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Work in Progress: Exploring Qualifying Exam Experiences in Engineering Doctoral Students using Well-Being Constructs

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Introduction

This work-in-progress research paper outlines the pilot testing of interview protocols aimed at examining the qualifying exam (QE) experiences of engineering doctoral students (EDS) using the PERMA-V framework for well-being. The QE is a crucial milestone towards earning a doctoral degree and serves as the entry point to both candidacy status and increasing research independence [1], [2]. Despite their importance, QEs are an understudied element in doctoral programs especially for underrepresented populations [3]. However, the gatekeeping nature of QEs [4], [5] carries major implications for EDS' trajectory within their programs [6], [7]. As a major stressor, QEs may threaten well-being [2], [8], [9]. Several factors contribute to this phenomenon such as misalignment with coursework [4], vagueness of assessment parameters [1], [4], and unpredictability (particularly for oral exams) due to hidden expectations [4]. Qualifying exams may also contribute to attrition rates, a well-established concern in doctoral engineering education [10], [11]. Studies on attrition have described how advisor support, academic climate, personal traits, and funding affect engineering doctoral education [11]. The QE, being a foundational experience, and intersecting with all four of the above factors, highlights the value of specifically investigating its impact on EDS' well-being.

The EDS population is not a monolith and we expect to find different subgroups of students for whom the QE process has different impacts. This study outlines the pilot testing of interview protocols developed using the PERMA-V well-being framework [12], [13], [14]. This framework consists of six constructs that define well-being: positive emotion, engagement, relationships, meaning, accomplishment, and vitality. Pilot studies are necessary in qualitative research to establish and refine theoretical frameworks, research questions, and interview questions, and to establish a rapport between the interviewer and the participants [15], [16]. The results of this pilot study will help fine tune the protocols for a later, more comprehensive study of 2nd year EDS about to go through the QE process.

Qualifying Exam Context

The biomedical engineering (BME) department's QE at [host institution] are required for 2nd year EDS and occur immediately after the Spring Quarter. Three examiners are assigned to each exam, two of which have familiarity with the EDS' research area. A 5–6 page proposal describing research to be done in the next ~1 year is submitted ahead of time to the examiners as background reading, but is not part of the assessment. The exam takes an oral, closed-door, format of 55-min. length: the first 10 min. is a presentation given by the student (also for context but not assessed); the remaining 45 min. are for Q&A directed by the examiners. Topics for the Q&A are not restricted to material presented by the EDS. The exam is pass/fail; final decisions are made by convening all examiners at the end of the second day of scheduled exams. Total program attrition rate is ~10% and attrition associated with QE passage is estimated to be <5%.

Participants

Participants for this pilot interview were recruited from a pool of 3rd and 4th year BME EDS at a mid-size private R1 university. Students were recruited from this pool because they had already taken the QEs and have insights on this experience which can help refine the interview protocol. Consent and demographic information were collected using a Qualtrics survey exploring the relationship between Engineering Identity (EI) and Research Scientist Identity (RSI), which will be used in the comprehensive study of 2nd year EDS about to go through the QE process. To date, sixteen participants have completed the survey and six participants volunteered to be interviewed. The 30–40 minute interviews were conducted over Zoom. The participants included four females and two males. Four participants identified as White, one identified as White and Asian, and one identified as Black. The Black participant also identified as a first-generation student. Pseudonyms are used to ensure anonymity (see Appendix 2 for the participant descriptors of each pseudonym). International or domestic student status was not collected, and protocols will be revised to include this data.

Data Analysis

A constant comparative approach was used whereby a primary coder analyzed the data using constructs from the PERMA-V framework. Discussion with the second researcher yielded that an additional construct, "negative emotions" would be beneficial to distinguish negative emotions related to stress and anxiety that QEs brought about from the positive emotions construct of PERMA-V. Through a second round of coding, subcodes for each construct were generated (e.g. *relationships:family*). Matrices—one per participant—were then used to map out interconnections between constructs. For most coded statements a primary construct was identified in the matrix with other constructs denoted as secondary (e.g. a statement might be coded as *relationships* [primary] associated with *positive emotions* [secondary] and *negative emotion*s [also secondary]). Preliminary analysis of patterns resulted in findings that captured experiences across the participants.

Findings

Three preliminary findings emerged from the data analysis that give some insight to the experiences of the EDS going through the QE process, namely: (1) some EDS wanted to impress their PI and the examiners, (2) PI's can be viewed viewed as accommodating and understanding, and (3) *engagement* modulated the EDS' *positive* and *negative emotions*.

<u>Finding 1: A desire to impress PI and/or Examiners</u>
Some EDS reported that a key motivator for them was a need to impress their PI and/or examiners and they were conscious about having a desire to be seen as competent. Fish articulated that he "was worried about…impressing the people" that he was speaking to and that he wanted "to do well because I want people to think that I'm good at what I do." Jane, explained that "there was also a sense of...I needed to pass the qualifying exam to show that I know what I'm talking about." For these students, passing the QE was a means to impress their PI and be seen as smart enough to be in their doctoral program.

<u>Finding 2: A perception of their PI as "accommodating"</u>
Some EDS expressed that their PIs were accommodating and understanding of the impact of the

QE process on research progress. Fish described his PI as "very...accommodating". "At our like weekly update meetings where I would normally show results or give progress reports, they were very much just asking me where I thought I was in terms of readiness for quals." Jane described her PI as "really nice....respectful in a sense of...he knew that I was in the qualifying exam so he wasn't very like, expecting all of this data" and reflected "so that was nice that I...didn't have as many responsibilities in the lab." Both students articulated that their PIs were amenable to them shifting their focus to QE preparations in exchange for a drop in research productivity.

Finding 3: *Engagement* levels are linked to changes in *emotion* strength and valence

Disengaging from research and/or QE-related work was related to positive emotions. Fish explained how he was "ramping down my research productivity" to focus on QE preparations. Leslie went to a conference before the QE so she "didn't really do a lot of quals prep. During that time, I was very much focused on enjoying the conference and making the most of it."

On the other hand, not having a defined project for the QE presentation was linked with negative emotions. Leslie explained that "I did have a project given to me when I came in but it was not something that I could present for quals." She was working on another clinical trial but "unfortunately, the data...was not super interesting...there was a lot of floundering happening... and figuring out...where do we go from here. So that part was really hard and super stressful." Avenger explained that ambiguity about "how much preliminary data is needed" was "confusing for lots of people." "As a second year [student], you expect to now have some. But you're never sure...because...it's research. It's like...how much of my own data? Do I have enough? Is this enough for people...that's the other stressor."

The data showed that all EDS talked about their engagement levels concurrently with the emotions they felt. Emotions, both positive and negative, were variable over time as well as with level of engagement. Avenger described that stress built up and then decreased "it [stress, *negative emotion*] build up a little bit more...as we got closer...as I rehearsed with more people was able to answer most people's questions, it [stress] was slightly going down and down." Jane, who lived with two other EDS also taking the QEs described them as, "they help a lot." Jane and her roommates "spent a lot of time studying together and practicing with each other" preparing for the QEs. Leslie voiced that "talking to the older grad students...in my lab. Some practice sessions were really great" helped with formulating her explanations and answering questions coherently. Fish felt "very confident...I wasn't worried about the exam overall" because "both my advisors would have me practice my oral component and practice giving me the questions." He felt that if "I crush this part [QE]," his advisors would feel "very confident in me." "I wanted them to feel like I really know what I'm talking about."

Discussion

The findings offer tentative insights into the experiences of EDS as they go through the QE process. Students seem to be perceptive of their levels of PERMA-V(N), but it should be noted that all participants had passed their QE and this fact might introduce retrospective bias in the form of diminished recollection of negativity. First, it is not surprising that students taking the QEs wanted to impress their PIs and examiners to "show that I know what I'm talking about." Only two students explicitly expressed the need to impress their PIs and examiners though we suspect that this is a common sentiment worth exploring deeper because of how the need to

impress can be related to negative emotions. Avenger explained that "the main source of concern was when it came to the project itself, is this not 'engineering enough'." The "source of 'fear' that will they question...they say the engineering...and I was like, this not really that here." Perhaps a concern that his project was not "engineering enough" stemmed from a desire to prove to his PI that he knew enough engineering to be granted a degree in biomedical engineering. An EDS' relationship with their PI based on respect [17] manifests in their desire to impress.

Second, the finding that PIs were viewed as accommodating and understanding of the burden of the QE process may mask an underlying tension between the need to pass the QEs, entailing time off from research to be optimally prepared, and the need to continue research activities. Sarah explained that "[my] experimental pace had slowed...but I hadn't completely stopped," possibly because she thought that her PI "definitely has more of the attitude of like you're not stopping research for quals." PIs are "balancing two different expectations," one expectation centered on wanting to mentor and ensure that the students pass the QEs, and the other centered on wanting the research to continue. She further contextualized this insight that "if you've done good lab work up until that month before quals and you take like a month or so hiatus from the lab to do really well on your qualifying exams. I don't think she (PI) would fault anyone for that." However, "I don't know that she [PI] would outright encourage it either." This segment sheds light on the tension PIs might feel as they manage the two competing expectations of mentoring and wanting students to succeed and needing to keep the research going. We suspect that this tension is common due to the competitive nature of, and accountability required of research.

The first two findings were observed in the same subjects, suggesting that the ability to disengage from research, primarily focus on QEs, and reflect on impressing departmental faculty with their QE performance represents a privileged position, perhaps through PI accommodation or a well-suited project [18] that could be incorporated into the QE proposal. The third finding reveals correlations between EDS activities and emotional states, particularly highlighting how social interactions influence emotions. Specifically, QE preparation activities involving peers, experienced lab members, or PI mentoring correlated with positive emotions, while isolation correlated with negative emotions. These complex social-emotional dynamics merit further investigation, specifically whether QE preparation activities help EDS become successful members of scientific communities of practice, which doctoral programs seek to achieve [2].

Conclusions and Future Work

That the students were perceptive of their levels of PERMA-V(N) may be due to the fact the students had time to process their experiences. The semi-structured nature of the interviews let the students speak freely about their activities and well-being (e.g. strategies for QE preparations, specific stressors, stability of relationships). Accordingly, protocol development includes planned addition of questions about meaning and about accomplishments to give a more holistic view of their experiences. The second and third findings are worth exploring deeper in future work. We wonder about how the tension between the need to mentor students through QEs and the need to progress research shapes the relationship between the PI and student. Similarly, we wonder about how structures (e.g. university, collaborations, funders) [17] affects, not just the interconnections between engaging in research or QE preparations, and emotions, meaning, and accomplishment, but also identity-related constructs such as engineering identity, research-scientist identity, and other social or personal identities.

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Appendix 1: Interview Protocol

Hello and thanks for taking part in this interview. I'm going to be asking you about your experiences around the QE process particularly your research, preparation work, relationships, and your well-being. Please feel free to answer as much or as little as you want. You may skip questions, or stop the interview for whatever reason. Everything that you say will be confidential and will be used only for this study. All information from this conversation will be recorded on Zoom for transcribing purposes. Know that your privacy will be protected by assigning pseudonyms (etc.). Only me and [name of PI] will be viewing this recording.

Is it OK if I record this call?

[Start recording] To confirm verbally, for our records, do you consent to take part of this study?

1. Please think of a pseudonym to use to ensure your privacy, e.g. "Steve" or "Beyonce"
2. Why are you doing biomedical engineering? Why [university]?
3. Thinking back to when you were preparing for quals, can you tell me a bit about your experiences leading up to, and taking the QE?
    a. Tell me about your academics; were you taking classes, what was the workload etc.?
    b. Tell me about your research activities at that time. Was it a busy time? What kind of activities were you doing? (lab work, pilot experiments, collecting data, coding etc.?)
    c. Tell me about your relationships during that time (personal, academic, etc.)
        i. Were they stable, volatile? Rapid or gradual?
    d. Tell me about your feelings and physical health during that time.
        i. Any changes here over time?

4. Can you tell me about how you prepared for the QEs?
    a. Do you remember when you started preparing? Start of Spring Quarter? Before/after?
    b. Tell me about the amount of effort (i.e. energy, time) you put in.
    c. Tell me about the strategies you employed.
    d. How did you balance preparing for quals with classes and/or research?
    e. Did things change over the quarter?
        i. Intensity of quals prep
        ii. Overall workload

5. Can we talk a bit about well-being and stress?
    a. Can you tell me about your stress levels leading into, right before, and immediately after the QEs?
        i. Were there particular stressors (people? events? expectations?)
    b. Can you tell me about your well-being over this time period? Physical, emotional, psychological?
    c. Tell me about the highs and lows for stress and well-being? Fluctuations vs a consistent build as quals approached?

d. Looking more broadly, do you have any throughs on how your well-being and stress compared to your peers?

6. Are there other things you would like to add to what's been said?
    a. How did the QEs go?
    b. We're planning a study that explores changes in well-being and engineering identity over the quals period. We were thinking of conducting interviews ~3months before, 2–3 weeks before, and then shortly after. Do you think these would be appropriate? Too early / too late?

Appendix 2: Table of participant demographic data

Participant pseudonym (pronouns offered)	Descriptors
Fish	Male, white, 3rd year
Avenger	Male, black, 3rd year, 1st generation
Jane (she/her)	Female, Asian/white, 3rd year
Leslie (she/her)	Female, white, 4th year
Sarah	Female, white, 4th year
John (she/her)	Female, white, 4th year