Exploring Hypotheses Regarding Engineering Graduate Students' Identities, Motivations, and Experiences: The GRADs Project

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Project Goals & Overview

This project, funded by U.S. National Science Foundation (EHR-1535254 & EHR- 1535453), was developed with a goal of exploring engineering graduate students' (EGSs') identities, motivations, and experiences. A growing literature base and increasing awareness regarding the importance of identity and motivation for engineering students has focused on the undergraduate population [1]-[6]. However, there are growing concerns about attrition in graduate school, graduate students' mental health, and the need to examine the engineering discipline apart from the wider STEM context [7]-[10]. We planned to explore identity, motivation, and experiences of EGSs through three central research questions:

1. What are the identity and motivation profiles of engineering doctoral students, which are based on previous academic and research experiences in STEM?
2. How does the STEM community influence identity formation and motivational goal setting processes of engineering doctoral students?
3. How do these processes related to identity formation and motivation influence engineering graduate student retention, productivity, and the pursuit of doctoral-level engineering careers?

Three phases were planned: (1) an initial qualitative phase to explore existing constructs in a new population (complete), (2) a quantitative phase to administer a nationally representative survey (complete), and (3) a final qualitative phase to more deeply explore the quantitative findings (in progress).

- **Phase 1.** From 2015-2016, we began exploring EGSs' identities, motivations, and experiences through in-depth interviews and the use of Interpretive Phenomenological Analysis [11],[12]. Four interview protocols were developed: three anchored securely in psychological frameworks (Future Time Perspective [13], Identity-Based Motivation [14], and Engineering Identity [15]) and one designed to complete a basic understanding of EGSs' experiences. Overall, the results of this phase suggested that EGS identity development draws from three domains (scientist, engineer, and researcher) [16], that they look to both the past and the future when making present-day decisions [17], and that they actively integrate their multiple identities into their engineering research [18]. Additionally, results from this analysis were used to refine existing measures for use with the EGS population in anticipation of the upcoming quantitative phase.
- **Phase 2.** This phase began with the development and analysis of a pilot survey (administered to approximately 300 EGSs, collection completed fall 2017) and the development of the final survey instrument [19]. The completed measure consisted of 106 Likert-type (i.e., multiple-choice response option items ranging from 'Strongly Disagree' to 'Strongly Agree') questions to explore constructs of identity and motivation, based both in Phase 1 results and existing research [3], [6], [20]-[22]. An additional 61

questions collected data about EGS's graduate experiences (e.g., the length of time in their program, their teaching and research experiences, and their peer and advisor relationships) and a comprehensive survey of their demographics (including race/ethnicity, gender identity, sexuality, and disability status [23]). Stratified random sampling was used to select a representative national population: strata were created based on location (state), program type (e.g., electrical, chemical, industrial, etc.), and program size (small, medium, and large, determined based on number of Ph.D.'s previously awarded) [24]. Data from approximately 2300 EGSs was collected until spring 2018, and confirmatory factor and missingness analyses were conducted before beginning analyses detailed in the section below [19], [25], [26].

- **Phase 3.** As analysis of quantitative data from Phase 2 commenced, the final qualitative phase began. Latent Profile Analysis (LPA) was used to create 11 identity and motivation profiles from the collected survey data, and 33 participants who indicated willingness to engage in future studies were contacted for brief, structured interviews. Participant recruitment and collection of qualitative data continues as of February 2019, and is expected to be finished by summer 2019. Once complete, this data will be analyzed in light of results from both previous phases and initial research questions, with a goal of developing a deeper understanding of how EGS identity and motivation develop over time and impact desired outcomes.

Recent Contributions & Project Impacts

Since completing data collection for Phase 2, a number of manuscripts, conference papers, and posters have been created to explore and share quantitative results. This project's recent contributions are organized according to their central framework and presented below.

Engineering Identity

1. **A Case for Disaggregation.** This work-in-progress paper explored how aggregation of demographic groups (gender within race/ethnicity) can obscure meaningful differences in the experiences of EGS. Researchers should disaggregate race/ethnicity by gender and other demographic groups, where possible, to uncover meaningful within group differences [27].
2. **Influence of Laboratory Group Makeup on Recognition.** This work-in-progress paper explored the relationship between laboratory groups and engineering identity. We found that participants with two or more undergraduate lab mates reported significantly more recognition as scientists, suggesting that interactions with labmates are an important component of scientist identity but may not contribute significantly to engineer and researcher identity [28].
3. **Influence of Research Experience on Recognition.** This work-in-progress paper highlighted the ways in which research experiences are correlated to aspects of EGSs engineer, scientist, and researcher identity. We found that previous research experience bolster some domains of engineering identity (scientist and researcher) but do not contribute to others (engineer), with potential implications for student identification and attrition into other STEM fields [29].

4. **Identity and Academic Relationships.** This poster examined the impact of advisor and peer relationships on identity, persistence, and difficulty assessing degree progress. Advisor and peer relationships were positively related to engineering identity, while peer relationships predicted persistence and advisor relationships predicted difficulty assessing progress. This suggests that intervening and building relationships carefully can produce targeted outcomes regarding EGS persistence and assessment of progress [30].
5. **Intersectional Exploration of Identities and Academic Relationships.** This journal paper (currently under review) found that peer and advisor attitudes and engineering identity are related in different ways depending on student characteristics (e.g., White women's peer attitudes are positively related to engineering identity, while women of Color show no effect). These results suggest that interventions addressing identity and relationships should take an intersectional approach when studying students' engineering identities [31].
6. **The Perfect Storm.** This journal paper (currently under review) examined the teaching and research experiences of four engineering graduate students and how each participant managed their identities. Participants struggled to balance identities such as researcher, educator, or parent; external forces, particularly advisors, perpetuated such struggles causing three participants to drop out of their doctoral program or abandon their Ph. D. This work suggests that graduate programs should support development and management of graduate students' different identities, and advisors should be supportive and understanding of students' home lives [32].

Future Time Perspective

1. **An Identity-Based Motivation Conceptual Framework.** We developed an identity-based motivation model that integrates the future time perspective and identity frameworks. Traditionally, the future time perspective framework describes how goal setting processes and future goals serve as motivation for students to persist through academic tasks. Our conceptual framework adds to the future time perspective framework by considering the influence of the past (how identities were developed) on goal setting processes. Such past identities then influence how students persist through present tasks and they develop future identities [33]-[35].
2. **Future Time Perspective and Gender Identity.** In this study, we tested for differences between gender identities on future time perspective factors. Unlike traditional gender studies that limit their analyses to men and women, we included identities transgender students and those who did not report their gender. Results showed that future time perspective factors did not differ between gender identities, indicating that each gender identity perceived their futures similarly [25].

Identity-Based Motivation

1. **Salient Identities as Predictors of Perceived Task Difficulty.** This research paper examines the relationship between identity salience and task difficulty. Prior work found that students leverage researcher, scientist, and engineer identities when completing

research tasks: this paper uses linear regression to test the salience (likelihood that identity will be leveraged in a given situation) of these identities as a predictor of task difficulty. Researcher identity salience was the strongest predictor of task difficulty, a relationship moderated by degree type (Master's or Doctoral) [36].

Graduate Student Experiences

1. **Improving Experiences.** This guest editorial focuses on the ways in which graduate educators can and should support their students. The editorial leverages stories and messages that have emerged as part of this larger research project to highlight practical solutions that can be implemented by faculty and administrators working with EGS [37].
2. **Factors Affecting Attrition Rates.** This work in progress paper presents results of a systematic literature review of graduate student experiences. Papers from 2008 to 2018 within the Journal of Higher Education and Frontiers in Education Conference Proceedings were included; from an initial 167 articles search results, 5 articles were found to leverage qualitative data examining graduate student experiences. Three themes were found to influence graduate student experiences: internal, programmatic, and external factors [38].
3. **Intersection of Identity, Experiences, and Relationships.** Gender identity, sexual identity, and ethnicity significantly predicted differences for peer relationship scores in EGS. Interactions for gender and sexuality and sexuality and ethnicity were also noted. This finding is being used in future analyses of EGS experiences [39].

Methodology

1. **Exploring Methodological Tensions.** This paper highlights the tensions that emerge from conducting qualitative research in environments that do not align with the philosophical underpinnings of the methodology. Specifically, we note the ways in which tension occurred during the use of interpretative phenomenological analysis in engineering education research and how our process of addressing these tensions transfers to other cultural contexts [11].
2. **Making Sense of Missingness.** This paper collates best practices regarding missing data, e.g. checking amounts of missingness and when to practice data imputation. In addition to detailing the missingness analyses conducted within this project, it also acts as a resource for others in engineering education and provides R code for other researchers to use [26].

Future Work

Analyses of Phase 2 data are continuing, with an ultimate goal of producing a testable model to predict and explain how EGS's identities and motivations inform one another (primarily under the Identity-Based Motivation framework). Analyses are also being conducted to examine which experiences inform identity development and how they do so, to help advisors and others in the field address issues of identification and persistence. Cluster analyses will be used to identify patterns within student experiences, identities, and motivations, to paint a holistic and inclusive

picture of EGS's experiences. Additionally, work is underway for Phase 3, which will allow for the exploration of these questions in more depth using quantitative and qualitative methods.

Overall, current results from this project suggest a need to understand the importance of identity domains (scientist, engineer, and researcher) to student outcomes, as key graduate experiences do not impact each domain equally. This work suggests that Identity-Based Motivation may be used to integrate Engineering Identity and Future Time Perspective, but how these frameworks relate to each other remains to be explored. There is also a great need to examine the impact of social identities on EGS outcomes and experiences, particularly for those students from marginalized backgrounds, and to identify characteristics of struggling students so they can be more readily (and capably) assisted.

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