnicity, including one historically underrepresented within engineering (11.7%).

The average age of returners surveyed was 37.1. A more detailed breakdown of participant ages can be found in Figure 1. 41 percent of all returners surveyed were between the ages of 31 and 35, though ages ranged from 26 to 64 at the time of the survey.

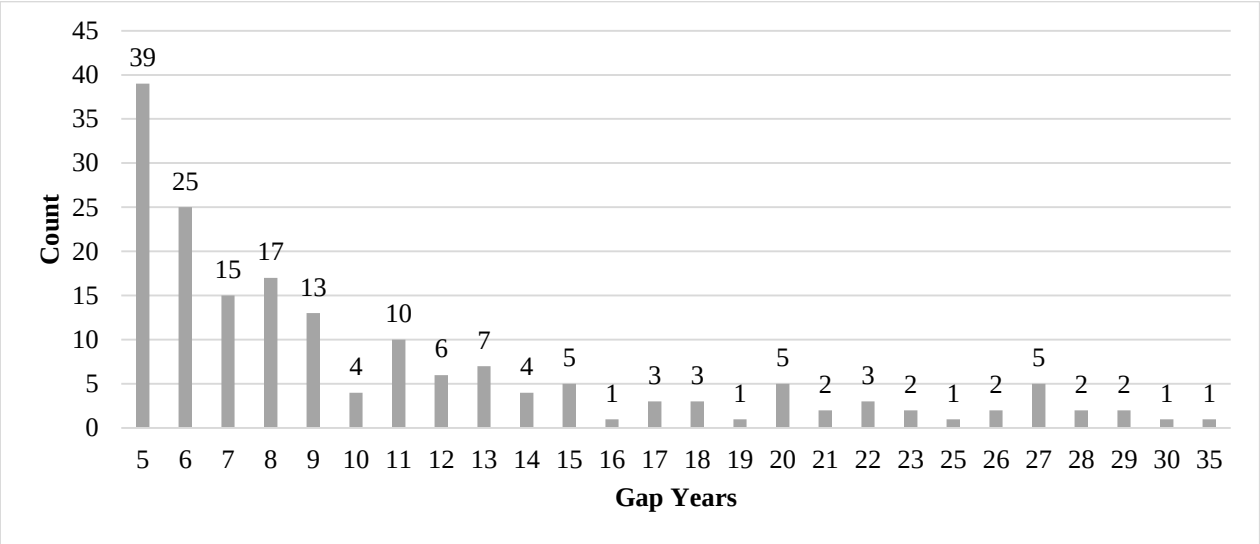
Figure 1: Summary of age range of returners surveyed



We determined returner status by calculating the "gap years" or total years spent between the completion of undergrad and the beginning of the PhD not enrolled as a full-time student. As

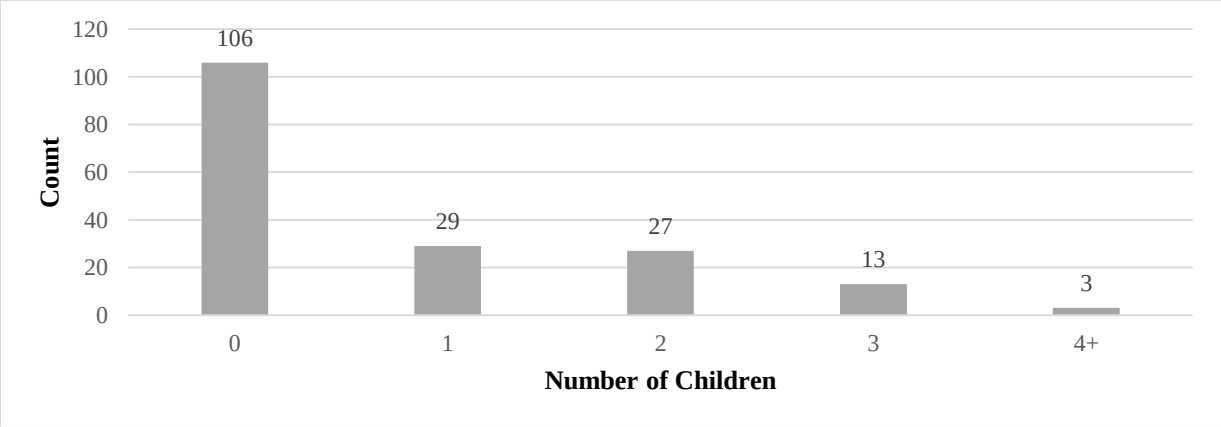
previously discussed, students had to have reported 5 or more gap years not enrolled as a full-time student to be classified as a returner and a majority of returners reported between 5 and 8 gap years prior to enrolling in a PhD program. However, students reported a fairly wide range of gap years prior to beginning a PhD, with the highest number of gap years being 35. Figure 2, below, shows a detailed look at the distribution.

Figure 2: Years out of full-time education between completion of undergraduate degree and beginning of PhD



We included questions about marital status and children in our survey as several studies have suggested these factors can play a role both in students' likelihood of pursuing graduate study and their success within the programs[29,30]. Over 61 percent (110) of returners were married or equivalent immediately prior to starting their PhD, while slightly over a third (62) reported being single and 7 were divorced or separated. There seemed to be little change in the relationship status of students during the course of the PhD as participants' reports of their current status indicated that 115 were married or equivalent, 53 were single, and 11 were divorced or separated. A slight majority of returners did not have any children in their household, while others had several children. More detailed information on the number of children is listed in Figure 3 below:

Figure 3: Count of number of children living in household



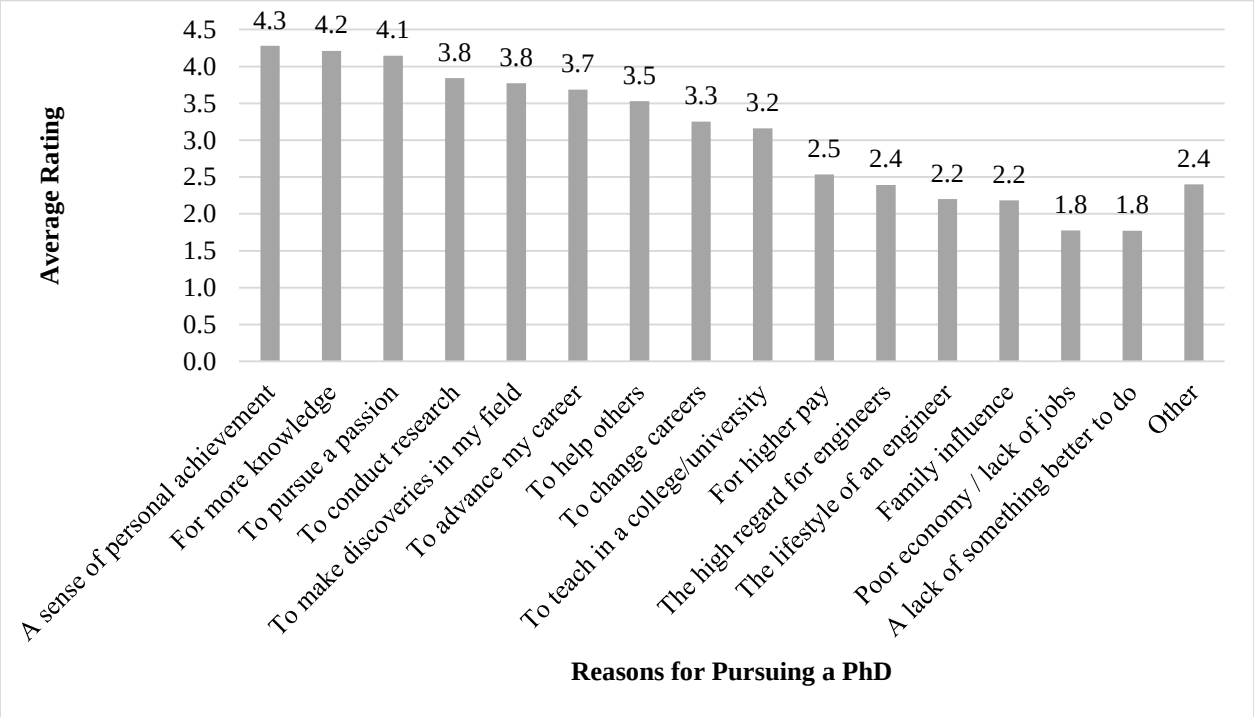
B. Decision to Return

Understanding students' motivations for pursuing a PhD and their decision processes in selecting a program is key in developing resources both for students and for universities to support students in their application process and in providing relevant information in an easily accessible format. We asked participants about various elements of their decision process, including:

- Please first indicate the amount you consulted with each of the groups below and the degree to which they were resistant or supportive of your decision to pursue a PhD.
- Please indicate how important each of these factors was in your decision to attend to graduate school prior to enrolling.
- Please indicate how much you used each of the following sources of information when you were selecting a PhD program.
- Please rate how important each type of information was when selecting a PhD program:
- Did you already know the topic of your dissertation work prior to beginning your PhD?
- Did you already know which professor(s) you wanted to work with prior to your PhD?

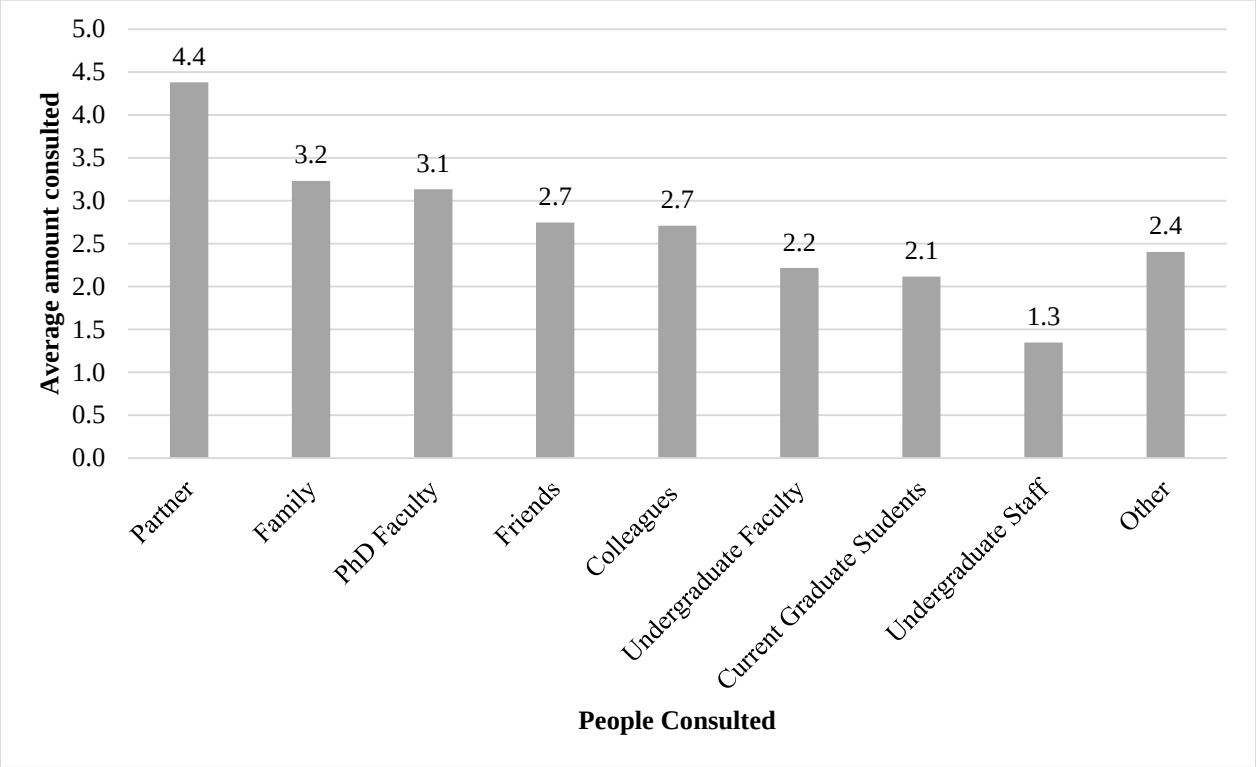
Returners considered numerous factors and rated them with varying importance in making their decision to return for a PhD. Participants were asked to indicate the level of importance of 15 potential factors in their decision to attend graduate school on a 5-point Likert Scale ranging from 1=Not at all important to 5=Very important. The most common reasons cited by returners in their decision to return for a PhD were: for a sense of personal achievement, a desire for more knowledge in their field, and to pursue a passion, closely followed by a desire to conduct research, make new discoveries in their field, advance in their careers, and help others. On average, returners rated a lack or jobs or a poor economy and a lack of better options as the least important reasons for deciding to return.

Figure 4: Returners' average rating of importance of various factors in decision to pursue a PhD



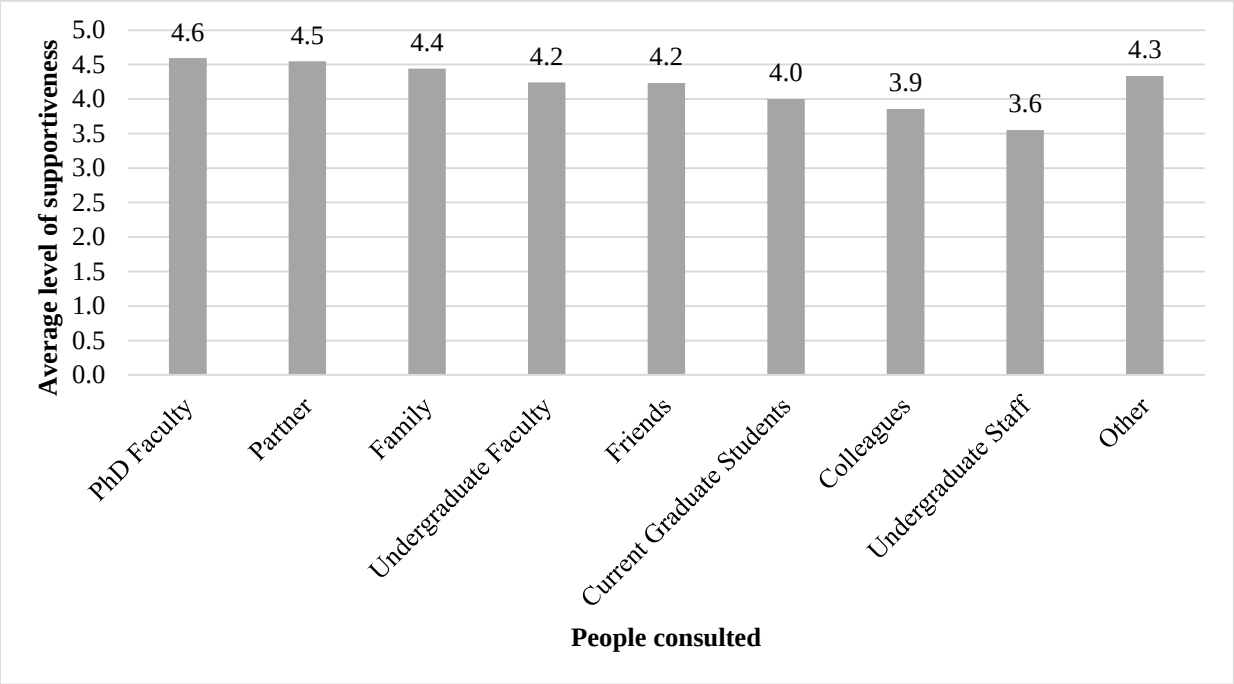
In making the decision to return for a PhD, returners consulted with a variety of individuals. Participants were asked to indicate first whether a given individual or group was applicable to their situation (for instance, not all participants have a partner) and if so, rate the amount their consulted with each group regarding their decision to return on a 5-point Likert scale where 1= Not at all and 5= A great deal. Participants consulted with their partners significantly more frequently than any other group or individuals with an average score of 4.4. Family and PhD faculty were the second two groups participants consulted with most frequently with scores of 3.2 and 3.1, respectively. Figure 5 displays the results in more detail.

Figure 5: Average rating of the amount student consulted with various individuals



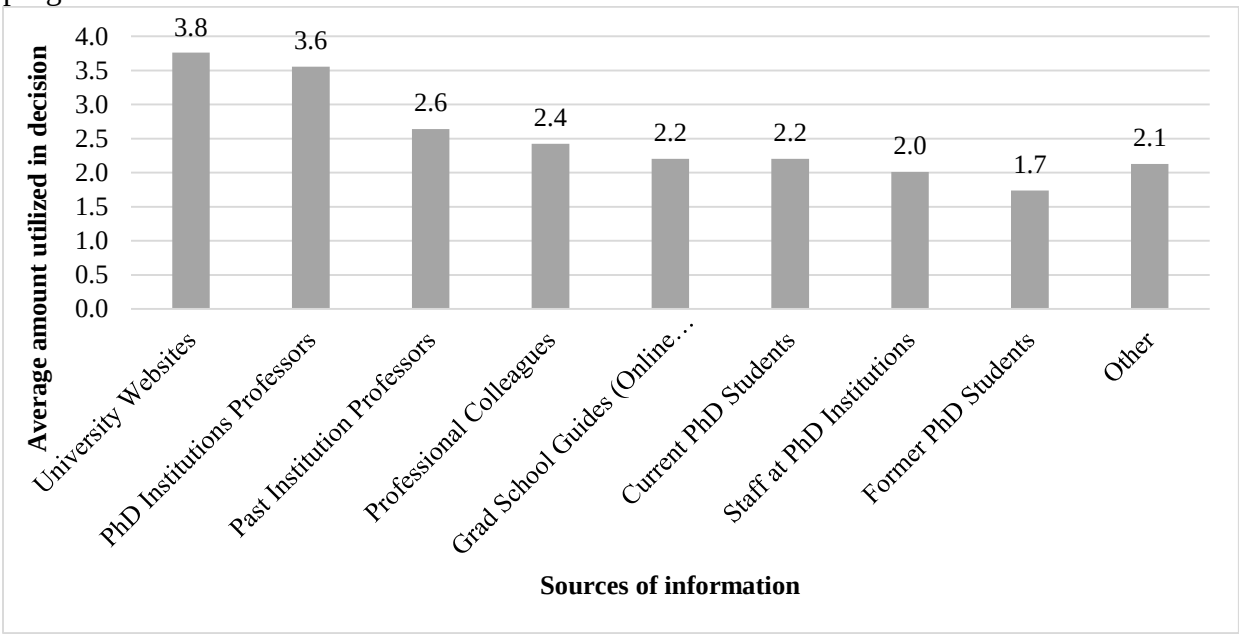
Participants were also asked to indicate (on a 5-point Likert scale ranging from 1= Very resistant to 5= Very supportive) of those they consulted with, how supportive each group or individual was in their decision to return. Overall, the three groups students consulted with the most (partner, family, and PhD faculty) were also those they indicated were most supportive. However, participants rated all groups as, on average, supportive of their decision to return to pursue a PhD. It is worth noting that it is possible that those students who have people who are supportive of their decision to return to graduate school may very well be those who are most likely to be able and willing to do so, a topic that warrants further study.

Figure 6: Average rating of supportiveness of various individuals consulted



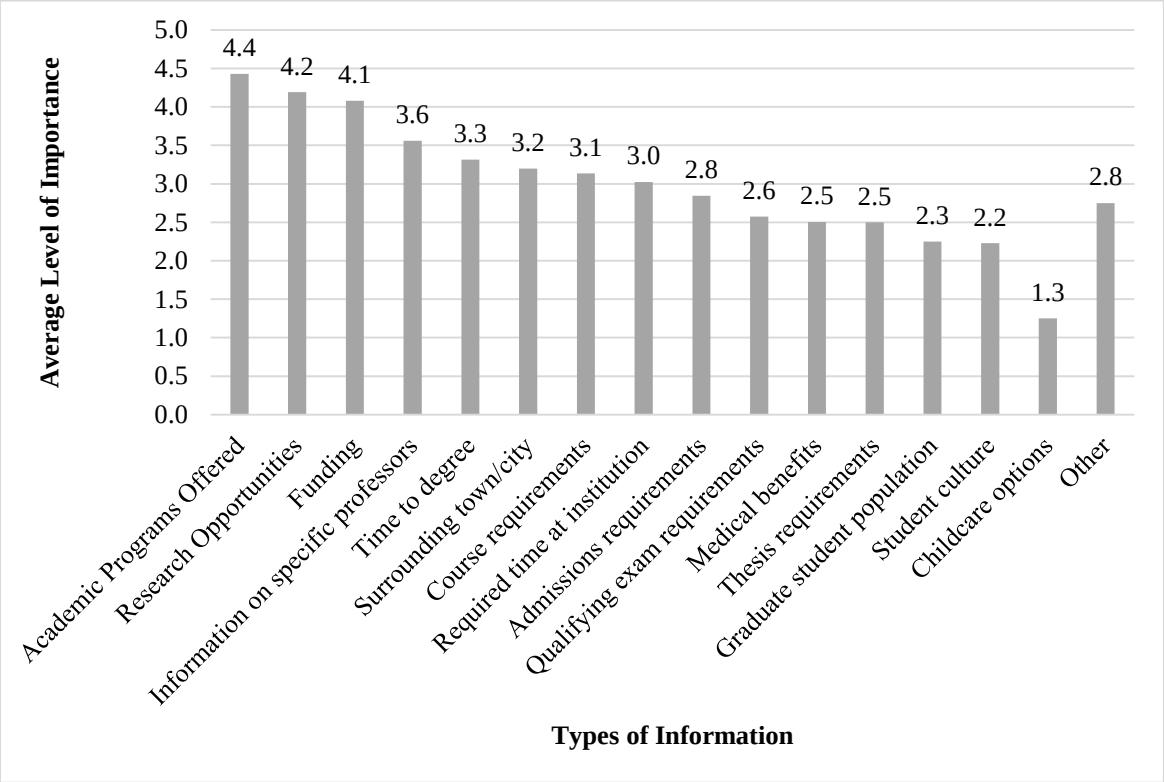
When selecting a particular PhD program, returners consulted a variety of sources in their decision. Students were asked to indicate on a 5-point scale how often they consulted each source where 1= Not at all and 5= A great deal. Though no particular source was rated above a 4 on average, the two sources of information used most frequently in selecting an institution were university websites (3.8) and faculty at the PhD institution (3.6).

Figure 7: Average rating of the frequency student utilized various resources in selecting a program



Returners indicated they considered a range of program characteristics in selecting a PhD program. They were asked to rate the level of importance of each aspect of graduate programs in their decision on a 5-point scale where 1= Not at all important and 5= Very important. The two most important factors were the academic programs (4.4) and research opportunities (4.2), with funding (4.1) also indicated as an important factor in students' decisions.

Figure 8: Average rating of the importance of various factors in selecting a PhD program



Two-thirds (119) of returners entered their PhD program already knowing for which faculty member they wanted to work. However, slightly less than a third of them (54) entered the program knowing the research topic they wanted to explore for their dissertation work.

C. Past Work Experiences and Educational Trajectory

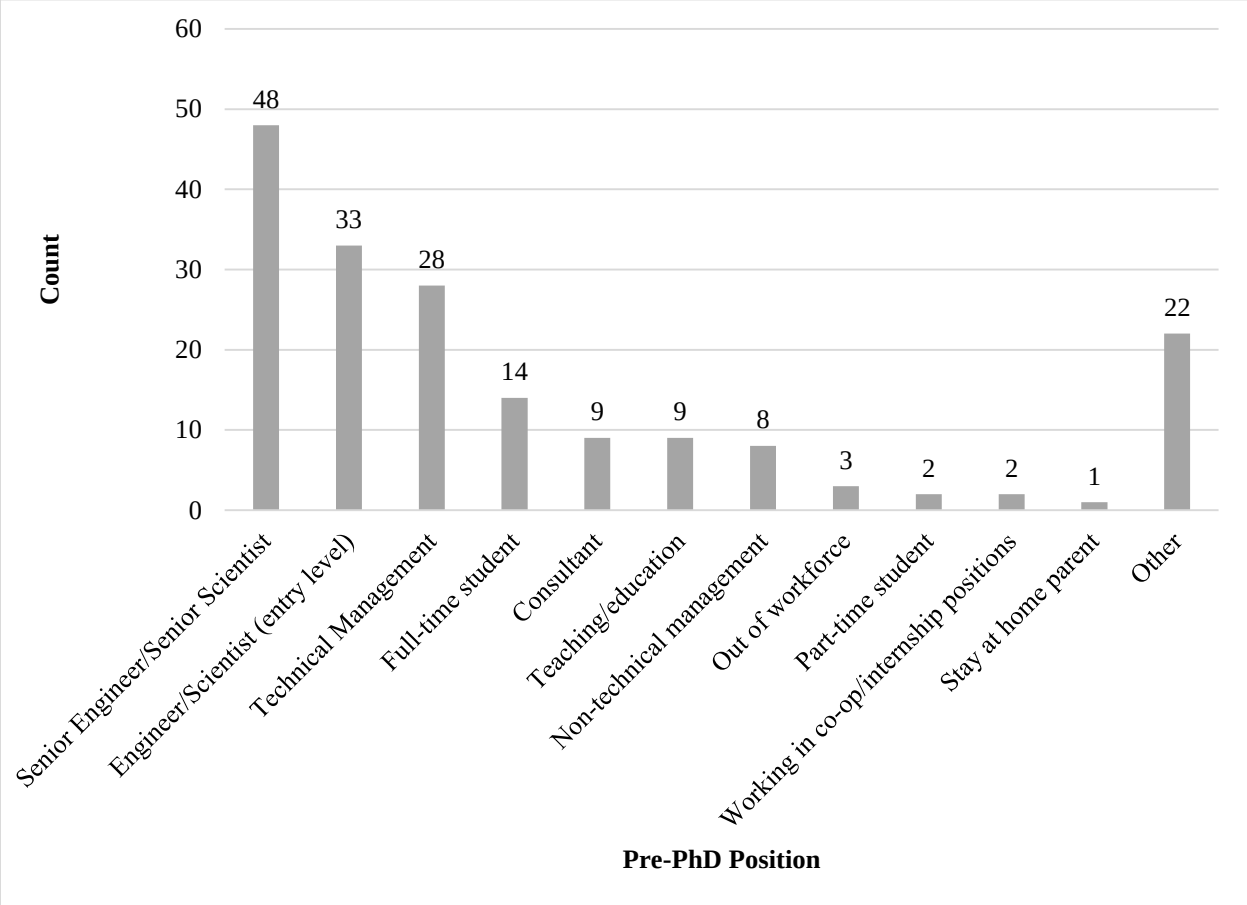
Participants were also asked to provide information about their past education and work experience in order to identify the various paths returners take to pursuing a PhD. Questions in these sections included:

- What year did you complete your undergraduate degree?
- Have you completed a Master's degree?
- Was your undergraduate major/primary field of study in engineering?
    - If so, in which field of engineering did you receive your undergraduate degree?

- What bests describes your educational and career experiences from the year you began your undergraduate degree until enrolling in a PhD program? Please indicate the number of years spent doing each, representing portions of a year in decimal format
- What best describes your most recent position prior to pursuing your PhD?

Immediately prior to beginning the PhD, a majority of returners were working full-time, most commonly as senior engineers/scientists, entry-level engineers/scientists, or in technical management roles. Others were working as consultants, in education, or in non-technical management positions and several were out of the workforce. About 8 percent of returners were most recently enrolled in school full-time, having worked for some time prior to enrolling full-time in a Master's program immediately before beginning their PhD. A detailed breakdown of the positions held by returners prior to their PhDs is shown in Figure 9.

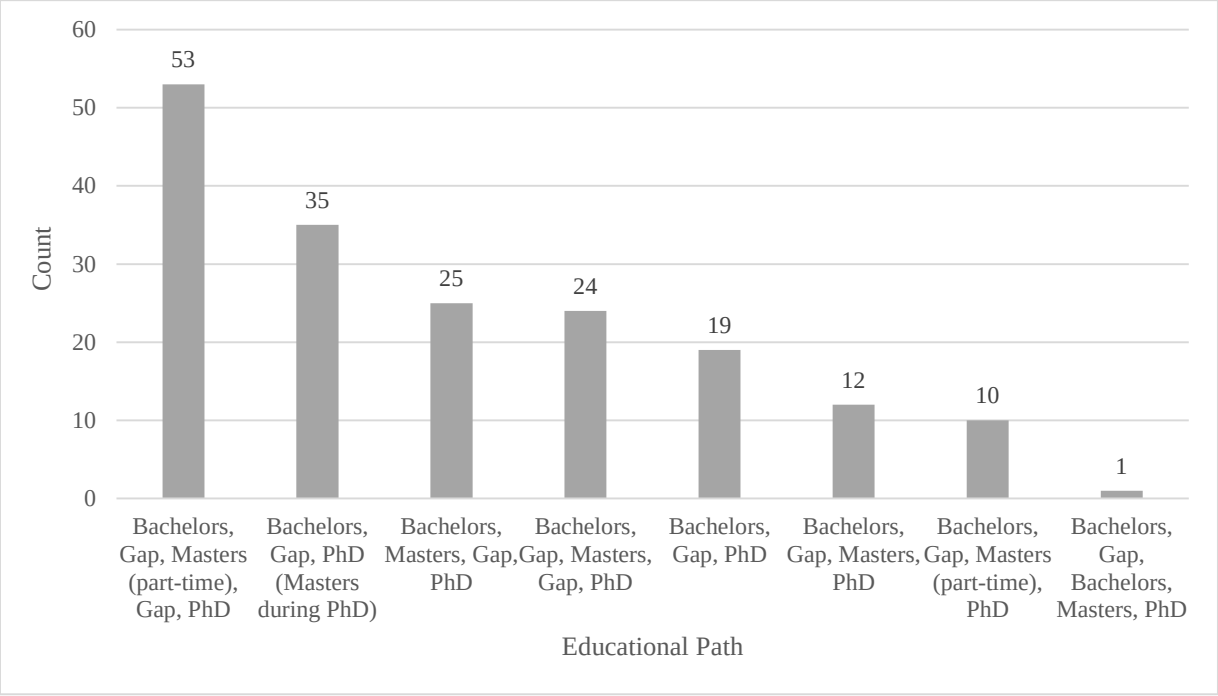
Figure 9: Count of position most recently held by returners prior to pursuing a PhD



It was common for returners to have completed a Master's degree prior to enrolling in a PhD program, with nearly 70 percent (125) reporting doing so. An additional 24 students in our population had already completed a Master's during the course of their PhD program with another 11 students reporting plans to do so. Only 19 students reported planning to complete their PhD without ever earning a Master's degree. Of those students who completed a Master's

prior to beginning a PhD, the particular time and manner of Master's completion varied. In some instances, participants reported pursuing a Master's degree full-time immediately after their Bachelor's or immediately prior to their PhD. Others worked for several years before enrolling in a Master's program full-time and then working for several more years before beginning a PhD. Commonly, returners worked full-time and earned their Master's part-time at some point between completing their baccalaureate degree and beginning their PhD. Figure 10 below shows a more detailed breakdown of returners' different educational paths.

Figure 10: Count of returners' education and work trajectories prior to a PhD



To better contextualize our understanding of returners' past educational experiences and the paths they take to the PhD, we compared their undergraduate area of study with their PhD field. Over a quarter (46) of returners earned their undergraduate degrees in a non-engineering field. Many of those students (32 of the 46) earned their degree in another STEM field including math, physics, chemistry, biology, and geology. The remaining non-engineering students most commonly pursued degrees related to business but several students completed their undergraduate degrees in areas as diverse as music, language, and social science. Of those students who did earn an undergraduate engineering degree, mechanical engineering was the most common major with 37 students, followed by Electrical Engineering (23) and Civil and Environmental Engineering (21).

A little more than a quarter of returners pursued study in the same single field for both their undergraduate and doctoral work. This finding, in combination with the finding that a quarter of returners did not earn an undergraduate degree in engineering, suggests that a PhD may be for some a strategy to change their career focus. Additionally, returners most commonly indicated multiple degree areas compared to any individual discipline for their doctoral study, a finding

that may reflect too narrow of degree options listed in the survey or may suggest their specialties often span multiple disciplinary areas within engineering. The most common individual fields of study for returners were Mechanical Engineering (20), Computer Science and Engineering (17), and Industrial and Operations Engineering (16). A more detailed breakdown of undergraduate and doctoral field of study can be found below in Table 1.

Table 1: Comparison of undergraduate and PhD fields of study

	PHD DEGREE FIELD																					
UNDERGRAD DEGREE FIELD	Aerospace	Atmospheric, Oceanic, and Space Sciences	Bioengineering	Biomedical Engineering	Chemical Engineering	Civil Engineering	Computer Engineering	Computer Science and Engineering	Design	Electrical Engineering	Engineering Education	Environmental Engineering	Industrial and Operations Engineering	Macromolecular Science and Engineering	Materials Science and Engineering	Mechanical Engineering	Naval Architecture and Marine Engineering	Nuclear Engineering and Radiological Sciences	Systems Engineering	Multiple	Other	**TOTAL UNDERGRAD**
Aerospace	2																			1		3
BME																						0
Chemical Eng.					2						1	1	1		1	1					2	9
Civil/Enviro						9						5	2			1				3	1	21
Computer Eng.								1			1									1	1	4
Computer Sci.								3								1						4
Electrical	2			2			1	2		9										4	3	23
IOE													2									2
Materials Sci.					1					1			1		2							5
Mechanical	2	1		2	1	1					3	1	1		1	16				5	2	36
Nav.Arch/Marine																	2					2
Nuclear																		1				1
Other Eng Maj.						1		1			1		1							1	1	6
Two+ Majors	2		1	1				3			1		1			1			1	5	1	17
Non-Eng. Major	1	1	1	4	1	2		7		2	2	5	7	1	1				1	7	3	46
TOTAL PHD	9	2	2	9	5	13	1	17	0	12	9	12	16	1	5	20	2	1	2	27	14	179

Note: Shading is used to highlight the frequency of a particular undergraduate and PhD field combinations. Darker grey indicates relatively higher frequencies.

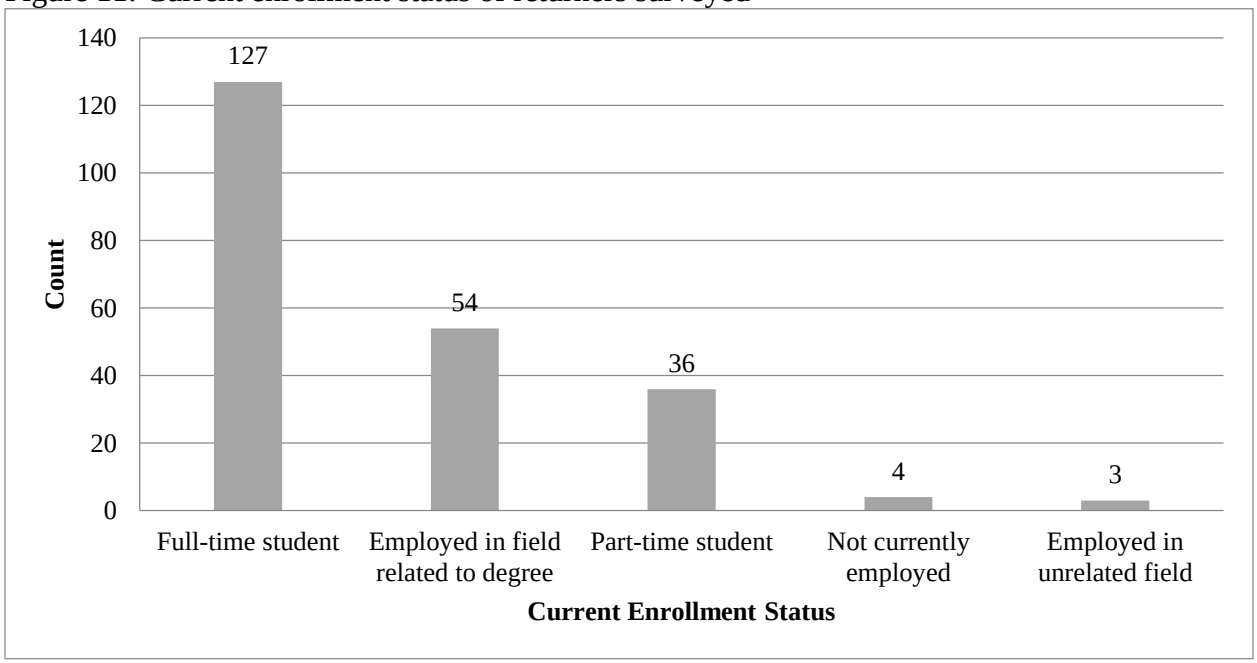
D. During the PhD

We also included several questions meant to characterize what returners' PhD programs looked like, including how they spend their time and fund their degree. Questions regarding the PhD program included:

- What is your current status? (Full-time, Part-time, Employed in degree field, Employed in unrelated field, Not currently employed)
- When did you start your PhD program?
- What year do you anticipate completing your PhD program?
- Please estimate the average time you currently spend on each work-related activity below during an average work week (Monday through Friday, including evenings)
- Do you complete work (including homework, research, and other academic duties) related to your PhD on weekends? If so, how many hours do you work on average per weekend?
- Please indicate your source(s) of funding for your academic program.

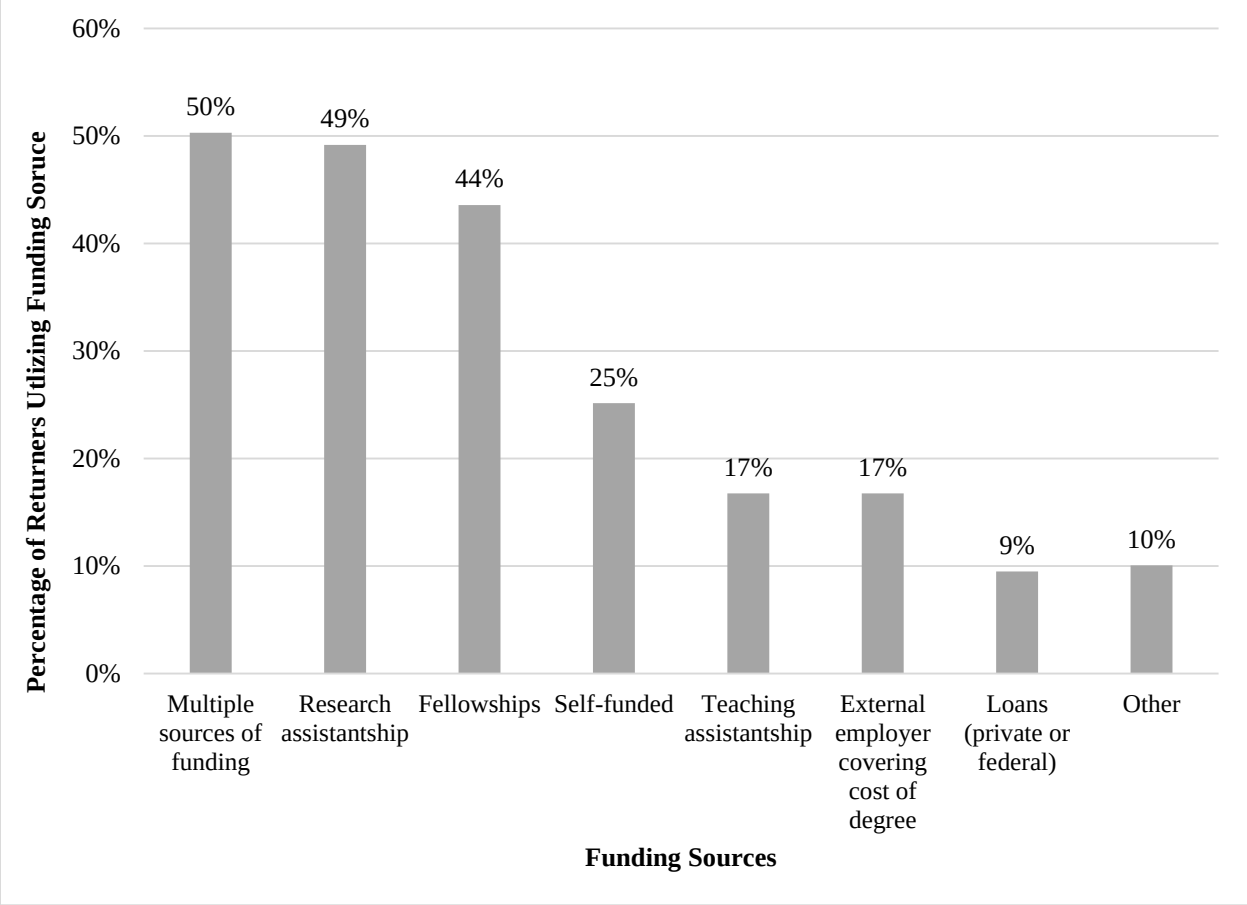
The majority of returners (about 71 percent) of returners were enrolled full-time in a PhD program, while about 22 percent were part-time students. Several other participants had very recently graduated or did not provide enrollment information. About a third of the students were also employed full-time in an engineering-related field, many of them part-time students, though notably, 20 returners were both employed full-time and full-time students.

Figure 11: Current enrollment status of returners surveyed



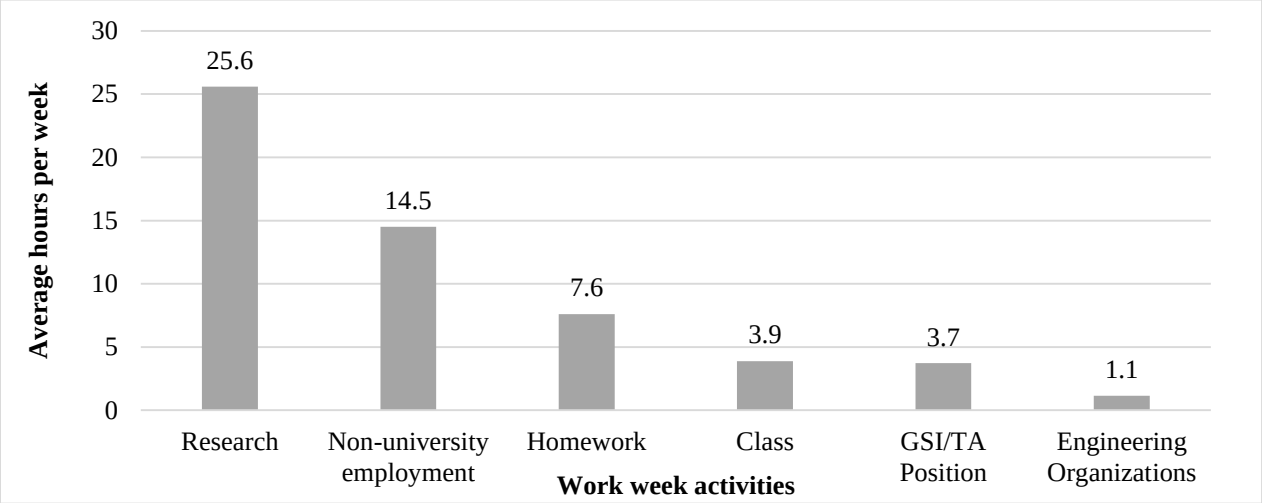
Students drew funding from a variety of areas. Many returners were funded through research assistantships and/or fellowships. Others were funded through private loans, teaching assistantships, or an employer covering the costs of the degree. A notable 25 percent of returners reported being at least partially self-funded. Approximately half of the students drew aid from two or more difference sources. Of those students who relied upon multiple sources to fund their degree, the most common combination was both a fellowship and research assistantship, with 42 of the 90 returners who drew on multiple sources of aid receiving both, sometimes in combination with a third source of funding.

Figure 12: Percentage of returners surveyed utilizing various funding sources



Although the returners surveyed varied in their degree progress and related obligations as well as in their work commitments outside of their degree, on average, students reported spending by far the most time during the week on research commitments. The average hours spent on each of the activities listed in Figure 13 below represent only the hours spent during the typical Monday through Friday work week. The vast majority of returners (93.3 percent) also reported working on the weekends, with an average of an additional 9 hours devoted to academic-related work each weekend.

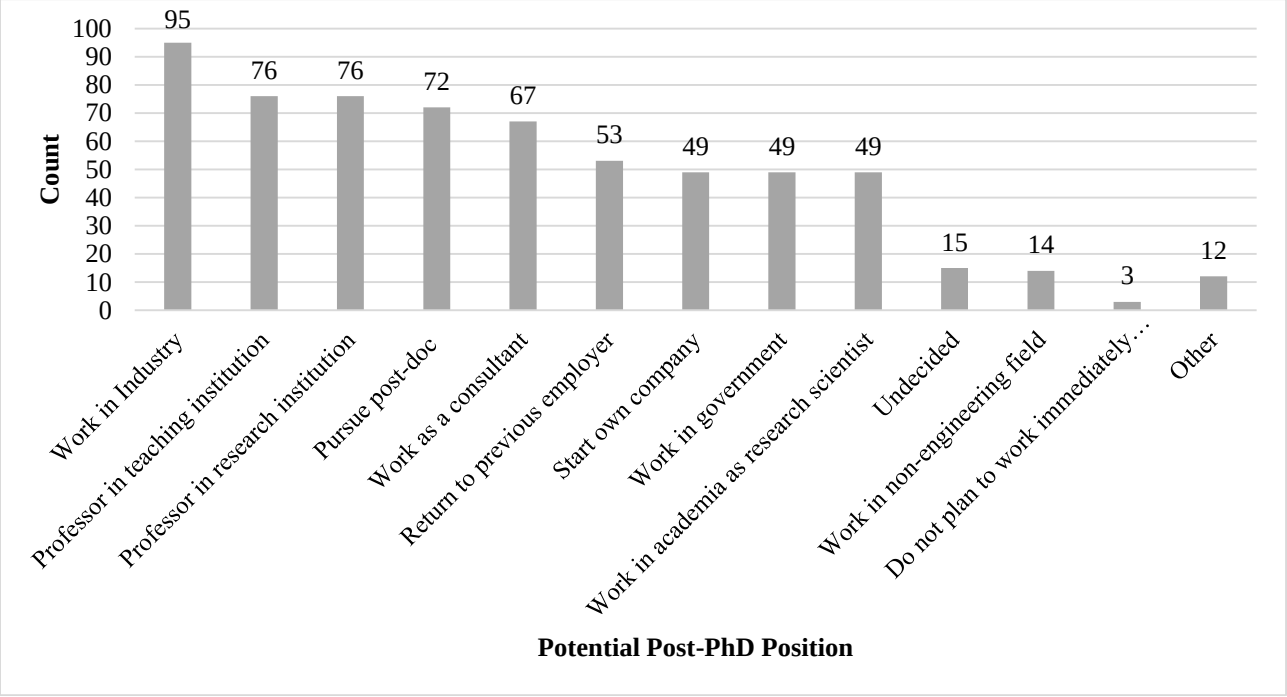
Figure 13: Average hours per work week spent on various academic activities



E. Post-PhD

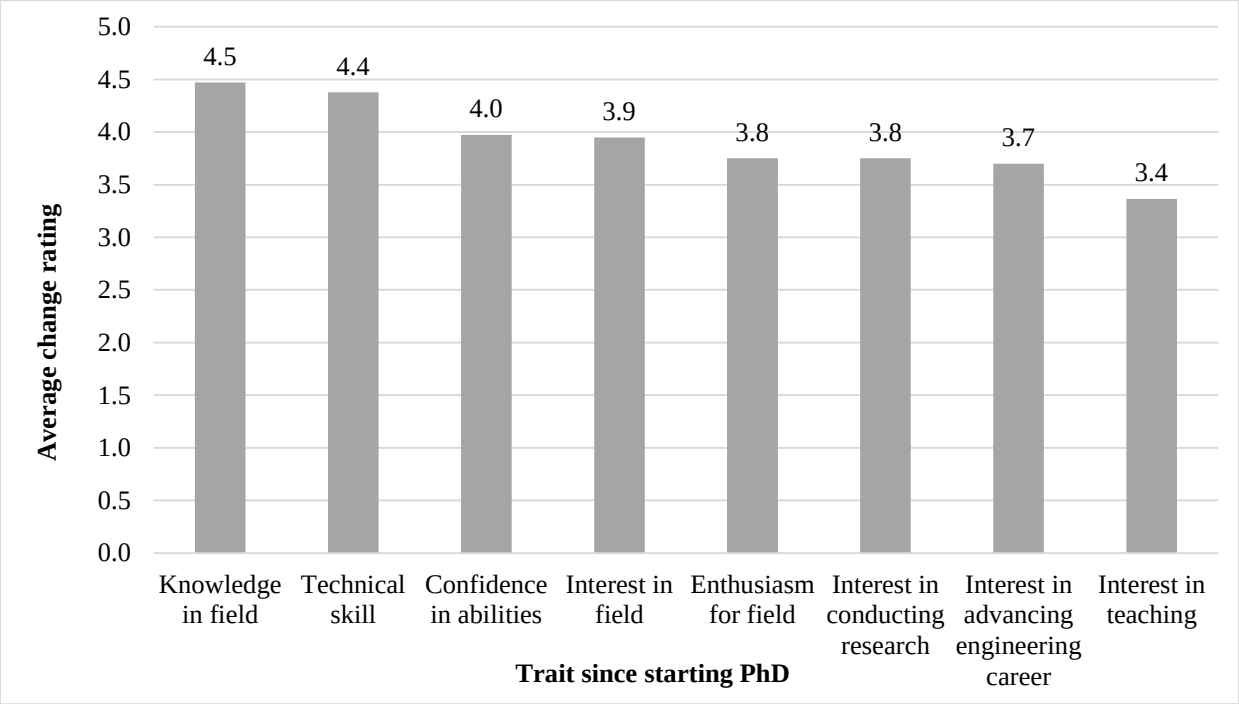
Returners were considering a variety of options for their career plans upon completing the PhD. The survey asked students to indicate the various career paths they were considering post-PhD. Survey participants had the opportunity to select more than one potential position. The most common response with over half of returners considering it, was to work in industry. Working in academia, either as a professor in a teaching or research institution or as a post-doc, was also indicated as an option by many students, as was working as a consultant. Very few participants (3) reported that they did not plan to work after completing their degree.

Figure 14: Count of potential post-PhD positions considered by returners



Finally, we asked participants how their experiences in their PhD program changed their skills, knowledge, confidence, and interest in various aspects of PhD work. Returners responded that, on average, the change was in the positive direction. They were asked to rate their perceived level of change on a 5-point scale where 1 = Much less now and 5 = Much more now. Students reported the highest average levels of positive change in their knowledge in their field of study and technical skills and reported the least change in their interest in teaching.

Figure 15: Returners' average rating of their perceived change in various traits during their PhD



The information collected about graduate returners' characteristics, education and work history, motivations for pursuing a PhD, and their experiences as PhD students provides an initial understanding of this potentially important group of students within engineering about which little is known.

V. Discussion

A. Comparing Returner Experiences to Literature

Though the information collected about returners in our survey cannot be assumed to be representative of all returners given the sample size and recruitment process for our study, a comparison of our findings about returners and characteristics of the general population of engineering PhD students reveals several interesting trends. 33 percent of returners in our study were female, substantially higher than the national average of female engineering PhD students of 22.2 percent[20]. Unsurprisingly, the average age of currently enrolled returners surveyed (37.7) was substantially higher than even the national average age of graduating engineering PhD students, 30.5[19]. Compared to national data on graduating engineering PhD students, a higher

percentage of returners in our study identified as White (86 percent versus 69.8 percent nationally), Black or African American (6.1 percent versus 4.3 percent nationally), Mixed race (11.7 percent versus 2.2 percent nationally), Native American or Alaskan Native (1.1 percent versus 0.2 percent nationally), and "other" race (5.6 percent versus 2.5 percent nationally). The proportion of returners who identified as Asian and Hispanic, were both lower than national percentages (5.6 percent versus 15.7 percent nationally and 5.0 percent versus 5.4 percent nationally, respectively).

While it is difficult to compare funding sources directly, as much of the literature names only primary sources of funding, many of the commonly cited primary funding sources nationally were also common sources of funding among the returners surveyed. There seems to be a need for more national data on supplemental sources of funding, as among the returners in our study, 47 percent drew from two or more sources of funding for their degree, commonly from both a fellowship and a research assistantship. This provides insight into how some students may need to piece together multiple sources of funding for their PhD, rather than relying exclusively on one funding source. Returners did seem to more commonly receive funding from fellowships, external employers, and other sources of funding, such as the GI Bill, compared to national data[31] on primary funding sources, though further study would be needed to determine the proportion of total funding coming from these sources. Likewise, returners were over five times as likely to be at least partially self-funded (though again the proportion of their total funding is unknown) compared to the percentage of PhD students nationally who are primarily self- funded (25.7 percent versus 4.1 percent, respectively) suggesting that while a majority of returners do receive some sort of additional funding, a large percentage of them also utilize their own funds, possibly due to higher living expenses, more difficulty in securing funding from external sources, or simply the ability to partially self-fund with income or savings from past work.

Many of the reasons returners cited for pursuing a PhD overlap with those pointed out in previous works as primary motivators for returning to school. It is worth noting that the formulation of our survey drew upon existing works so some overlap in this domain is not surprising. It does appear that the reasons returners cited as the most influential in their decision to pursue a PhD were largely personal: for a sense of personal achievement, to pursue a passion, and for more knowledge in a given field. Reasons related to particular career options (to conduct research or teach) or to advance in or alter their field were also common, though slightly less so than the aforementioned intrinsic motivations. These top motivations seem to largely align with those motivations identified by Mills and McCright[32], who found the decision to pursue a PhD was strongly driven by a desire for growth and development and for students' desire to have an impact on the direction of the discipline and the lives of others.

A comparison of undergraduate major and PhD field of study suggests that a change of focus, perhaps to better align with personal interests or career goals, may be another motivation for pursuing a PhD. Over a quarter of returners surveyed did not earn their baccalaureate degree in an engineering discipline and this, coupled with the finding that nearly 75 percent of all returners surveyed, including those who stayed within the field of engineering broadly, did not pursue a PhD in the same single field as their undergraduate work, suggests a doctoral degree is being used as an opportunity to gain expertise in a new engineering area. We were unable to find any

national data on engineering doctoral students' specific field of study compared to their undergraduate degree for sake of comparison.

B. Significance and Implications

Learning more about how returners make the decision to pursue a PhD and select an institution is valuable information for universities wishing to broaden their recruitment efforts to include returners. The survey results suggest that returners most commonly consult their partner, family, and PhD faculty at the institution(s) of interest in their decision to return and it is also these three groups who returners report as being most supportive of their decision to return. This suggests partner and family support plays an important role for those students who are able to successfully able to return to pursue a PhD and that universities should take this into account in recruitment and orientation practices, possibly highlighting partner relocation, childcare, and other partner/family benefits or including programming for partners or family in recruitment visits or orientation activities.

The importance of consulting with PhD faculty in returners' decision to return (and also as a top source of information) highlights the value in ensuring faculty are well-informed about the priorities and interests of returners that may factor into their decision process, as well as the potential benefits of recruiting returning engineering professionals into graduate programs. Much of the information returners report as most important in making their decision is often already highlighted on college websites (the other most common source of information for these students), such as academic programs, research opportunities, and funding, but other important information may be less prominently displayed, including time to degree, time required in residence at an institution, and more cultural information about the surrounding town or city. Including more of this information or encouraging faculty recruiting students to be mindful of these information needs may be another helpful measure for engineering colleges in better attracting returners to their programs. It's also worth considering engineering Master's degree programs as an opportunity to identify and communicate with potential doctoral-level returners who may be hoping to pursue further education – survey data suggests that a vast majority of returners pursue a Master's degree at some point prior to their PhD.

Detailed information about returners' experiences and their motivations and decision processes for pursuing a PhD is an important foundation for future effort to support these students' return to graduate study and to enable universities to provide an education that empowers returners to better utilize their unique backgrounds. Returners are positioned to have the potential to make unique contributions to the field of engineering in academia, industry, and government by leveraging their combined experience as practitioners and as students trained as advanced engineering researchers. The results of this survey provide a preliminary understanding of the traits of those engineering practitioners who desire to return for a PhD and are able to successfully do so: their backgrounds, their motivations for returning, what and who they consult in their decision to return and for support, their funding during their PhD, and what they feel they've gained from the experience and what they hope to do with their degrees.

C. Limitations and Future Work

It's helpful to understand the experiences of those who successfully return for a PhD, but it's equally important to gain insight into the experiences of those practitioners who may desire further education but who ultimately decide not to or unable to pursue a PhD. What barriers exist for these potential students and how can universities better attract and support those engineers who want to enroll in an advanced engineering degree program?

While the study presented here provides valuable insights, it only captures some of the relevant aspects related to the returning decision process and experience. It is difficult identify, learn from, and support returners when returner status or information about previous non-academic experience is not a commonly tracked demographic by universities. It would be beneficial for universities to collect this information on their incoming students to learn what opportunities exist for better recruiting experienced practitioners and to better support and utilize the talents of their current students. It may also be enlightening for universities to gain further insight into what those students who decide not to return ultimately decide to do and their interest in further study, information that could be obtained through alumni surveys.

Though this study provides a useful preliminary look at the experiences of engineering returners, there are several limitations and areas that necessitate further study. One of the most challenging aspects in this study of returners is the lack of readily available information that allows us to identify and reach out to returners. Returners who participated in this study responded to a preliminary survey gathering basic information about their education history prior to being asked to complete this study. Thus, it cannot be assumed that these students who volunteered to participate in several survey rounds are necessarily representative of returners as a whole. Another tradeoff of surveys such as ours is that while we were able to collect information from a large group of returners, we were also limited by the length and structure of the survey, which cannot fully capture the potential range of experiences of returners. Additionally, we were only able to capture the experiences of those students enrolled in graduate programs; as stated previously, understanding the experiences of those prospective returners who are unable to return or those who drop out of their PhD are will be an important next step.

Further exploration into how the experiences of returners compare to those of students who enter a PhD program shortly after completing their undergraduate work is another important element that we will explore in detail in future work. In addition to a basic understanding of who returners are, we also plan to explore how students draw on their previous experiences in their academic and future work, through the analysis of over 50 in-depth interviews with returning and direct pathway students from across the country. It is our hope that this will provide insight into how specifically returners integrate concepts, methods, and experiences from their former positions into their academic work and how, if at all, this is or can be leveraged into more innovative outcomes. The final element we hope to explore is how stakeholders in academia, industry, and government perceive returners and the role they may play as well as institutional policies that may relate to returners' experiences and their ability to pursue graduate study. We ultimately hope to use findings from the multiple elements of this study to develop informational materials and interventions that universities can utilize to better recruit and support returners.

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