RFE: Understanding graduate engineering student well-being for prediction of retention: Year 1

Introduction

In addition to facing the ongoing mental health crisis in academia, including unprecedented rates of mental health concerns in university students [1] and overburdened counseling centers [2], doctoral students face an additional crisis of retention, with national attrition rates of 43% for doctoral students [3]. Evidence suggests that these situations are worsening in light of the COVID-19 pandemic [4].

Previous studies of graduate student stress have linked stressors and anxiety to student retention [5]. Studies promoting graduate student well-being have generally focused on reactive interventions (e.g., [6], [7]) and a wide range of studies involving stressors focus on particular sources of stress, labs, or populations, meaning the broader landscape of stressors and populations must be contextualized using multiple sources (e.g., [8], [9], [10]). Additionally, studies of wellness and coping related to graduate students are rare. While studies of specific stressors and populations all constitute valuable contributions to the study of doctoral student retention, our team posits that there is a need for studies which explore multiple sources of stress. These stressors can then be compared to each other and to literature for existing coping strategies to better understand which stressors are the most severely and frequently experienced by graduate students. Such an effort can promote proactive interventions which improve upon doctoral students' habits and the cultures they are situated in as an effort to avoid retention issues.

Our project proposes to situate and compare different sources of stress with their effects on retention and stress and anxiety levels. To achieve this, the first year of research in this project applied a mixed methods design which explored the sources (of common stressors, from interviews) and effects (on mental health, using existing questionnaires) of common stressors in graduate engineering programs. In this paper, we describe our project and its timeline and goals, as well as preliminary findings related to a qualitative data analysis of interviews related to graduate student stress and coping.

Project Overview

This project, *Understanding graduate engineering student well-being for prediction of retention*, is a three-year mixed methods study which aims to develop a measure of stressors experienced by doctoral engineering students. In the first year of the study, longitudinal interviews were conducted with a sample of 55 engineering PhD students in various years in program and engineering disciplines and explored the most prominent stressors mentioned by those students. Simultaneously, we collected questionnaire data from the same sample on validated measures of anxiety, stress levels, and intention to remaining in an engineering PhD program.

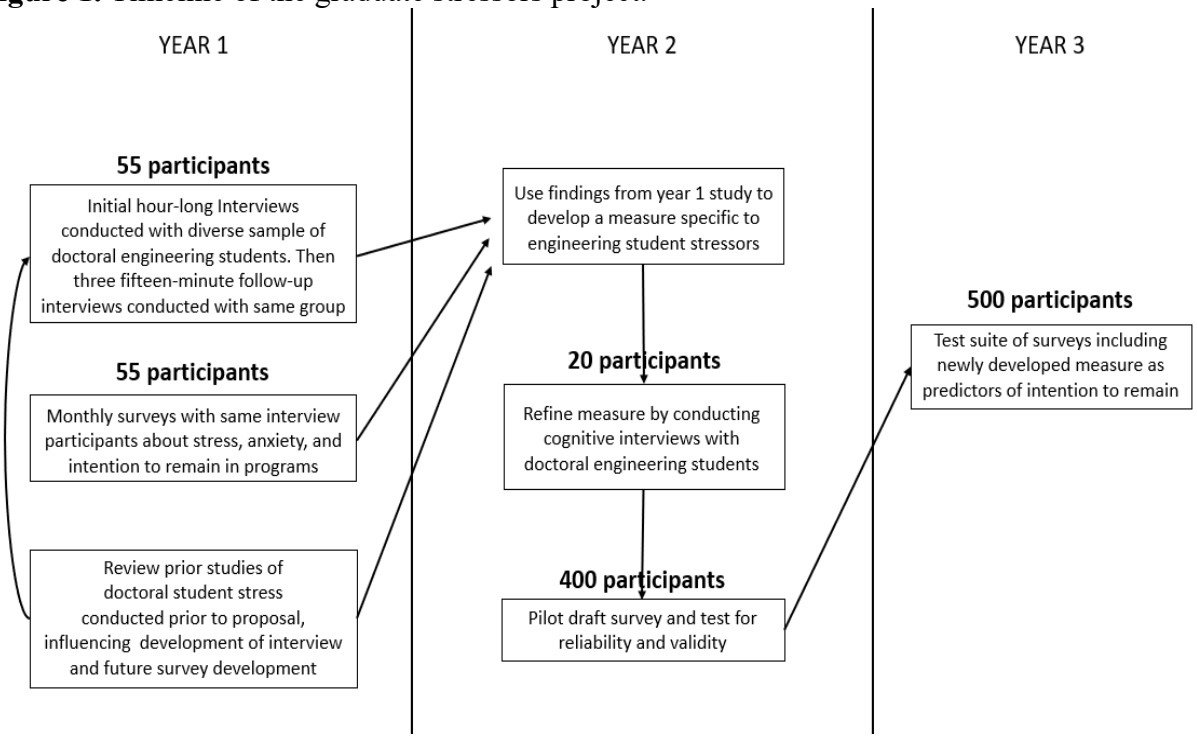
In the second year of the study, results from the first year's work will be leveraged to develop and validate a measure of frequency and severity of stressors to predict student intention to

remain. In the third year of the study, the developed survey will be applied to a large sample of graduate students. The research design was guided by the job hindrance-control-support JHCS model [11] and prior studies of doctoral student stress (e.g., [8][9][10]). The overall research question for the project is *What is the nature of and what are consequences of stressors for graduate students?*

Study Design

This project mixes qualitative and quantitative research methods in a sequential design for the purpose of triangulation [12] to in Year 1 uncover the identities of top stressors experienced by doctoral engineering students and in Years 2-3 to measure their effects on student well-being and retention. The goal of the longitudinal interview phase of study in the first year of the project is to collect data supporting the creation and testing in years 2 and 3 of a novel survey (involving ranking of stressors) which predicts doctoral students' intention to remain in their engineering programs by providing a suite of questions including existing survey measures and new ones developed as a result of work in year 1. Figure 1 shows an outline of the study's timeline and how the components of the study are used.

Figure 1. Timeline of the graduate stressors project.



In the project's first year, 55 students were recruited for a longitudinal interview and questionnaire study. Students were intentionally stratified to represent different departments in the host institution's college of engineering and to be at different stages of their doctoral student journeys (as described in [13]). Further, students were stratified by gender, enrollment status (e.g. domestic, international), and race to be representative of the host institution's population. Participants were administered monthly 22-item questionnaires for eight months, with subscales related to stress and anxiety [14] and intention to remain in their engineering programs [15]. In

the first month, participant demographics were also collected. One initial hour-long interview was conducted with each participant in October, and shorter, fifteen-minute follow-up interviews were conducted with participants in December, February, and April. Initial interviews included questions about students' doctoral student experiences, housing and access to food and other quality of life needs, self-assessments of class and research performance, top-rated student sources of stress, experiences with microaggressions, intention to remain, and coping strategies. Sample questions include "Do you experience any stress when it comes to doing research work or interacting with labmates or your advisor?" and "What sorts of things do you do to cope with stressful situations, or just to relax in general?". Follow-up interviews included questions about changes in sources of stress or coping strategies between the current and prior interview and assessments of progress and goals set and accomplished before and after each interview, i.e., "What was the most stressful aspect of your program since our last interview?" For February follow-up interviews, a question about the impact of the omicron variant on participants' stress levels and work was added and for April, questions contrasting the prestige and stress of different roles taken by students in doctoral programs, such as research and teaching assistants, were added.

In the project's next years, findings from year 1 will be leveraged to develop a measure of engineering student stressors. Subscales will be created for different sources of stress identified in year 1, particularly those which were considered to be the most frequent or intense sources of stress by participants in year 1. The newly developed scale will be tested by cognitive interviews in year 2, and then a pilot survey with 400 participants will be conducted. The pilot survey will be analyzed for reliability (e.g., Cronbach's alpha and McDonald's omega) and validity (e.g., exploratory factor analysis). In year 3, a suite of survey measures will be administered to 500 participants. Measures will include the newly developed stressors scale developed in year 2 and existing measures related to intention to remain, mental health, social and advisor relations, and engineering culture [16].

Data Collection

The research design and instruments were approved by the site university's Institutional Review Board before data collection began.

Participants were recruited using targeted emails to student societies, professional development mailings, TA teacher trainings, and courses with significant engineering doctoral student attendance. Over one hundred students responded with interest. A sample of 55 students were recruited, stratified to create a representative sample of the university's graduate engineering students by race, gender, department size, progress in doctoral program, and domestic or international student status. All participants interested in the study were invited to complete the first month's survey to gather reliability data; 98 students took part in the month 1 survey. Throughout the study, participants were compensated with Amazon gift cards for their participation. Participants were given $40 gift cards for initial interviews and $10 for each follow-up. Participants who completed all 8 monthly surveys in year 1 were given an additional $20 gift card. All participants interested but not recruited into the stratified sample were offered to complete the October survey to contribute to reliability data; these participants were entered into a lottery for a $100 Amazon gift card.

Participants completed a digital consent form during the initial October survey in year 1 and were given consent information before the study began. The interviewer reviewed consent information and collected recorded, verbal consent before beginning each interview and follow-up interview. Table 1 summarizes major participant demographic data.

Table 1. Participant demographics

		Longitudinal Study Sample (Total N = 55)
*Department Size**		
	Small	20
	Medium	18
	Large	17
Stage in Program		
	Early (pre-qualifying exam)	21
	Middle (post-qual, pre-prelim)	23
	Late (after preliminary exam)	11
*Gender***		
	Male	31
	Female	23
	Nonbinary	1
Enrollment Status	International	26
	Domestic	29
*Race***		
	White, Caucasian	26
	Asian or Pacific Islander	20
	Black/African American	2
	Hispanic	7
	Indian subcontinental	5
	Arab/Middle Eastern	2
	American Indian	1

All demographic information collected was optional, however participation was complete from longitudinal participants. Options from the demographic questionnaire with no responses have been omitted from this table.
*Cutoff values for department size were determined by the team before recruiting participants. The site institutions large departments were considered to be Mechanical Engineering, Electrical and Computer Engineering, and Computer Science; the medium departments were considered to be Civil and Environmental Engineering, Materials Science and Engineering, and Physics; all other departments were considered to be small size.
** For *Race* and for *Gender*, multiple options could be selected.

Interviews

A total of 55 interviews were conducted in October and a further 54 follow-up interviews were conducted in December. All interviews were conducted using recorded audio on the Zoom platform. The interviews lasted approximately 45 minutes but ranged from approximately 30 minutes to 1 hour and 5 minutes. Follow-up interviews had an average duration of 12 minutes and were conducted with the participants every other month. Further follow-up interviews were scheduled at the beginning and end of the spring semester.

Monthly Surveys

Survey participants were recruited into the Canvas LMS and were assigned monthly survey time slots. In October, a larger sample of students participated, and reliability was calculated using Cronbach's alpha and McDonald's omega. The monthly survey included three subscales: a

seven-item measure of stress and a seven-item measure of anxiety [13] and a six-item measure of intention to remain in a doctoral engineering program (modified from [14]).

Table 2 summarizes each measure in terms of reliability data collected in October, and participant counts for each month. While participant retention was generally high during the study, participation decreased during the winter break and some participants partially completed the surveys.

Table 2. Reliability and participation count

	DASS 21 Anxiety Subscale	DASS 21 Stress Subscale	Intention to Remain Subscale
Cronbach's Alpha (October)	0.69	0.85	0.90
McDonald's Omega (October)	0.82	0.91	0.96
October Participant Count*	91 (54)	89 (53)	90 (54)
November Participant Count	55	53	54
December Participant Count	50	47	46
January Participant Count	53	52	52
February Participant Count	51	50	50
March Participant Count	50	50	49

* Parenthetical numbers are totals of longitudinal interview and survey participants; the preceding number includes those participants and additional participants used for a larger sample for reliability calculations as described above

Preliminary Results

Participants stated numerous sources of stress present in their engineering doctoral programs. Coding is in progress, but from our reading of the transcripts, there was significant alignment between prior literature on individual student stressors and stressors discussed by participants as relevant to their experiences as doctoral engineering students. For example, consistent with prior literature, a number of stressors emerged as themes, including stress due to research group presentations, writing papers and receiving feedback, preparing for milestones such as qualifying exams, test-taking, language barriers, finances, and navigating the process of research (e.g., dealing with equipment failure, deciding on novel research questions). Some additional themes emerged. These themes are ones our team has not observed to be the focus of existing literature about STEM doctoral student experiences and stressors. However, these themes are in most cases closely related to known stressors in the general workplace stress literature and in studies of academic culture and postsecondary student stress. To highlight these themes, we briefly report these stressors below.

Travel-related stressors for international students. International students often spoke of stressors related to being unable to travel to or from home, either due to travel bans or restrictions, difficulty getting flights, visa problems, and/or COVID-19 outbreaks. Both the uncertainty of future plans and homesickness related to being unable to be in person with family were noted as

major stressors for many international students, particularly immediately following and preceding the Thanksgiving and winter holiday breaks. To a lesser extent, domestic students reported the same stressors during the omicron outbreak of the pandemic, however visa issues were generally non-existent for that population.

Tensions between teaching and lab responsibilities. Participants spoke of how research and teaching demands and teaching assistant demands often competed; this is often described as role conflict in the workplace stress literature. The fact that different faculty supervise a single student for these two different jobs may contribute to role conflict for doctoral students and was described by participants. Further, doctoral students' roles evolve during their PhD, creating stress by breaking previously established routines, changing finances and budgets between semesters, and causing priorities and goals to be reassessed, potentially multiple times in a single year.

Importance of a car. Participants who did not have use of a car more often spoke of difficulty making friends and connecting with friends. They also spoke of trade-offs between the time needed to access less-expensive but more distant large grocery stores and the easier access to more-expensive but less well-stocked nearby stores. In the winter, these issues were further exacerbated by poor weather and increased darkness, leading to participants feeling unsafe.

Work-life balance. Participants spoke of labs that put extreme hourly demands on students, such as never observing university holidays, 60-hour work weeks, lengthy data collection windows, little vacation time, and conflicts between family or partners as a consequence of working hours or irritability due to stresses at work. To a lesser extent, preparation for qualifying exams, midterm and final exam periods for coursework, and final grading for teaching assistant work also contributed to these same demands and consequences.

Friction with advisors. Participants spoke frequently and intensely of challenges with advising relationships, including difficulty in receiving feedback from advisors, pressure to take part in projects or courses of less interest to participants, differences in desired and actual advising styles, and demanding weekly expectations. A small number of participants also described political challenges, such as switching or finding advisors, or personal challenges, such as friction with the advisor's personality or treatment of lab workers.

Microaggressions. Participants spoke of being publicly, rudely criticized around their race and around being a parent. These microaggressions occurred on campus, in departments, and also in the surrounding community. Some participants were the victims of such actions; others witnessed or learned of these microaggressions occurring to their peers.

Uneven quality in courses taken. Students noted some uneven quality in the teaching they receive, such as whether course materials were well-organized, faculty gave clear explanations, and assignments were aligned with stated course objectives. Some participants attributed this to the switch to mostly online courses from March 2020 through May 2021.

COVID-19 and the omicron variant. During the study, participants experienced the later stages of the delta variant "wave" of the pandemic and the entirety of the omicron variant's winter

2021-2022 wave. Participants described impacts to their health, stress levels, working environments, class environments, relationships, travel, and finances as a result of the pandemic, which influenced the experience of many of the existing and novel themes above.

Future Work

Future work will include completing the analysis of the monthly survey data, primary hour-long interviews, and follow-up interviews, including counts of codes. This analysis will be leveraged to create and validate a measure of engineering doctoral student stressors during the next year of the grant. If successful, this measure will have predictive power to measure intention to remain in PhD programs based on the experience of stressors. A qualitative analysis of the year one data will be published as an analysis of the landscape of stressors described by engineering doctoral students. As a result of a prevalence of COVID-19 stressors reported by the interview participants and co-occurrence of follow-up interviews with the rise of the omicron variant of the pandemic, our team is also completing a manuscript about the experience of stress by doctoral engineering students during the COVID-19 pandemic. These results can inform recommendations for proactive interventions, policies, and better information about resources to support graduate engineering students.

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