

Seeking Alignment: Exploring Underrepresented Minority Students' Motivations to Pursue Doctoral Degrees in Engineering

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Abstract— This Work in Progress Research paper aims to shed light on the reasons that inspire minoritized students to pursue a Ph.D. degree in engineering. Thus, this study investigates the motivations that URM students give as their deciding factors for pursuing doctoral degrees. We examine the research question: How do URM students describe their decision to pursue a doctorate in an engineering discipline? To explore our question, we conducted a modified grounded theory analysis of survey data collected from 51 URM students during a summer workshop held prior to the commencement of their respective programs. Their answers to open-ended questions and other contextual details formed the basis of our data sample. Our diverse sample includes representations of students from various engineering disciplines as well as various racial and ethnic backgrounds. Our study employs the principles of Social Cognitive Career Theory (SCCT) to analyze the environmental variables, personal outcome expectations, and other factors that influence students' decisions to pursue a doctoral degree in their respective fields. Next steps of this work will employ SCCT, as we can gain a deeper understanding of students' motivations and identify the factors that play a significant role in their decision-making processes. Continuing work in this area can be valuable to engineering graduate programs by providing insights into how URM students can be supported throughout their degrees.

Keywords— *Minoritized Students, Graduate Education, Motivation, Social Cognitive Career Theory*

I. INTRODUCTION

Minoritized students have been reported to exhibit significant underrepresentation in doctoral engineering programs, as well as lower completion rates of the doctoral milestone [1]–[3]. Although some research has explored the nuanced experiences of minoritized students in their pursuit of a doctoral degree [4]–[7], there is limited research that has specifically addressed these

students' motivations for pursuing a Ph.D.. It is imperative to comprehend these rationales to design appropriate support systems that can sustain minoritized students throughout the challenging journey of obtaining a doctoral degree [8]–[10].

Research has demonstrated that the motivations of minoritized students entering Ph.D. programs are notably different compared to their majority peers. In addition to reasons such as interest and curiosity [11]–[13], minoritized students also pursue advanced degrees in STEM fields for the purpose of self-empowerment and alignment with personal values that seek to benefit their communities [14]. Furthermore, some studies have taken a more specific approach by examining the experiences of Black students through the lens of community cultural wealth and holistic perspectives [12], [15], [16]. Previous research by our team has also investigated the ideals that inform minoritized students' decisions on where to pursue their Ph.D. [17]. However, most of these accounts have been scoped in terms of demographic sample or lack contextualization of the responses.

Following calls for more thorough and specific assessments of minoritized student experiences in graduate engineering education [18]–[21], we aim to generalize beyond the findings from these prior studies to understand the broader context of why minoritized students pursue an engineering Ph.D. The purpose of this work in progress is to explore the motivations of minoritized students to pursue a doctoral degree in an engineering discipline. Specifically, we address the question: How do minoritized students describe their decision to pursue a doctorate in an engineering discipline? In this study, we utilize a national workshop series with a substantial participant pool to

explore the detailed and contextualized rationales that drive minoritized students to pursue a doctoral degree in engineering. We collect data from a survey administered to minoritized students across various engineering disciplines during a summer workshop held prior to the commencement of their respective programs. Drawing upon the Social Cognitive Career Theory (SCCT) [22], we analyze the influence of environmental variables, personal outcome expectations, and other relevant factors on the student's aspirations to obtain a doctoral degree in their respective engineering disciplines. The findings of this research can contribute to a deeper understanding of how minoritized students in engineering graduate programs can be better supported by their institutions throughout their academic journeys and can inform the development of program orientations tailored to their unique needs.

II. THE CONTEXT: THE RISING DOCTORAL INSTITUTE

Our data hails from the intervention titled The Rising Doctoral Institute (RDI). The purpose of the RDI is to help minoritized students (Black or African American, Hispanic, Native American, or Pacific Islander) to gain knowledge and build skills that will help them to succeed in their doctoral programs prior to commencing their doctoral degrees. It was designed as a one-week intervention in which first-year students attend a series of workshops and discussion sessions covering subjects that previous researchers have suggested have an impact on doctoral students' persistence, followed by monthly check-ins with a support group throughout the first year of doctoral study. We have reported on the details of this project elsewhere [23]. In the summer of 2021, our team conducted an online version of the intervention with a national set of participants. Thirty-four minoritized students were recruited from different universities across the USA. In 2022, we invited and trained leaders from five universities to join the project and host an RDI even at their campuses. During this series, a combined total of twenty-nine URM students took part in the workshops and subsequent discussion sessions. In both iterations of the RDI, participants we invited to take part in IRB-approved evaluation activities, which consisted of a series of surveys and interviews, including the pre-survey from which we source the data for the analysis presented herein.

III. METHODS

To provide a preliminary answer to our research question: How do minoritized students describe their decision to pursue a doctorate in an engineering discipline? As our primary data source, we analyzed the survey responses from participants of our 2021 and 2022 RDI interventions. We conducted a qualitative analysis of the answers to an open-ended question within the presurvey. More specifically, we followed the recommendations of Case and Light [24] to conduct a modified grounded theory analysis. This approach suggests the use of grounded theory methods [25] to allow alternative insights and conceptualizations and to challenge preconceived notions of the topic under study by analyzing newly acquired data and then contrasting, comparing, and interpreting the data through the

lens of a well-established theory. That is, we used this approach to obtain our research findings and relate them to theory while at the same time not circumscribing them to existing thinking or previous research. In this paper, we present the emerging codes and preliminary analysis. Future work will illustrate how the theory informs additional analysis and interpretation.

We collected data from the RDI participants in the Summer of 2021 and the Summer of 2022. A presurvey was distributed at the beginning of each RDI, which included the following open-ended question: 'Why did you decide to attend graduate school?' alongside other contextual details. Our diverse sample included a representation of students from various engineering disciplines as well as various racial and ethnic backgrounds: 23 students identified as Black, while 26 identified their ethnicity as "Hispanic or Latino" with other shared racial identities that included Black, White, Native American or a mix of these. In addition, 33 of our participants self-identified as female and 18 as male.

The analysis process consisted of two phases. In the first phase, we extracted the 51 responses to the open-ended question, and a subgroup of three researchers created a preliminary code book. Subsequently, five researchers met to discuss the codebook and train themselves with some examples. After this initial alignment, the five researchers proceeded to individually code each of the 51 excerpts. In the second phase, we conducted a frequency analysis to determine which codes were most present, which codes had the most agreement between researchers, and which codes could be integrated after coding. The thematic analysis with these newly classified data allows us to suggest the existence of three initial common themes hailing from the students' responses. The following section shows a description of these themes, including examples of quotes and an interpretation of their meaning.

IV. FINDINGS

Our findings showed three initial themes as the primary descriptions of why students pursued a doctoral degree in engineering: (1) gaining access to better jobs, (2) pursuing a career in research, and (3) pursuing intrinsic interests. We detail these themes herein.

A. *Gaining Access to Better Jobs*

About half of our students shared that their decision to attend a doctoral program in an engineering discipline was influenced by their career interests and goals. Some students identified their pursuit of a Ph.D. as necessary to achieve their specific career goals, such as those who had a goal of becoming a professor or growing in their specific industries. Others described how their fields required them to have a Ph.D. to be considered for better positions, with a general sense that having a doctoral degree would allow them access to more career opportunities. Caroline, a Latina student who was returning from a job in the biomedical engineering industry, shared the following answer:

"I wasn't satisfied with my options career-wise, with only a bachelor's degree. I feel that a Ph.D. will help me find a job or start a career in an area that brings me joy and I am interested in." – Caroline

Here, Caroline shared how the career opportunities that were open to her with her bachelor's degree were not satisfactory, so she decided to further her education to gain access to other areas in her field that aligned with her interests. Satisfaction with potential career and job opportunities was an important factor and was often accompanied by personal interests, such as a desire to fill knowledge gaps that could lead to their goals. Similarly, Samara, a Black student about to begin her Ph.D., mentioned how attending graduate school would better prepare her for a career while bringing together her interests:

"I decided to attend graduate school because I wanted to further my education to become an expert in my field. Additionally, most jobs and/or careers within my intended field of study require a Ph.D. for consideration. I also value mentorship, STEM education youth programs, and conducting research within my career, and felt graduate school also combined with these interests." – Samara

Like other students, her decision was influenced by the requirements of her field but was also accompanied by the possibility of pursuing other intrinsic interests while furthering her career opportunities. In sum, these students saw the Ph.D. as a pathway to gain the expertise that could advance or realign their careers to their interests.

B. Pursuing a Career in Research

A second group of students specifically focused on pursuing a career as researchers. This category was distinct from the prior as participants herein described the Ph.D. as a preparatory step for conducting research work specifically and not as a pathway to positions that simply required a higher credential. Most of these students had sought out and participated in undergraduate research opportunities and perceived the doctoral degree as a credential to achieve positions where they could lead research efforts. Logan, a Black student with extensive undergraduate research experience, shared his personal aspirations as a deciding factor:

"It is my mission to conduct research as a career. My ambition is to participate in biomedical engineering research, where I am a principal investigator. It is my belief that to hone the skillset necessary to do so, and I should complete a doctoral degree." – Logan

Logan's remarks show that his decision to attend a doctoral program was made to pursue his field-specific interests and obtain the necessary tools and skills to do so. These skills, as well as the Ph.D. as a credential, were also sought to elevate the impact of the research the students wanted to pursue in their careers. Amaya, a Black student who also had previous

undergraduate research experience, shared this outlook on her decision:

"I really like doing research in my field of study, and I realized to make the impact that I wanted to, graduate school was needed to further my skills." – Amaya

In this way, Amaya stated that her choice to attend graduate school was influenced by the idea that it was the place to obtain the abilities and expertise to create impactful research. Thus, students such as Amaya and Logan, who had previous research experience and wanted to pursue a career as researchers, saw graduate school as the place where they could obtain the skillset and qualifications to do so.

C. Pursuing Intrinsic Interests

In our last emergent category, a number of students explained that their decision to go to graduate school was not connected to their pursuit of a specific career path but rather to follow their interests. In these cases, the student's desire to learn more about their field intersected with their passions, personal interests, and the impact they wanted to create. Troy, a Black student returning from an industry position, shared how his path led to graduate school:

"After confirming that corporate America was not my cup of tea, I moved to determine how my passions could intersect with what I learned in undergrad. Discussing potential outlets with a couple of grad students and the head of the [program at my future institution], I landed on engineering education for graduate school as it seemed to be the perfect combination of my love for interacting and advocating for youth while also implementing my love for learning/my engineering degree."

– Troy

Troy's personal experience gave him a sense that he could not follow his passions for learning and community outreach through his position in industry; this influenced his choice of joining a discipline in graduate school where he could do so. Rio, a native Latino, also shared similar sentiments:

"I decided to attend graduate school because I wanted to better myself and commit myself to something greater than myself. While some research areas may come and go, I wanted and will give my best effort to work towards fulfilling my technical curiosity that sparked from both my digital hardware experience and working at [the semiconductor industry]."

– Rio

While Rio's decision to join a doctoral program involved his previous industry experience, his decision was rather based on his passion for learning and desire to commit himself to a meaningful purpose. In this way, these students did not base their choice on the requirements of a specific career path but on exploring their intrinsic interests to their personal satisfaction.

V. NEXT STEPS

Through this preliminary analysis, we have demonstrated the initial findings for the rationales by which minoritized students pursue doctoral study in engineering. These initial themes are in line with foundational elements of SCCT. For example, gaining access to better job opportunities illustrates outcome expectations in a tangible way, the intent to pursue a career in research is an example of a choice goal, and pursuing intrinsic interests aligns directly with the interests construct. For the next steps in the analysis, we plan to further explore the nuances in the data so that we can understand the connections within and across constructs. For example, we have the tension of having the outcome expectations of more career options (broad) and the specific goal of pursuing a career in research, and we need to understand how nuances connect and or differentiate these options. We have also only offered limited examples of constructs here (due to space limitations), but our data are much richer. For example, our full data set suggests that research experiences (an example of proximal environmental influences) are related to a career choice goal of a research-focused position, but we need to further explicate the nuances of that relationship. Future work will continue our present trajectory to identify how the constructs are evident in our data set, how they align with SCCT, and what elements might be missing.

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REFERENCES

- [1] Council of Graduate Schools, "Ph.D. Completion and Attrition: Analysis of Baseline Program Data from the Ph.D. Completion Project." 2007.
- [2] National Academies of Sciences Engineering, Medicine, and others, *Minority serving institutions: America's underutilized resource for strengthening the STEM workforce*. National Academies Press, 2019.
- [3] National Academies of Sciences, Engineering, and Medicine, *Graduate STEM Education for the 21st Century*. Washington, D.C.: National Academies Press, 2018. doi: 10.17226/25038.
- [4] C. T. Amelink and C. D. Edwards, "Exploring The Socialization Experiences Of Underrepresented Engineering Graduate Students," *J Women Minor Scien Eng*, vol. 26, no. 4, pp. 357–379, 2020, doi: 10.1615/JWomenMinorScienEng.2020032606.
- [5] N. Bouhria and J. M. Cruz, "System Factors Affecting Underrepresented Minorities in Doctoral Programs in Engineering: A Literature Review," in *2021 IEEE Frontiers in Education Conference (FIE)*, IEEE, Oct. 2021. doi: 10.1109/fie49875.2021.9637208.
- [6] J. A. Henderson *et al.*, "Factors Impacting Engineering Advanced Degree Pursuit And Attainment Among Black Males," *J Women Minor Scien Eng*, vol. 28, no. 4, pp. 1–24, 2022, doi: 10.1615/JWomenMinorScienEng.2021036005.
- [7] F. Nicole and J. DeBoer, "A systematized literature review of the factors that predict the retention of racially minoritized students in STEM graduate degree programs," in *2020 ASEE Virtual Annual Conference Content Access*, 2020.
- [8] J. S. London *et al.*, "Motivations for pursuing an engineering Ph.D. and perceptions of its added value: A US-based study," *International Journal of Doctoral Studies*, vol. 9, pp. 205–227, 2014.
- [9] B. Miller, M. Tsugawa, J. Chestnut, H. Perkins, C. Cass, and A. Kim, "The Influence of Perceived Identity Fit on Engineering Doctoral Student Motivation and Performance," in *2017 ASEE Annual Conference & Exposition Proceedings*, Columbus, Ohio: ASEE Conferences, Jun. 2017, p. 28982. doi: 10.18260/1-2--28982.
- [10] V. Yi and D. Ramos, "Collective achievement and resistance: Understanding the motivations of doctoral women of color," *Journal of Diversity in Higher Education*, Jan. 2021, doi: 10.1037/dhe0000296.
- [11] M. Borrego, D. B. Knight, K. Gibbs, and E. Crede, "Pursuing Graduate Study: Factors Underlying Undergraduate Engineering Students' Decisions: Pursuing Graduate Study," *Journal of Engineering Education*, vol. 107, no. 1, pp. 140–163, Jan. 2018, doi: 10.1002/jee.20185.
- [12] B. A. Burt and J. T. Johnson, "Origins of early STEM interest for Black male graduate students in engineering: A community cultural wealth perspective," *School Science and Mathematics*, vol. 118, no. 6, pp. 257–270, Sep. 2018, doi: 10.1111/ssm.12294.
- [13] E. A. Mosyjowski, S. R. Daly, and D. L. Peters, "Drivers of research topic selection for engineering doctoral students," *International Journal of Engineering Education*, vol. 33, no. 4, pp. 1283–1296, 2017.
- [14] N. R. Lewis, S. M. Jones, and H. T. Frierson, "REASONS AFRICAN AMERICANS PURSUE THE SCIENCE DOCTORATE: AN EXPLORATORY STUDY OF CURRENT DOCTORAL STUDENTS' PERCEPTIONS," *J Women Minor Scien Eng*, vol. 23, no. 3, pp. 231–247, 2017, doi: 10.1615/JWomenMinorScienEng.2017013323.
- [15] B. A. Burt, J. J. Roberson, J. T. Johnson, and A. Bonanno, "Black Men in Engineering Graduate Programs: A Theoretical Model of the Motivation to Persist," *Teachers College Record: The Voice of Scholarship in Education*, vol. 122, no. 11, pp. 1–58, Nov. 2020, doi: 10.1177/016146812012201109.
- [16] B. M. Spencer, S. Artis, M. Shavers, and S. LeSure, "Expectations Vs. Reality: Reimagining The Engineering And Computing Doctoral Experience For Black Women," *J Women Minor Scien Eng*, vol. 28, no. 5, pp. 25–47, 2022, doi: 10.1615/JWomenMinorScienEng.2021035465.
- [17] A. Mercado Rivera, M. S. Artilles, J. Cruz, H. M. Matusovich, and S. G. Adams, "Choosing Where to Pursue a Ph.D.: Ideals Sought and Compromises Made by Traditionally Minoritized Students," in *2022 IEEE Frontiers in Education Conference (FIE)*, IEEE, Oct. 2022. doi: 10.1109/fie56618.2022.9962571.
- [18] M. Bahnson *et al.*, "Inequity in graduate engineering identity: Disciplinary differences and opportunity structures," *J Eng Educ*, vol. 110, no. 4, pp. 949–976, Oct. 2021, doi: 10.1002/jee.20427.
- [19] B. A. Burt, C. M. McCallum, J. D. Wallace, J. J. Roberson, A. Bonanno, and E. Boerman, "Moving toward stronger advising practices: How Black males' experiences at HPWIs advance a more caring and wholeness-promoting framework for graduate advising," *Teachers College Record: The Voice of Scholarship in Education*, vol. 123, no. 10, pp. 31–58, Oct. 2021, doi: 10.1177/01614681211059018.
- [20] F. Curry and J. DeBoer, "A Systematized Literature Review of the Factors that Predict the Retention of Racially Minoritized Students in STEM Graduate Degree Programs," in *2020 ASEE Virtual Annual Conference Content Access Proceedings*, ASEE Conferences, 2020. doi: 10.18260/1-2--34069.
- [21] T. Holloman, J. London, W. C. Lee, C. M. Pee, C. Hawkins Ash, and B. Watford, "Underrepresented and Overlooked: Insights from a Systematic Literature Review about Black Graduate Students in Engineering and Computer Science," *IJEE International Journal of Engineering Education*, vol. 37, no. 2, 2021.
- [22] R. W. Lent, S. D. Brown, and G. Hackett, "Toward a Unifying Social Cognitive Theory of Career and Academic Interest, Choice, and Performance," *Journal of Vocational Behavior*, vol. 45, no. 1, pp. 79–122, Aug. 1994, doi: 10.1006/jvbe.1994.1027.
- [23] M. S. Artilles, J. M. Cruz, S. A. Blackowski, H. M. Matusovich, S. G. Adams, and G. Lee-Thomas, "The Rising Doctoral Institute: Preparing Minority Students for the Transition into the Engineering

- Ph. D.,” in *2021 ASEE Virtual Annual Conference Content Access*, 2021.
- [24] J. M. Case and G. Light, “Emerging research methodologies in engineering education research,” *Journal of Engineering Education*, vol. 100, no. 1, pp. 186–210, 2011.
- [25] A. Strauss and J. Corbin, “Grounded theory methodology: An overview.,” 1994.