Engineering Doctoral Students' Expectations, Reflections, and Concerns Regarding Future in Academia

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Abstract

Doctoral students who choose an academic career path will essentially be required to teach courses. However, literature says most doctoral students have more research experience than teaching experience. Additionally, the teaching experience they have is through their graduate teaching assistantships, which may or may not have associated training on how to teach. Teaching can be difficult if you are not fully aware of the different dimensions associated with it. Engineering doctoral students who look to enter academia after graduation are incentivized to take a research-first career, though they likely would also be in instructional positions. However, some doctoral students go out of their way to gain experience as course instructors. This research project aims at understanding engineering doctoral students' expectations, reflections, and concerns regarding their future in academia. To understand engineering doctoral students' expectations, reflections, and concerns regarding future in academia, a survey instrument was designed with questions pertaining to participants' expectations and concerns for a career in academia, interpersonal interactions' influence on their teaching preparedness, and help from their PhD program in teaching preparedness. The survey was distributed in Fall 2023 and 115 responses were included in the analysis.

The analysis of participant responses participants who preferred a career in academia expressed the expectation that they would generally be working in both research and academia and provide some service to the university. Some expressed hopes for working in research primarily, including hopes for working at a top university, but a few did specify that they hoped to work at an R2 institution to have an opportunity to have a greater focus to teach, which echoed some of the goals of participants in previous literature. Some described a broader expectation of an open environment or a potentially stressful environment. Most participants described being influenced by either experiences with mentors, peers, and/or other instructors as having influenced their process of preparation, though a large portion of respondents specified that interactions with instructors influenced their process of preparation, but not peers or mentors. Many respondents described their experiences in seeking and receiving feedback as a TA from both peers and mentors as beneficial. A few respondents stated that no one has helped them prepare. Regarding concerns for a career in academia, many expressed worries regarding the pressures of research, potential lack in work-life balance, low salaries, and the difficulties of finding a faculty position. Additionally, some expressed concerns regarding the culture of academia; including factors such as gender and ethnic biases, the competitive nature of seeking funding in research, having the resources to adequately support students, and discovering how their branch of study will fit within the boundaries of the university.

Keywords: academic career, engineering doctoral students, teaching preparedness

Introduction

Doctoral students who choose an academic career path will essentially be required to teach courses. However, the structure of graduate education typically prioritizes developing researchers, rather than future educators [1] Additionally, the teaching experience they have is through their graduate teaching assistantships, which may or may not have associated training on how to teach. Teaching can be difficult if you are not fully aware of the different dimensions associated with it. Engineering doctoral students who look to enter academia after graduation are incentivized to take a research-first career, though they likely would also be in instructional positions. However, some doctoral students go out of their way to gain experience as course instructors. In a survey of engineering doctoral students, a subset of the respondents reported being uninterested in working in the professoriate, and among that group, a small portion of them were uninterested due to their perceived lack of ability to teach [2]. This research project aims at understanding engineering doctoral students' perceptions on their readiness to teach courses once they begin their academic careers.

There is no singular shared opinion of the purpose of a doctoral degree in America. The resulting career sectors of an engineering PhD can include industry, government, and academia, where each field has different demands and necessities from a graduate. Currently, a significant portion of engineering PhD recipients have academic or post-doctoral commitments, with 42.7% of recipients having these commitments in 2022 [3]. Academic responsibilities can be quite varied; often featuring research, teaching, and institutional service requirements. Despite the diverse responsibilities, there is usually a focused emphasis on research, especially for early career academics. This can lead to instructors feeling that the time they spend on teaching interferes with the time they could spend on research [4].

While a career in academia typically requires research, teaching, and service, most doctoral degrees in the United States are conferred at research intensive universities, where research accomplishments are prioritized over instructional training for future faculty members [5]. However, as some engineering PhD students wish to pursue a more teaching-focused career at a PUI, or a primarily undergraduate institution, these future faculty members eventually find they did not feel adequately prepared for their career [1].

Further investigation on the self-efficacy regarding instruction for engineering PhD students is needed. Specifically, there is a need to better understand which areas of instruction self-efficacy are related to each other and which areas engineering PhD students lack confidence. This paper aims to support these efforts through identifying how the experiences of PhD students who intend to pursue an academic career affect their perceptions on their preparation to teach. The survey instrument was utilized as part of a larger project undertaken to determine how different external factors may influence engineering PhD students' self-perceptions on their abilities to teach as well as exploring the expectations, concerns, and experiences regarding a career in academia and pedagogical preparation of engineering PhD students who are considering careers as academics.

Prior studies have focused on areas such as STEM PhD students' perceptions of their skills in relation to their career plans and self-perceptions of graduate students' teaching skills regarding determining the efficacy of a teaching workshop, but prior studies have not investigated the general self-perceptions of engineering PhD students regarding teaching [6-7]. Additionally, previous studies [8-10] investigated the ways self-efficacy was constructed and developed in STEM

graduate and doctoral students. However, the focus of these studies lies on the shaping of self-efficacy, rather than the doctoral students' perceptions of their abilities to teach. Regarding engineering instruction, there is always room for improvement. Proposals for improving engineering education vary from improving teaching training to overhauling the culture of academia [11]. There are options for PhD students to begin instruction through resources such as teaching assistantships or workshops. Some students opt to participate in these while others do not. In addition, some PhD students have extensive prior teaching experiences while others have none.

Methods

This study is part of a larger project focused on understanding engineering doctoral students' perceptions of their preparedness to teach. In this study, the focus is on the experiences of engineering doctoral students who intend on entering academia as a career after completing their doctoral degree and the students' reflections on if/how the PhD student experience prepared them for teaching, as well as their concerns and expectations for a career in academia. In a parallel study of this project, we discuss the design and development of the survey instrument and validated the survey through exploratory factor analysis [12]. In another parallel study, we further analyze the findings from the aforementioned study by examining the variance in engineering doctoral students' perceptions of their preparedness to teach based on their demographic characteristics, prior teaching experiences and trainings, etc. [13]. A specific aim of the current study was to investigate the career expectations, concerns, and reflections of engineering doctoral students who seek a career in academia. In this study, we relied on code enumeration, or the categorization and counting of the frequency of themes within the participants' responses, to quantify the data and allow us to find patterns within the responses [14-15].

Data Source

We used data from a larger Qualtrics survey distributed through email of engineering doctoral students we conducted who were asked about their perceptions of their preparedness to teach as well as demographic information (N=298). While the majority of this survey instrument was done through quantitative measures through Likert scale questions, we also asked additional open-ended questions asking respondents about their reflections, expectations, and concerns for their career. For this analysis, we were focused on understanding the expectations and concerns for those entering academia, so the open-ended questions were only asked to respondents that answered that they decided that they would prefer joining academia over industry careers, government careers, and other careers. Out of 298 survey respondents, 119 answered that they would prefer entering academia, and all except 3 respondents within that group answered at least one of the open-ended questions. The participants were all from U.S. based R1 institutions, with 59.5% identifying as men and 35.3% identifying as women. Additionally, 1.7% identified as genderqueer and 3.4% preferred not to respond or did not respond to the question.

Analytic Strategy

We downloaded the 116 responses from Qualtrics and made a copy to isolate the responses which answered the open-ended questions. Responses for each question were then exported to NVIVO files separated by question and codes were given based on the themes of each response. Each group

of responses was analyzed twice, first to create potential codes and a second time to fit each response into refined codes. The grain size used for analysis was the clauses which fit each code, with the exception of responses which were not written in a complete sentence After the second analysis, themes were defined for each question to fit the codes through a combination of NVIVO's built-in cluster analysis and individual discretion by one of the authors conducting the analysis. After the creation of themes for a question, the authors met to discuss the results of the analysis and clarify the definitions used. A single response fell under multiple codes if there were multiple distinct topics within a single response.

In this analysis, the questions were separated into two question sets. The first set being questions on concerns and expectations for their careers as faculty, and the second asking about their reflections on how their PhD program helped prepare them for future teaching.

Results

On our survey, the respondents offered a large variety of information regarding their reflections on how the doctoral process prepared them for a future in teaching, as well as expectations and concerns on their future career in academia.

Question Set 1 – Looking towards the Future – Expectations and Concerns for an Academic Career

The first question asked, "what are your expectations for a career in academia?", and responses fell under two overarching themes: descriptive qualities of an academic career (n = 36) and the specific work responsibilities required by a career in academia (n = 178). Tables 1 and 2 detail codes, code descriptions, and code frequencies established in the data analysis process for the first question.

Table 1. Codes and Code Frequencies for Work Qualities of Academia

Code	***N***
Challenging	4
Fulfilling	3
Stability	2
Impact	14
Freedom	10
Work-life Balance	3

Table 2. Codes and Code Frequencies for Work Responsibilities in Academia

Code	***N***
Research	44
Mentorship	26
Responsibility Balance	19
Teaching	50
Communication	5
Collaboration	8
Seeking Funding	3
Tenure	8
Ideal Location	9

Work Qualities

Work qualities are listed as separate from work responsibilities as the authors saw them as less quantifiable than the responsibilities identified. For example, how one faculty member may interpret challenges and fulfilment in work can differ from how another, when both are conducting active research. One respondent described their expectations for the qualities of work in an academic career,

> *"[A career in academia would be] challenging, rewarding, and [providing of] security."*

Fulfillment. Several responses mentioned that a career in academia would provide fulfillment to them. This personal level of feeling rewarded resulting from completing one's works is related and often tied to the impact one has on their career, but they are not inherently the same. One respondent write:

> *"A fulfilling career with relationships and influence on the next generation of engineers."*

Impact. Multiple respondents wrote that they expected to have an impact on the field that they focus on and/or an impact on their academic environment through their future accomplishments. This ranges from seeking a position with academic and teaching tasks to contributing to world-class research.

> *"I aspire to leverage both existing research and my own findings to enhance the classroom experience for teachers, students, and overall academic practices."*

Challenges. Responses coded as work qualities include identifying a perceived difficulty of a career within academia. The areas of difficulty may vary by person, but a degree of difficulty in an academic career seems to be expected by several respondents. One respondent stated,

> *"It will be challenging considering that faculty members are expected to contribute in teaching, research, administrative, and extension works."*

Stability. A small number of responses mentioned an expectation of career and social stability in academia. One previously mentioned response stated that they expect a career in academia to provide stability, and another states:

> *"[I expect] respect, stability, a stable work environment, and being able to spread my knowledge and get to know a lot of new people."*

Freedom. Several responses describe how working in academia comes with inherent flexibility in how one's work is accomplished. This flexibility is perceived to be available in both research and teaching.

> *"[I expect to have the] freedom to pursue interesting and important research, freedom in curricular design for specific courses."*

Work-Life Balance. Respondents discussed expecting work-life balance as work either synergizing with or competing with their personal life. Respondents perceived a career in academia

as being very time consuming, but some viewed it as providing an opportunity for personal growth. One respondent stated,

> *"[I expect] long hours but fulfilling work."*

How people interpret freedom, stability, challenges, impact, the relationship between career and one's life, and fulfillment can vary, but these are qualities that the participants have identified as qualities they expect to find within academia. One engineering PhD student may expect to derive fulfilment from instructing undergraduate students, while another may expect this to be a difficult but necessary task to continue onto their intended goal of contributing to research in their preferred field.

Work Responsibilities

A career in academia involves a broad range of responsibilities. These can range from research and teaching to seeking funding or an ideal institution to work for. Work responsibilities are the expectations of the experiential aspects of the work and/or aspects which have an impact on the experiences, instead of work qualities which are the interpretations of these experiences and their traits. One response which focuses on the responsibilities of work in academia states,

> *"I hope to be a professor in a research-oriented university with active involvements of teaching for both graduate and undergraduate courses."*

Research. Responses coded as research discussed both expectations that some amount of research will need to be done as well as expectations that research will be a priority in their academic career.

> *"I am seeking a PhD to promote the research I am already doing."*

Teaching. Responses which were coded as teaching were made up of those which expected teaching and those which would prefer teaching.

"I would like to teach at a primarily undergraduate institution. With this, I hope to have an experience that is center [sic] around the classroom and encouraging students to pursue any and all avenues of their degree."

Responsibility Balance. A large portion of responses mentioned a combination of expecting to conduct research, instruct students, complete institutional service, and mentor students, as well as the compromises made to complete these tasks.

> *"[I expect to have] to focus in the early years on research and having to find ways to effectively teach without spending to much time on it."*

Mentorship. Respondents identified serving as a mentor to students as a requirement in a career in academia. This can include mentoring students through research, as well as mentoring them to be prepared for a career outside of academia.

> *"I would like to be a professor who gives all experience to students and tries to make them able in or to work in any career, whether in industry or other fields."*

Tenure. Several responses mention their goal to eventually achieve tenure or work in a tenure track position. In many of these responses, tenure and tenure-track careers are hoped for, though in others tenure-track positions are explicitly expected.

> *"I currently teach full-time but still need to be tenure-track. I expect that to happen once my PhD is complete."*

Communication. Several respondents mentioned that they expect their career to rely on being able to share their knowledge with others.

> *"[I expect] to be able to pursue research as well as communicate knowledge in the field to students."*

Collaboration. Responses described expectations to work with others within academia as well as people and groups outside of academia.

> *"[I would like to] create networks between my institution and the greater community, and build relationships to foster productive engineers in my students early on."*

Funding Seeking. Respondents discussed the need to find funding for their research while completing the research.

> *"[I expect] a tenure trach position where I am expected to[…] conduct novel research in my area of interest while securing funding for said research."*

Ideal Location. Several respondents described an ideal location or type of institution where they believe their skillset will be best utilized or needs be met best. Some respondents mention preferring to work at smaller, four-year institutions to teach undergraduates or obtaining a position at an R1 institution to focus on research. Others mention preferring to land a position in a specific region.

> *"I aim to land a tenure track research faculty position at a public, four-year, land grant institution in the northern plains."*

These codes are placed under the theme of Work Responsibilities as they describe actions and requirements of a career in academia. Research is inherent to most careers in academia, and seeking funding is necessary to complete research. Additionally, to complete said research, collaboration is often a requirement as well. Teaching students at the undergraduate, graduate, and/or post-graduate level is also often a requirement in academia, and both teaching and research require communication of one's knowledge.

The second question asked the respondents, "what are your concerns for a career in academia?" The responses fell under three themes, the factors regarding the work done in an academic career, socio-environmental factors, and the factors surrounding the organization of academia). Tables 3, 4, and 5 detail codes, code descriptions, and code frequencies established in the data analysis process for the first question.

Work Factors

Work factors are those which are based on the types of work expected to be done and the sacrifices expected to be made to adequately complete the responsibilities of an academic career. For example, discussing one's discomfort regarding being in a position to teach or concerns over the size of the workload.

Table 3. Codes and Code Descriptions for Work Factors

Code	***N***
Responsibility balance	15
Teaching	15
Research	18
Positional Availability	22
Mentorship	6
Time commitment	8
Compensation	10
Tenure	10

Table 4. Codes and Code Descriptions for Environmental Factors

Code	***N***
Competition	9
Atmosphere	6
Funding	14
Pressure	12
Work-Life Balance	17

Table 5. Codes and Code Descriptions for Organizational Factors

Code	***N***
Diversity/Discrimination	6
Adjustment to Academic Life	8
Management and administration	3
Collaboration	5
Independence	6
Academic Politics	5

Responsibility Balance. Some respondents described concerns regarding the varied responsibilities of a faculty member (research, teaching, mentorship, service), and many mentioned their concerns over the apparent priorities of these responsibilities, such as expecting research to be valued by the university over instruction.

> *"I am concerned about striking the balance of being able to have a fulfilling research career while also being an effective instructor since these are often not equally weighted by administration for things like tenure and promotion."*

Teaching. Respondents identified teaching as a potential concern for several reasons. Some mentioned their limited teaching experience, managing a physical and/or virtual classroom, and understanding the standards of teaching to both be an effective instructor and teach students the requirements of the course and/or accreditation. Additionally, many voiced concerns that their desire to teach will not be adequately met as a result of the prioritization of research over teaching.

" [I am] concerned that many colleges express a strong commitment to the education pillar but may hire largely on a research basis, when I am equally interested in both."

Research. Responses that discuss research describe concerns in how the participants may not find a position to continue with their specialty, the apparent need to have more publications to find a faculty position, and how they would prefer to focus entirely on research but will likely need to balance that priority with other required tasks. Additionally, there are concerns regarding the choice of area to research, and if their choice will be interesting or novel.

"[I am concerned on] whether my research is interesting to other researchers in my domain."

Positional Availability. Several participants mention worries over finding a position that suits their needs or desires to continue in academia. Many discuss worries over finding a tenure-track position or jobs in areas of interest. Additionally, some responses express concerns over a lack of support for finding a position at a preferred institution after the completion of their doctoral degree.

"Getting a job is very challenging! Although I have the skills I need, I have no support to help me actually find and obtain jobs that are not at R1 institutions."

Mentorship. Respondents mentioned their concerns over tasks relating to mentoring students, including worries over declining student interest and needing to dedicate additional time to serve as a mentor.

"[I am concerned there is] not enough time to meet all of the added demands and extra work that comes with being a mentor of URM [underrepresented minority] students.

Time Commitment. One concern that the responses cited often was the considerable time commitment that comes with an academic career. Some described this concern in the context of how it may affect the respondent's life outside of academia, while other respondents discuss the extent to which they feel they could be overcommitting to too many tasks.

"[I am concerned with] keeping up with the demands of teaching and research while also having time for applying for grants."

Compensation. Respondents expressed their concerns over their potential future salaries. The responses specifically mention salaries not being competitive compared to alternative careers with a PhD and salaries not reflecting the efforts the respondents expect to make in academia.

"[I am concerned] that the pay will not match the work I do."

Tenure. Participants describe worries over the difficulties in achieving tenure, and how certain aspects of working as faculty may not be rewarded in the tenure process.

"*My primary concern is actually getting a tenure track position, which seems to be getting harder and harder. I think this is especially true if you want to focus purely on teaching."*

Environmental Factors

Environmental factors differ from work factors as they focus on the concerns regarding the social climate found in academia. This can include anticipated pressures to continuously seek funding and worries over competition distracting from research.

> *"I am concerned about the atmosphere of academia. I have heard that the environment can be competitive and harsh."*

Competition. The respondents described concerns regarding a competitive environment that can exist in academia rising from how career advancement is influenced by performance relative to peers. These concerns vary from worries over the high level of competition inherently being a worry to worries regarding the potential effects of this culture on the participants.

> *"[I am] concerned about being caught in an intensely competitive competitive [sic.] institutional culture."*

Atmosphere. Responses describe concerns over different aspects of the social atmosphere that may impact the experiences related to working in academia. These concerns can vary from exclusionary cultures to the working conditions in academia.

> *"I'm concerned about sexism, racism, and other toxic and exclusionary cultures in the workplace."*

Funding. Due to the uncertainty in securing funding for research, respondents describe concerns over the need to secure funding as well as how that ability to find funding could impact the results of research efforts relative to their peers.

> *"[One of my concerns is that] it is a largely competitive field, dependent highly on how much funding one can secure."*

Pressure. There were multiple responses that described concerns regarding the pressures of academia. These pressures include the focus on consistently publishing high quality work and the stress of deadlines.

> *"I feel pressure because you need to have more publications to get a position."*

Work-Life Balance. One of the more common concerns was over the balance of the respondents personal and professional lives. Some of the reasons given for this anticipation of an unbalanced relationship between respondents' work and personal lives include the varied responsibilities of faculty work and the large time commitments of working in academia that can lead to one sacrificing leisure time for working time.

> *"[I am concerned about the] life balance between family, research, and teaching."*

Organizational Factors

Organizational factors are the anticipated difficulties related to the traits of the respondents, their future institutions, and how these traits interact. This can include discrimination based on certain

characteristics, the adjustment to academic life, and the independence that can come with being part of faculty.

> *"[I am concerned over] working conditions, diversity, funding, management, [and] wellness."*

Diversity/Discrimination. Respondents expressed concerns regarding the effects of different forms of discrimination, as well as how universities may address diversity and inclusion. The responses primarily outline concerns regarding gender, ethnic, and racial biases and discrimination.

> *"[I am concerned about] gender and ethnic bias blocks to my efforts."*

Adjustment to Academic Life. Some responses mention concerns over the transition of interacting with the university and the people within it as an employee rather than as a student, as well as the transition from working in industry to working in academia.

> *"[I am concerned about] not knowing how to effectively navigate the world of academia, which is different from industry."*

Collaboration. Some participants identified the requirement and resulting uncertainty of needing to work with colleagues who they may not know before completion of their PhD program, as well as the balance of collaboration and independent thinking.

> *"[I am concerned about] having collaborative and supportive colleagues."*

Independence. Responses mention a concern regarding a lack of freedom offered in teaching and research.

> *"[I am concerned] that I will be restricted to a certain preset mold in my teaching method."*

Academic Politics. Some responses describe worries regarding the impact of the surrounding politics and internal politics of universities and the influence of the politics of these areas. This includes managerial ethics and the impact of local/state/national politics on academia.

> *"My concerns are on ethical principles of some people involved in academia, groupism."*

Analysis of Question Set #1 (Questions 1& 2)

Though some of the responses to these questions may have been influenced in how respondents responded to a set of Likert scale questions regarding their perceptions of their preparedness to teach, there are still some important notes regarding the responses. For instance, while none of the Likert scale questions mentioned positional availability, a plurality of responses to the question regarding concerns for academia mentioned the difficulty to achieve a faculty position. This concern is reflected in how the amount of tenured faculty positions has grown significantly slower than the number of Engineering PhD graduates [16].

The majority of respondents who reported that they did not learn English as a second language mentioned teaching as part of their career expectations (57.6%), whereas a minority of those who reported that they learned English as a second language also mentioned teaching in their career expectations (32.6%). Literature on ESL faculty compared to English faculty regarding their perception on teaching is limited and is a potential area for future research.

The second most mentioned concern among respondents was regarding potential difficulties managing work-life balance in academia. This is not unfounded, with academics often working in excess of 40 hours per week including weekends and evenings [17]. However, this concern was expressed much more often by women than by men, at 21.95% and 6.76% respectively. This is reflected in the history of work-life balance advocacy, where the Women's Liberation Movement in the 1980s pushed for more flexible schedules and maternity leave, though eventually many of these elements were expanded to encompass the needs and private lives of the workforce as a whole [18].

Among the work qualities expected in academia, respondents mentioned impact the most often. Some of these responses use terms such as "I really want to…" or "I would like to…" regarding how they would like to cause an impact. These terms suggest that some of the respondents are motivated by the potential outcomes of their academic careers. However, these terms alone are not enough to conclude whether the respondents are motivated intrinsically, extrinsically, or otherwise. Lechuga and Lechuga [19] describe four perspectives relating to types of motivation in faculty: intrinsic motivation, extrinsic motivation, dual-motivation (such as someone who enjoys the teaching process but does not teach their desired class), and stage-dependent motivation (the transition of motivation based on career stage, such as a tenured faculty member having the freedom to research a specific topic they could not otherwise). Through these approaches, we can see that most respondents are either intrinsically motivated by the desire to further their field and improving the world around them, though some discuss their dual motivation by their desire to be known for accomplishing world-class research.

Engineering professors can impact student confidence and motivation through their interactions and instruction [20]. Additionally, conducting novel research impacts the fields studied through synthesizing new information about a topic, suggesting that a career in academia is inherently impactful.

Question Set 2 – Reflecting on the Past – Do engineering PhD programs prepare one for teaching? and how?

In this second set of questions, respondents were asked about if the respondents feel that their experience in the PhD program has helped them feel prepared for teaching in the future and about the people in academia who influenced the process of their preparation as a teacher.

The third question asked the respondents about if and how their interactions with their peers, their instructors, and/or their advisors influenced the process of their preparedness to teach, and to explain how. 62% of responses identified peer interactions, 62% identified interactions with advisors, and 76% identified interactions with instructors as having influenced the process of their preparedness to teach.

In addition to identifying the types of influential interactions, the participants were asked to explain their reasoning for why they selected those interactions. Tables 6 and 7 illustrate the codes through which the responses fit under two themes: active-reflective and mentor support.

Table 6. Codes and Code Frequencies for Active-Reflective

Code	***N***
Collaboration	9
Discussion	22
Assisting Peers	7
Experience with Prior Instructors	6
Observation	21
Teaching Experiences	8

Table 7. Codes and Code Frequencies for Mentor support

Code	***N***
Career Guidance	21
Encouragement	7
Promotion of Teaching	6
Teaching Advice	32

Active-Reflective

Active-Reflective factors are those in which PhD students are able to actively seek out and or reflect on, such as their experiences with instructors in their undergraduate years or assisting peers in their studies. These factors are grouped into one group as they are factors which can be most directly influenced by the experiences and actions of a doctoral student, unlike authority guided factors, which are more dependent on the faculty surrounding the PhD student.

> *"Interactions with peers have helped [in the process of preparation to teach] as I can reflect openly with fellow students and how we feel about assignments, exams, course material, etc. and use that to guide my teaching. Interactions with instructors have helped as I can take the aspects of teaching I like from certain instructors and the aspects I don't and mold my teaching style to that."*

Collaboration. Respondents describe their experiences of working together with their peers, their instructors, and faculty as having helped their preparedness to teach. Responses mention how working collaboratively allows for exchanges of processes and feedback.

> *"I have TA'ed many different courses so far, so I interacted with a great deal of instructors. Everyone has their own unique approach, so this basically helps me shape my own unique approach"*

Discussions. Responses mention how discussing teaching methods and philosophies with their peers, instructors, and advisors has helped them develop their own thoughts regarding teaching. These discussions can occur in the context of collaborating with an instructor as a teaching assistant, or in courses specific to teaching.

"I have taken many classes devoted to the practices and philosophy of teaching in engineering settings. This allowed me to have many deep conversations with my instructors and peers, while also providing me opportunities to reflect on my own practices and philosophies"

Assisting Peers. Respondents discussed their experiences mentoring their peers and serving as tutors as having helped them in their preparation to teach. Some respondents mention this as an area where they found enjoyment in areas that they see as important in the teaching process.

"When I taught a class to my peers, I enjoyed the ability to organize content in a way that was clear, concise and well-communicated."

Experience with Prior Instructors. Respondents describe their experience with prior instructors as areas where they could analyze and reflect on to decide what they deem as valuable, allowing them to adopt attributes that they appreciated as a student and avoid those which they did not appreciate. Additionally, some respondents discuss how their prior instructors inspired them to become better teachers, though with some mentioning that poor experiences with bad teachers drove their interest in effective teaching.

"Honestly, the primary driver for me seeking out additional resources on effective teaching are my interactions with bad teachers throughout my collegiate career. When I reflect on my time as a student, the vast majority of my professors were implementing outdated/bad pedagogy. Especially as an undergrad, I was not engaged at all, which is a bummer and I hope to change that with my future students."

Observation. A large portion of respondents described how their current observations of instructors' teaching styles and the instructors' students' responses shaped their approach to teaching.

"I draw on all of these experiences to Inform my teaching practices. Specifically, I draw on the struggles in engineering and engagement strategies utilized by my peers to inform how I run my classroom"

Teaching Experiences. Respondents discussed their current and prior teaching experiences as having helped them feel more prepared for teaching in the future. Generally, these were experiences as teaching assistants, though some respondents mentioned having decades of teaching experience.

"I have been a teacher for 20 years so most of my experience was by doing it and observing successful peers was the best practice I could think of."

Mentor Support

Mentor support factors are those which are focused primarily on the interactions between doctoral students and experienced faculty. These factors are focused on the guidance of and respect towards the experienced faculty. This includes the experienced faculty imparting advice and encouragement towards the doctoral students.

"My mentors in my field have been instrumental in helping me grasp the current teaching methodologies and how I can incorporate them into my own practice. They offered tailored guidance for specific situations, imparted valuable pedagogical insights, and I also conducted in-depth studies from various sources. Additionally, I sought advice from seasoned faculty members and gleaned insights from their teaching experiences. Their collective support and motivation drive me to continually enhance my skills, striving to become a more proficient academic practitioner."

Career Guidance. Respondents described how their advisors and other faculty members offered them useful advice regarding the process of succeeding in academia. Responses varied from faculty members speaking with the respondents regarding the process of achieving tenure to discussing the difficulties faced by minority faculty members in engineering academia.

"My advisor has been very forthright about the complications that come with being a minority group in engineering academia."

Encouragement. Respondents described how their confidence grew as their advisors actively voiced their support towards the respondents.

"When I interact with my advisor, I am excited by their belief in me to overcome challenges."

Promotion of Teaching. Some responses discuss how advisors supported the respondents' interest in teaching. Respondents mentioned how their mentors have actively supported their interest in teaching.

"Well, through my interactions with different mentors and advisors, I have been able to streamline my interests in such a way that now I know that even though I do not like the research part of academia, and I want to just teach, I can also have a career as a Professor of Practice."

Teaching Advice. A plurality of respondents describes how their advisors and other faculty members offered them specific advice on improving their teaching.

"My instructors have been excellent in explicitly teaching how to teach (engineering education faculty members)"

Question 4: In regard to explaining their answer for why their experience in the PhD program has/has not helped them feel prepared to teach, Tables 8 and 9 show how the responses fell under two groups: experiential factors and structural factors. Experiential factors are those that are directly related to the experiences of taking part in a PhD program, such as understanding different methods of learning through being exposed to several different instructors with unique priorities and styles and the development of soft skills (such as time management and presentation skills). Structural factors are those that relate to organization of academia, such as the rules regarding teaching requirements or how advisors may encourage or discourage teaching.

Table 8. Codes and Code Frequencies for Experiential Factors

Code	*N*
Understanding Learning	12
Field Experience	16
Soft Skills Development	10
Collaborative Experiences	8

Table 9. Codes and Code Frequencies for Structural Factors

Code	*N*
Advisors	9
Low Teaching Emphasis	5
Teaching Training Courses	21
Teaching Experience	56

Experiential Factors

Experiential factors focus primarily on the experience which comes with the engineering PhD experience that can affect one's preparation for teaching. Engineering PhD students will encounter a variety of instructors, peers, and faculty who have different methods of teaching and learning, which may help future instructors through understanding a large variety of methods to achieve their goals in the classroom. For some engineering PhD students, this understanding can stem from their specialization in Engineering Education, where they are not just exposed to, but also actively seek further understanding of how different educational practices operate through a variety of perspectives. Additionally, the process of researching and expanding one's knowledge of a subject may also help the potential future instructors through achieving a greater expertise in an area as well as improving skills that may transfer to instruction, such as presentation skills.

Understanding Learning. Respondents mention how, through interactions with instructors and faculty, they have learned about methods to solve problems and varieties of teaching styles. Additionally, a large portion of respondents mentioned currently being in their university's engineering education department, where they have focused on the educational process and philosophies in their research and instruction.

> *"I've acquired knowledge in pedagogy, instructional techniques, and assessment design. I've also gained proficiency in course design and the methodologies for conducting research in engineering education."*

Field Experience. Throughout their PhD program, respondents have furthered their expertise regarding the technical concepts in their field. While some respondents cite this as how their PhD program has helped them feel prepared to teach, other respondents do not feel that this enhanced knowledge may be able to translate directly to improved teaching.

> *"[My PhD program] has helped me with technical content, but not with teaching skills"*

Soft Skills Development. In the process of being an Engineering PhD student, respondents identified a variety of ways their research and work has helped them in ways that may transfer to being an instructor.

"The Ph.D. program itself has helped me hone my critical thinking and problem-solving skills such that I can transfer this into a classroom to implement during lectures."

Collaborative Experiences. In addition to the soft skills developed throughout the PhD program, respondents mention working with both peers and faculty as providing them with opportunities to develop their perspectives regarding teaching styles as well as improving their ability to communicate with others.

"Collaborating with professors and attending in various classes help us to teach in the future."

Structural Factors

Structural factors describe how the infrastructure and organization of their PhD program and university has impacted the respondents feeling of preparation for teaching. For example, some respondents describe that their PhD programs require instructional experiences with training, while others mention that their programs actively discourage teaching.

"The program's provision of courses, workshops, and resources, the support from advisors and faculty, access to a comprehensive library, and opportunities for practical teaching experience all contribute to a strong foundation for my teaching and research endeavors."

Advisors. Respondents generally describe their experiences with advisors as encouraging them to teach, though some responses mention pushback by their advisors against spending time on teaching.

"No, my PhD program has actively discouraged teaching careers. I've had to go behind my advisor's back to gain the experience I need to get the job I want."

"[…] I worked as a teaching assistant. I also always talk (sic.) with my advisor about how he teaches his classes."

Low Teaching Emphasis. Some respondents mention that they feel that teaching is not a priority in their PhD program. This includes expressing doubt in the necessity of PhD programs involving teaching training and citing the lack of importance of being able to teach in regard to acquiring an academic career.

"However, the PhD program didn't do too much to prepare me (to teach), nor would it actually be helpful in acquiring an academic position. Hence, there is little motivation to pursue education, when the job is offered only to the top researchers."

Teaching Training Courses. Several respondents mentioned that they took teaching-focused classes. In some cases, these were required to complete their PhD, while in other cases, these classes were optional. This includes training classes for teaching assistants and teaching seminars.

"We take a Learning, Assessment, and Pedagogy class, and are required to have a one-year teaching experience during the degree."

Teaching Experiences. Most respondents mentioned their teaching experiences. In some cases, these teaching experiences were required in conjunction with the aforementioned teaching training courses, while in other cases, these teaching experiences were completely optional. Generally, these experiences were as teaching assistants.

> *"I think that the PhD can be done in a way that avoids giving you any preparation to teach. All of the preparation I've gotten has been as a result of what I sought for myself outside of classwork and research."*

> *"I have had two teaching experiences, one teaching a graduate-level course and one undergraduate, with support from university resources and the primary instructors."*

Analysis of Question Set #2 (Questions 3 & 4)

This set of questions asking respondents to reflect on their experiences in their PhD programs in regard to their feelings of preparation for teaching, revealing how there exists factors which can be influenced primarily by doctoral students, such as how working on their PhD program helped them in developing soft skills that can translate into instructional practices or how their reflections on their prior experiences as a student influenced their thoughts on teaching.

In addition to these factors, there are also factors which are influenced more heavily by their institutions, such as the availability of teaching training courses or the active support from faculty members regarding developing teaching skills. However, given the varied experiences of all the participants, we see how the support of advisors, faculty members, and the institution is not a guarantee in the experience of a doctoral student. For instance, some respondents describe how they feel that teaching is not a necessity in achieving an academic position, so they view their teaching ability and experiences as a much lower priority than their research output. This is reflected in current research, where Buswell [1] discusses how non-R1 engineering professors discussed how they felt underprepared for their teaching roles despite expressing interest in focusing on teaching throughout their PhD program. In addition to feeling underprepared for their roles as teachers, some of the non-R1 professors described experiencing some resistance from their advisors towards seeking teaching experience and teaching-first positions.

Limitations and Conclusions

One of the limitations in this study is the inability to ask participants to expand on their thoughts. This is a result of the data collection method, which allows for a broader breadth of respondents in exchange for depth of responses for being a free response question. A future study could utilize interviews to expand on the depth of the responses. Another limitation of this study is the participant group being made up of students at American, R1 institutions, limiting the extent to which this study can be applied to international institutions and doctoral student experiences. As a result of this set of questions being presented after a set of Likert scale questions about teaching, the responses to questions regarding general academia expectations and concerns. The study found a large difference between the expectations of those who learned English as a second/foreign language and those who did not in their expectations to teach. However, the form factor of the data collection limited the ability to find a reason for this relationship.

This study found the gendered differences in concerns regarding work-life balance continued, as well as clarifying the extent to which positional availability is a concern to doctoral students looking to enter the field of academia. Additionally, the study discussed how the structure of academia and the influence of faculty can affect how the respondents feel about their preparation to teach while doctoral students can independently affect their perception to their preparation to teach through their own experiences. Part of these experiences include the continuation/completion of their PhD program, as the participants felt that the skills required to complete a PhD program, such as collaboration, presentation, and the development of other soft skills can transfer over to teaching.

References

[1] N. T. Buswell, "The purpose of a Phd in engineering: Where does teaching fit in?," *Studies in Engineering Education*, vol. 1, no. 1, p. 83, Jan. 2021. doi:10.21061/see.8

[2] E. O McGee *et al.*, "Turned off from an academic career: Engineering and computing doctoral students and the reasons for their dissuasion," *International Journal of Doctoral Studies*, vol. 14, pp. 277–305, 2019. doi:10.28945/4250

[3] K. Kang, "Data tables," NSF, https://ncses.nsf.gov/pubs/nsf24300/data-tables (accessed Feb. 2, 2024).

[4] I. Mena, H. Diefes-Dux, and B. Capobianco, "Doctoral students as course instructors: Three engineering teaching assistants' socialization experiences," *2011 ASEE Annual Conference & Exposition Proceedings*, 2011. doi:10.18260/1-2--17790

[5] R. R. Baiduc, R. A. Linsenmeier, and N. Ruggeri, "Mentored discussions of teaching: An introductory teaching development program for future STEM Faculty," *Innovative Higher Education*, vol. 41, no. 3, pp. 237–254, Nov. 2015. doi:10.1007/s10755-015-9348-1

[6] H. Horta, "Phd students' self-perception of skills and career plans while in doctoral programs: Are they associated?," *Asia Pacific Education Review*, vol. 19, no. 2, pp. 211–228, Apr. 2018. doi:10.1007/s12564-018-9532-y

[7] J. S. Boman, "Graduate Student Teaching Development: evaluating the effectiveness of training in relation to graduate student characteristics," *Canadian Journal of Higher Education*, vol. 43, no. 1, pp. 100–114, Apr. 2013. doi:10.47678/cjhe.v43i1.2072

[8] M. R. Connolly, Y.-G. Lee, and J. N. Savoy, "The effects of doctoral teaching development on early-career STEM scholars' college teaching self-efficacy," *CBE—Life Sciences Education*, vol. 17, no. 1, Mar. 2018. doi:10.1187/cbe.17-02-0039

[9] L. Charleston and R. Leon, "Constructing self-efficacy in STEM graduate education," *Journal for Multicultural Education*, vol. 10, no. 2, pp. 152–166, Jun. 2016. doi:10.1108/jme-12-2015-0048

[10] K. I. Maton *et al.*, "Outcomes and processes in the Meyerhoff Scholars Program: Stem PhD completion, sense of community, perceived program benefit, science identity, and research

self-efficacy," *CBE—Life Sciences Education*, vol. 15, no. 3, Sep. 2016. doi:10.1187/cbe.16-01-0062

[11] C. J. Finelli and J. E. Froyd, "Improving Student Learning in Undergraduate Engineering Education by Improving Teaching and Assessment," *Advances in Engineering Education*, 2019.

[12] Garcia, O. J., & Kittur, J. (2024). Factors Influencing Engineering Doctoral Students' Perceptions on their Readiness to Teach Engineering Courses. In *2024 ASEE Annual Conference & Exposition*.

[13] Garcia, O. J., & Kittur, J. (2024). Engineering Doctoral Students' Expectations, Reflections, and Concerns Regarding Future in Academia. In *2024 ASEE Annual Conference & Exposition*.

[14] Saldaña, J. (2021). The coding manual for qualitative researchers.

[15] Kittur, J., & Tuti, S. (2024). Conducting Qualitative Research Study: A Step-by-Step Process. *Journal of Engineering Education Transformations*.

[16] R. C. Larson, N. Ghaffarzadegan, and Y. Xue, "Too many Phd graduates or too few academic job openings: The basic reproductive number R0 in Academia," *Systems Research and Behavioral Science*, vol. 31, no. 6, pp. 745–750, Sep. 2013. doi:10.1002/sres.2210

[17] E. Drew and C. Marshall, "Work-life balance in academia: Myth or reality?," in *The Gender-Sensitive University*, S. Canavan, Ed. New York, NY: Routledge, 2021, pp. 52–66

[18] S. Raja and S. Stein, "Work–life balance: History, costs, and budgeting for balance," *Clinics in Colon and Rectal Surgery*, vol. 27, no. 02, pp. 071–074, Jun. 2014. doi:10.1055/s-0034-1376172

[19] V. M. Lechuga and D. C. Lechuga, "Faculty motivaiton and scholarly work: Self-determination and self-regulation perspectives.," *Journal of the Professoriate*, vol. 6, no. 2, pp. 59–97, 2012.

[20] A. F. Cabrera, M. Steven, and L. Nasa, "On college teaching methods & their effects: ten lessons learned," *Consejo de Universidades*, 2000.