The Future of Engineering Education
2024 Annual Conference & Exposition
Oregon Convention Center
Portland, OR . June 23 - 26, 2024
Paper ID #43782

Unveiling Demographic Influences and Differential Career Preferences among Engineering Graduate Students: A Comparative Analysis of Mechanical, Electrical, and Computer Engineers

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ABSTRACT:
In the last decade, engineering education has undergone significant transformation, with mechanical, electrical, and computer engineering emerging as the most popular and fastest-growing engineering disciplines. However, there is a significant gap in the literature on how engineers from these disciplines differ in career trajectories and attitudes, especially regarding race and gender diversity. Existing research emphasizes the unique social dynamics within specific engineering fields and their potential to attract diverse students and support varied career paths (Brawner et al., 2012). To probe these distinctions, our study, grounded in Social Cognitive Career Theory (SCCT; Lent et al., 1994) and Critical Race Theory (CRT; Crenshaw et al., 1995), investigates the career pathways and attitudes of engineering graduate students. Leveraging a dataset of 847 engineering graduate students, we examine differences across these three engineering disciplines and the impact of demographic factors like race and gender on career decisions and attitudes. Findings suggest that clear demographic distinctions emerged at the intersection of race and gender: female students across all disciplines displayed a greater preference for nonprofit careers compared to their male counterparts, while underrepresented racially minoritized (URM, that is Blacks or African Americans, Hispanics or Latinx, and American Indians or Alaska Natives) students exhibited a stronger inclination toward entrepreneurial endeavors than their non-URM, that is White and Asian, peers. Even after accounting for these demographic variables, it is noteworthy that computer engineering students exhibited a higher level of interest in nonprofit positions and careers in K-12 education compared to their counterparts in mechanical and electrical engineering. Disparities in attitudes were also observed; URMs were more concerned with racial justice issues and experienced greater race-related stress. Similarly, computer engineering students were more involved in racial justice activities. These findings underscore the complex interaction of demographic and disciplinary differences and the unique position of computer engineering in promoting social justice interests. This study contributes to the broader discourse on engineering education, providing valuable insights into its evolving landscape while also highlighting the necessity for further research to explore the specific factors within computer engineering that might encourage greater diversity and social justice initiatives.

INTRODUCTION

Engineering education serves as a pivotal force propelling advancements in mechanical engineering (ME), electrical engineering (EE), and computer engineering (CE) (ASEE, 2021). The dynamic growth of these disciplines has attracted doctoral students who ultimately pursue career paths in academia, industry, government and beyond. However, given the diversity of career trajectories within this population, it becomes important to explore the intricate interplay of motivations, attitudes, and health factors influencing their decisions. In 2020, a mere 10% of engineering doctoral students secured definitive employment in academia, and less than 40% immediately pursued postdoctoral positions post-graduation (NCSES, 2021). Given the growth and popularity of ME, EE, and CE disciplines, coupled with the imperative to enhance race and gender diversity within these fields, understanding disciplinary distinctions and the demographic factors shaping the career paths of doctoral students becomes paramount (Brawner et al., 2012).

Our study focuses on doctoral students in mechanical engineering, electrical engineering, and computer engineering, investigating potential similarities and differences across three domains: career trajectories, mental and physical health, and psychosocial factors (incl. race-related stress and engagement in racial activism). This study enhances our understanding of the factors steering doctoral students' career trajectories and delves into how these engineering disciplines diverge in health outcomes and racialized experiences. Recognizing both commonalities and distinctions among engineering disciplines and their constituents is indispensable for advancing research in engineering higher education. Grounded in Social Cognitive Career Theory (SCCT; Lent et al., 1994) and Critical Race Theory (CRT; Crenshaw et al., 1995), our study explores career pathways across ME, EE, and CE, extending the inquiry to discern differences in career interests, mental and physical health, and the experiences of minority stress and a commitment to racial justice—two pivotal aspects crucial among underrepresented racialized minority (URM) doctoral students in shaping their career interests (Monroe-White & McGee, 2023; McGee et al., in press).

Statistics from the ASEE reveal that mechanical, computer and electrical engineering were among the top disciplines in 2020 in terms of the number of doctoral degrees awarded. Table 1 below summarizes these numbers. While the table below suggests that these engineering disciplines are among the most popular, it also suggests that these disciplines awarded doctoral degrees to URMs students at an alarmingly low rate. For example, out of 1,708 mechanical engineering doctoral degree awarded in 2020, only 60 or 3.5% went to URM students (ASEE, 2021). This glaring disparity in the representation of URM students within these popular engineering disciplines prompts a deeper inquiry into the factors contributing to this underrepresentation. Understanding the challenges and barriers faced by URM doctoral students is essential for addressing diversity and fostering inclusive environments within ME, EE, and CE. It also raises questions about the effectiveness of current recruitment and retention strategies, the prevalence of supportive academic environments, and the existence of systemic biases that may impede the progression of URM individuals in these fields. Our study is deeply attuned to the prevailing concerns surrounding the underrepresentation of minority students in mechanical engineering, electrical engineering, and computer engineering. Through an exploration of the complex interplay of career interests, attitudes, and health factors within these three disciplines, our goal is to illuminate the nuanced experiences of underrepresented racialized minority (URM) individuals. Specifically, we seek to discern and address the potential differences in experiences between URM students and their counterparts both within and across the three most popular engineering disciplines.

Table 1. Engineering Doctoral Degrees Awarded in 2020

Discipline	Number of degrees	Number of degrees awarded to URM*
Mechanical	1,708 (13.6%)	60 (3.5%)
Computer (inside Engineering Programs.)	1,273 (10.1%)	40 (3.1%)
Electrical	1,165 (9.3%)	37 (3.2%)

Note. ASEE uses the definition of underrepresented minority (URM) from NSF's Science and Engineering Indicators report (https://ncses.nsf.gov/pubs/nsb20201/glossary): "This category comprises three racial or ethnic minority groups (blacks or African Americans, Hispanics or Latinos, and American Indians or Alaska Natives) whose representation in S&E education or occupations is smaller than their representation in the US population."

Disciplinary Differences across ME, CE, and EE

Disciplinary distinctions among mechanical engineering (ME), electrical engineering (EE), and computer engineering (CE) are evident not only in academic trends but also in the professional landscape. According to the ASEE survey in 2018, computer science/computer engineering experienced substantial growth in graduate degrees, with a 63% increase, while mechanical and electrical engineering lagged behind with growth rates of 21.8% and 6.5%, respectively (ASEE, 2019). The U.S. Bureau of Labor Statistics (2019) projected higher job growth for computational roles (12%) compared to mechanical, electrical, and computer hardware engineering (4-6%). Reflecting this demand, computer science and computer engineering faculty emerged with the highest salaries in academia, surpassing their engineering counterparts (ASEE, 2022).

These disciplinary distinctions permeate beyond academic and professional spheres, influencing socialization, enrollment, and persistence, and carrying significant implications for underrepresented groups. Hocker and colleagues (2019) pinpoint challenges in academia contributing to a noteworthy doctoral dropout rate in engineering, particularly impacting women and URMs. The prevalence of myths surrounding meritocracy and the ideal academic worker, often portrayed as white, male, and deeply committed to research, may explain the heightened attrition rate among traditionally underrepresented groups. This contributes to a growing determination to address these disparities. Rohde and colleagues (2019) also emphasized the significance of engineering identity and belongingness as crucial factors in student retention and engagement, and suggest potential variations among EE and CE students.

Amid these trends, the experiences of Black students majoring in EE, CE, or ME were recently studied by Brawner and colleagues (2020) and further shed light on discipline differences. With respect to the choice of discipline, Black engineering students show a higher likelihood of choosing EE and CE compared to their counterparts, with a similar rate for ME. However, ME appears more effective at retaining a larger fraction of its Black students than both EE and CE (Lord et al., 2011; 2013; 2014; Orr et al., 2014; 2019). This suggest that ME may be more effective at retaining Black students than the other two disciplines. Further nuances emerge in perceptions of belongingness, with Black CE students less inclined to feel a sense of belonging compared to EE and ME counterparts. Moreover, CE students exhibit a higher likelihood of considering changing their majors compared to Black students in EE and ME. Examining the learning environments further illuminate why these disciplinary differences may have emerged. Black students in ME and EE departments indicate more positive faculty relationships and more collaborative learning curriculum than in CE disciplines. Brawner and colleagues (2020) infer that these factors may have, in part, accounted for the lower sense of belonging and lower graduation rates among Black students in CE compared to ME and EE. Overall, these findings underscore fundamental differences in ME, CE, and EE, impacting not only job growth, but also issues of belongingness and persistence, particularly for historically underrepresented groups.

Career Interests and Trajectories

Examining the career trajectories within the distinct domains of ME, EE, and CE reveals some notable trends. Per the US Bureau of Labor Statistics (2022), computer and information research scientists are projected to witness a substantial 22% growth in employment between 2020 and 2030, commanding an annual average salary of $142,650. In contrast, the annual average salary for mechanical engineers is $97,000, while electrical engineers earn $100,420 on average in 2021. These figures underscore the discipline-specific variations in salary and job growth prospects.

Overall, a significant shift is observed in the career preferences of engineering doctorates, with over one-third opting for industry roles despite the predominant emphasis on academia during their training (Choe & Borrego, 2020). Delving into the reasons behind this shift, studies highlight factors such as a perceived divergence in academia being money-driven rather than research-driven (Hocker et al., 2019), incongruence between students' career aspirations and faculty culture (Jaeger et al., 2013), and conflicts with personal values and identity within the academic realm (Jaeger et al., 2013). While this observation may have implications across all three disciplines, there is a lack of extensive research to confirm whether the inclination towards industry roles remains consistent across ME, CE, and EE. Considering the noted disparities in salary, as mentioned above, it can be inferred that variations between these three disciplines may emerge.

While little research has been conducted to explore variations in career trajectories, one study investigating industry, academia, and government careers found a few notable differences (Choe & Borrego, 2020). The researchers found that ME graduate students were more likely to pursue career in government compared to their EE and CE and counterparts. However, across the three disciplines, the likelihood to pursue a career in academia or industry did not significantly vary. Furthermore, a negative correlation was found between pursuing an academic career and pursuing an industry career, suggesting that those with a strong desire to pursue the latter had little desire to pursue the former, and vice versa. This preliminary study highlights certain distinctive disciplinary-specific differences and similarities among ME, EE and CE students concerning career trajectories. However, it does not consider the potential influence of demographics on driving career interests, nor does it explore other non-traditional career paths, such as entrepreneurship, nonprofit work, or K-12 career options. Considering recent findings indicating entrepreneurship as a growing field for Black students in STEM, further exploration in these areas would enhance and expand this initial study (Monroe-White & McGee, 2023; McGee et al., in press).

Mental/ Physical Health & Minority Status Stress

To attain a more holistic understanding of engineering doctoral students across the three disciplines and unravel potential variations, it is important to delve into mental and physical health differences. This investigation is particularly crucial considering that nearly 40% of all doctoral students meet the criteria for an anxiety and/or depression diagnosis (Evans et al., 2018). Notably, school-related stressors are cited as the primary contributor to their mental health challenges. These negative health effects particularly extend to engineering graduate students, as highlighted by Hocker and colleagues (2019) who found that 56% of engineering PhD students reported encountering mental health issues during their programs.

The impact is even more pronounced for underrepresented minority (URM) students in engineering, who face heightened stress levels compared to their non-URM counterparts (McGee et al., 2019). Microaggressions, in particular, have been shown to negatively affect not only the mental health but also the physical well-being of URMs (Miles et al., 2020). Considering the differences in belongingness, faculty relationships, and learning environments among ME, EE, and CE students discussed above (Brawner et al., 2020), exploring mental and physical health differences may offer valuable insights into addressing and mitigating the unique challenges faced by students within each discipline. This exploration may also extend to demographic contributors, offering a more comprehensive perspective on the nuanced factors shaping the mental and physical health disparities among students in these disciplines. Indeed, research has found that most racial and ethnic minorities experience more discrimination related to their minority status in their degree programs (Landrine & Klonoff, 1996). Such minority status stress negatively impacts their mental health outcomes and is related to more depressive and anxiety symptoms (Jones et al., 2007). In fact, in a path analysis, minority status stress (operationally defined as the degree of perceived stress experienced related to one's race) was a prime predictor of depression symptoms for URMs, suggesting that URMs may experience unique environmental stressors associated with their membership in a minority group (Arbona et al., 2018).

Racial Activism

In light of the profound impact that minority status stress has on the mental and physical well-being of URM students, it becomes imperative to explore avenues for coping and empowerment within this demographic. Delving into the realm of racial activism emerges as a critical lens through which to examine how URMs navigate and respond to the unique challenges they face. Racial activism is a crucial but understudied element within academia. Notably, 65% of Black undergraduate students participated in racial activist movements, such as Black Lives Matter (BLM), with prior political activism predicting Black students' involvement, and increased experiences of racial/ethnic microaggressions predicting Hispanic students' engagement in BLM (Hope et al., 2016).

While literature indicates both positive and negative consequences of racial activism on minoritized students' mental health, a growing body of research, including Reid (2018), suggests that involvement in racial activism can positively impact underrepresented minority students' mental health by fostering a sense of community and boosting self-esteem (Anyiwo, 2020; Hickson et al., 2021; Gin et al., 2019; Reid, 2018). Likewise, recent research suggests that racial activism plays a central role in shaping career interests among URM STEM doctoral students; in particular, racial activism was found to drive interest toward entrepreneurship and academia (Monroe-White & McGee, 2023; McGee et al., in press). This is an interesting finding considering that the majority of engineering doctoral students pursue careers outside of academia (Choe & Borrego, 2020; Hocker et al., 2019; Jaeger et al., 2013), and the field of entrepreneurship, including patent ownership and startup leadership, currently lacks adequate URM representation (Cook, 2014; Cook et al., 2022). Racial activism not only shapes career trajectories and impacts health outcomes, but also plays a role in the retention of URM students in STEM disciplines. Prior studies have found that social justice and activism serve as major motivators for URM STEM students, both attracting them to and sustaining their engagement in these fields (Garibay, 2018; Gibbs & Griffin, 2013; Thoman et al., 2015). Overall, this body of research underscores the potential of racial activism, particularly among URMs, to play a crucial role in fostering equity within the engineering ecosystem and addressing the prevailing mental health challenges among graduate students. Moreover, the distinctive perspectives brought by minoritized individuals' involvement in racial activism may prove indispensable for effectively navigating and overcoming the stress associated with being a target of racial discrimination (ASEE, 2021; Evans et al., 2018; Miles et al., 2020; Naphan-Kingery et al., 2019).

Theoretical Framework

In conducting our study on doctoral students in ME, EE, and CE, we draw on the foundational theories of Critical Race Theory (CRT) and Social Cognitive Career Theory (SCCT) to provide a comprehensive framework for exploring career trajectories, mental and physical health, and psychosocial factors, including minority status stress and engagement in racial activism. Critical Race Theory, as proposed by Crenshaw et al. (1995), serves as a crucial lens through which we examine the experiences of URM doctoral students within the context of engineering disciplines. CRT acknowledges the systemic nature of racial inequalities and allows us to delve into the nuanced ways in which race intersects with career interests, health outcomes, and experiences of racialized stress. By adopting CRT, we aim to uncover the underlying structures and processes that contribute to the disparities observed, especially in the representation of URM students within ME, EE, and CE. In our exploration, we extend our analysis beyond race to include a broader spectrum of demographic factors, including gender and US citizenship status. This inclusive approach is rooted in the recognition that students' experiences are shaped not only by racial dynamics but also by the interplay of gender identity and citizenship status. The consideration of gender recognizes the complex ways in which gender identity may intersect with race/ethnicity and influence career trajectories, health outcomes, and experiences of racialized stress. Moreover, a nuanced understanding of the impact of U.S. citizenship status is important given the findings from the National Science Foundation Survey of Graduate Students and Postdoctorates in Science and Engineering (2019) that revealed that a substantial portion, exceeding 50%, of graduate students in engineering fields are international students. This recognition is pivotal in contextualizing research on the distinct adversities confronted by international students, including challenges related to cultural adaptation and language barriers (Lee, 2015). Additionally, studies affirm that one's immigrant or international status plays a pivotal role in shaping perceptions within the campus environment, influencing both treatment received and the spectrum of opportunities available to them (Griffin et al., 2016; Constantine et al., 2005).

Social Cognitive Career Theory (SCCT), developed by Lent et al. (1994), provides another theoretical foundation for understanding the career development processes of doctoral students in engineering. SCCT emphasizes the reciprocal influence of personal factors, environmental factors, and behavioral outcomes in shaping career choices. In our study, SCCT guides the exploration of how doctoral students in ME, EE, and CE form their career interests, navigate through diverse career trajectories, and respond to external influences. By incorporating SCCT, we aim to elucidate some of the factors that may contribute to the observed variations in career preferences, as well as the role of social and environmental factors in shaping these preferences across the three engineering disciplines. Combined, CRT and SCCT offer a robust theoretical framework for examining the complex interplay of demographics, career development, and psychosocial factors among doctoral students in ME, EE, and CE.

Purpose & Research Questions

Our exploration of the literature highlights nuanced distinctions emerging between ME, EE, and CE in the context of this expanding research. The significance of race/ethnicity as a crucial factor in understanding these nuances is evident. Despite the widespread popularity of these engineering fields, there is a notable dearth of systematic research comprehensively examining the influence of disciplines and demographics on doctoral students' career goals, mental and physical health, and racialized experiences. This investigation holds the potential to uncover vital differences with implications for equity and inclusivity. Similarly, this research can assist in developing tailored strategies for recruitment, retention, and career development that cater to the specific needs of students in various demographic groups and disciplines.

Building upon the insights from the extant literature, our overarching objective is to unravel the differences in career trajectories, mental and physical health, and racialized experiences among doctoral students in the three most prominent engineering disciplines—ME, EE, and CE. Furthermore, we anticipate that demographic factors, particularly race/ethnicity, may play a pivotal role in shaping students' career choices, health indicators, and experiences of racialization within their graduate programs. Leveraging a national dataset encompassing over 800 doctoral students in ME, EE, and CE, our primary research questions guide the analysis across three main areas: career interests, health, and racialized experiences.

Research Questions

1. **Career Interests/Goals:** How does the likelihood of pursuing specific career trajectories, including faculty positions, industry roles, government positions, and K-12 education, vary among doctoral students in computer engineering, electrical engineering, and mechanical engineering? How do demographic variables such as gender and race/ethnicity influence these career interests?
2. **Health:** What are the discipline-specific variations in physical and mental health outcomes among doctoral students in computer engineering, electrical engineering, and mechanical engineering? How do demographic variables, particularly race/ethnicity, contribute to these health outcomes?
3. **Racialized Experiences**: How do racialized experiences, specifically race-based stress as a member of a minority group and engagement in racial activism, vary across engineering disciplines? To what extent do demographic variables, including race/ethnicity and gender,

contribute to the experiences of stress and racial activism among doctoral students in computer engineering, electrical engineering, and mechanical engineering?

The following data source was used to answer the research questions.

METHODS

Data Sources

For this study, data were consolidated from three nationally conducted surveys to comprehensively explore the experiences and career trajectories of doctoral students in the fields of science, technology, engineering, and mathematics (STEM). The surveys utilized were: 1) Exploring the Experiences and Career Trajectories of STEM Doctoral Students of Color (EECT-STEM); 2) Supporting Innovations and Diversity in Entrepreneurship 1 (SIDE 1); and 3) The Engineering and Computing Doctoral Experiences Survey (ECDES). These electronic surveys were distributed on a national scale from 2017-2022 to doctoral students primarily pursuing PhDs in engineering and computing disciplines. The central focus of these surveys was to investigate students' attitudes, health, and the influence of racialized experiences on their career interests. Recruitment efforts included: 1) introductions to key organizations that have members that fit the sample (e.g., National Society of Black Engineers); 2) invitations to colleagues in engineering and computing departments; and 3) posting with social media (e.g., LinkedIn and Facebook). Statistical power calculations were used to inform our recruitment plan, and recruitment numbers were monitored on an ongoing, twice-monthly basis.

The EECT-STEM survey aimed to delve into the experiences of underrepresented minority (URM) doctoral STEM students, specifically assessing how their racialized experiences, such as minority status stress resulting from discrimination and bias, influence their career aspirations. Similarly, the SIDE 1 survey explored the impact of mental health, racial activism, and minority status stress on students' likelihood of pursuing various career trajectories, with a particular emphasis on entrepreneurship. The ECDES concentrated on understanding the factors influencing the career decision-making of engineering doctoral students, with a special emphasis on uncovering the racialized experiences of underrepresented groups of color.

Variable Operationalization

Despite some variation in the objectives and focus of the three surveys, identical scales were utilized to evaluate aspects related to career interests/goals, mental and physical health, and race-based experiences. Utilizing consistent scales across all three surveys enabled us to amalgamate the data, resulting in a larger sample size for analysis. Specific scales related to our major themes—career, health, and race-based experiences— are described below:

Career: To assess students' career interests/goals, the survey asked respondents to indicate on a 4-point Likert scale (1, "Not at all likely" to 4, "Very likely") their likelihood of pursuing a position after obtaining their graduate degree. In particular, students were asked about their interest in pursuing a variety of careers including faculty positions: "How likely are you to pursue a position as a university faculty member with an emphasis on teaching?" and "How likely are you to pursue a position as a university faculty member with an emphasis on research?" Other career trajectories were also assessed, including likelihood to pursue a position in industry, a start-up company, government, nonprofit organization, or a postdoctoral fellowship.

Health: To evaluate mental and physical health, the surveys utilized well-established instruments, including Patient-Reported Outcomes Measurement Information System (PROMIS)-Physical Health (Hays et al., 2009) and PROMIS-Mental Health (Hays et al., 2009). PROMIS measures self-reported perceptions of health and includes ten items in total. Two constructs are measured – global mental health (PROMIS- Mental Health) and global physical health (PROMIS-Physical Health). An example of a PROMIS-Mental Health item includes: "In general, how would you rate your mental health, including your mood and your ability to think?" on a scale from 1 (Poor) to 5 (Excellent). An example of a PROMIS-Physical Health item includes "How would you rate your fatigue on average?" on a scale from 1 (None) to 5 (Very severe).

Racialized Experiences: To assess racialized experiences, two instruments were employed. The first, the Minority Status Stress Scale (Smedley, Myers & Harrell, 1993), gauged the extent to which students experienced stress based on their race and includes 37 items). An example item is "The university does not have enough professors of my race." Each item was rated on a 6-point Likert scale, from "Not Applicable" (0) to "Extremely stressful" (5). The second, the Racial Activism Scale (adapted from Szymanski, 2012), measured students' engagement in racial justice activism. The adapted scale was modified to be inclusive of all racial/ethnic groups, ensuring a broader representation. For instance, the term "African American" was adjusted to "People of Color," as reflected in statements like "I attend conferences/lectures/classes/trainings on issues pertaining to People of Color." There are 17 items that participants rate on a scale from 1 (Very untrue of me) to 7 (Very true of me).

All the scales mentioned above have demonstrated high reliability and validity, as evidenced by findings from prior peer-reviewed studies (refer to Cohen et al., 1983; Diener et al., 1985; Hays et al., 2009; Smedley et al., 1993; Szymanski, 2012; Taber, 2018). Furthermore, we conducted Cronbach's alphas across all constructs to ensure reliability within our specific population. The results indicated excellent reliability, with all constructs ranging from 0.86 to 0.93, as observed in previous research (Monroe-White & McGee, 2024; Taber, 2018; Cortina, 1993).

In addition to assessing the scales described above, the surveys also collected demographic information regarding students' gender, race/ethnicity, and U.S. citizenship status. Furthermore, students were queried about their degree program or primary discipline, with options including electrical engineering, mechanical engineering, and computer engineering.

Participants

Our sample consisted of 1,553 participants who completed the EECT-STEM, SIDE 1, or ECDES surveys between 2017 and 2022. Among these respondents, 847 specifically indicated their pursuit of a doctorate in computer engineering, electrical engineering, or mechanical engineering. To align with the study's focus on these three disciplines, only students meeting our selection criteria were retained in the dataset. The data presented in Table 2 suggest that 28% of the retained sample were in computer engineering, 33% in electrical engineering, and 39% in mechanical engineering. It is important to note that the majority of our sample (n=648) was derived from the ECDES survey; this may be attributed to the survey's exclusive focus on doctoral students in engineering and computing disciplines.

Table 2. Engineering Discipline by Survey Instrument

		Survey Participants			
		EECT-STEM	ECDES	SIDE 1	**Total**
Computer Engineering	n	81	144	14	**239**
	%	65%	22%	19%	**28%**
Electrical Engineering	n	18	240	23	**281**
	%	14%	37%	31%	**33%**
Mechanical Engineering	n	26	264	37	**327**
	%	21%	41%	50%	**39%**
Total	**n**	**125**	**648**	**74**	**847**
	%	**100%**	**100%**	**100%**	**100%**

Examining demographic variables, the data reveals that approximately 36% self-identified as female, while 64% identified as male. Regarding U.S. Citizenship status, 59% reported being U.S. Citizens, and 41% indicated non-citizenship. Additionally, 34% self-identified as belonging to an underrepresented racialized minority (URM) group, whereas 66% identified as non-URM. For classification purposes, we employed National Science Foundation (NSF) and National Center for Science and Engineering Statistics (NCSES) categories for URM and non-URM: URM encompassed African American or Black, American Indian/Alaska Native, and Latinx/Hispanic, and Multiracial; non-URM included White and Asian American/Asian (NSF/NCSES, 2023).

To examine potential demographic variations across disciplines, chi-square analyses were employed to assess the equivalency of gender, race/ethnicity, and citizenship status distributions among the three disciplines. The data indicates a significantly larger proportion of females (51%) among Computer Engineering compared to Electrical (31%) and Mechanical (28%) engineers in our sample, $\chi 2$ (2) = 22.67, $p<.01$. Similarly, there is a significantly larger proportion of URMs (49%) in Computer Engineering compared to Electrical (27%) and Mechanical (29%) engineers, $\chi 2$ (2) = 25.16, $p<.01$. Additionally, a significantly larger proportion of U.S. Citizens is represented among Computer Science (61%) and Mechanical Engineers (66%) compared to Electrical Engineers (48%), $\chi 2$ (2) = 15.54, $p<.01$. Overall, these results may suggest that historically underrepresented groups (females, URM) may be more represented in computer engineering than the other two disciplines. However, it is crucial to acknowledge that these distinctions may be specific to our population and not indicative of inherent differences between the disciplines alone. For further insights into the demographic profile of participants, refer to the tables in the Appendix A.

RESULTS

To address our research questions, descriptive statistics and Analyses of Variance (ANOVAs) were employed to investigate differences among the three disciplines on the survey constructs mentioned above. Tukey's HSD post hoc tests were conducted to assess the statistical significance of the observed differences between disciplines. Furthermore, multiple regression analyses were performed to examine the influence of race, gender, US citizenship status, and discipline on career outcomes, health, and race-based experiences. In the regression analyses, computer engineering was designated as the "reference" group, allowing for comparisons of electrical and mechanical engineering to computer engineering in the models.

Descriptive Statistics and ANOVA Results

Descriptive statistics and ANOVA results are displayed in Table 3 for all survey constructs. For *Career Interests/Goals*, the results of the ANOVA revealed significant differences by discipline for three careers: Nonprofit ($F(2, 556) = 2.54$, $p=.08$, *trending towards significance*), Government ($F(2, 560) = 5.19$, $p=.006$), and K-12 ($F(2,557)= 4.34$, $p=.013$). Post hoc tests indicate that computer engineering students are more inclined to pursue positions in the non-profit sector than mechanical engineers. Conversely, mechanical engineering students are more likely than computer engineering students to pursue positions in the government sector. Additionally, computer engineering students are significantly more likely to pursue positions in the K-12 education sector than their mechanical engineering counterparts. Regarding *Health*, significant differences were found across disciplines for physical health (PROMIS-Physical Health) ($F(2, 178)=7.61$, $p=.001$), with computer engineering students exhibiting significantly lower scores than both electrical and mechanical engineering students. For *Racialized Experiences*, Table 3 indicates no significant differences across the three disciplines for both Racial Activism and Minority Status Stress. Together, the ANOVA results highlight discipline-specific variations in Career Interests/Goals and Health, underscoring the importance of exploring these dimensions within the distinct contexts of various engineering disciplines. While no significant differences were observed for Racial Activism and Minority Status Stress, it is crucial to delve into the examination of race and other demographic variables to better unpack the nuanced experiences of students across various disciplines. This rationale guides the next set of analyses, which involve demographic considerations in regression models.

Table 3. Descriptive Statistics and ANOVA Results

Constructs		Computer Engineering		Electrical Engineering		Mechanical Engineering		ANOVA (p-values)
		Mean	*SD*	Mean	*SD*	Mean	*SD*	
Career Interests/ Goals	Faculty-Teaching	2.55	*1.05*	2.29	*1.05*	2.30	*1.02*	ns
	Faculty-Research	2.69	*1.05*	2.82	*1.19*	2.55	*1.08*	ns
	Post Doc	2.50	*1.02*	2.67	*.88*	2.85	*.93*	ns
	Join Startup	2.71	*.85*	2.53	*1.02*	2.67	*.85*	ns
	Nonprofit†	2.28_a	*.92*	2.13	*.86*	2.08_b	*.92*	p=0.080†
	Industry	3.11	*.87*	3.07	*.95*	3.20	*.82*	ns
	Government**	2.42_a	*.93*	2.59	*.97*	2.73_b	*.94*	p=0.006**
	Start Your Own Business	2.08	*.91*	2.21	*.97*	2.17	*.92*	ns

	K-12*	1.72_a	*.91*	1.59	*.75*	1.49_b	*.67*	p=0.012*
Health	**PROMIS-Physical****	3.73_a	*.45*	3.98_b	*.53*	4.03_b	*.48*	p=.001**
	PROMIS-Mental	3.27	*.61*	3.54	*.72*	3.34	*.81*	ns
Racialized Experiences	Racial Activism	4.48	*1.66*	3.83	*1.44*	4.29	*1.41*	ns
	Minority Status Stress (MSS)	2.13	*1.25*	1.75	*1.02*	2.23	*1.59*	ns

Note: ns = not significant; †p < .10 (trending toward significance); *p < .05; **p < .01. Means and standard deviations are displayed in the table above. Subscripts 'a' and 'b' suggest statistically significant different means as determined by post hoc tests.

Regression Results

Given the demographic composition of participants within the three engineering disciplines, it is important to consider the potential influences of race, gender, and US citizenship status on the study's outcomes. In an effort to explore how these demographic variables, along with the three engineering disciplines, contribute to the study's outcome variables, a series of regression models were conducted. The inclusion of race, gender, and US citizenship, alongside the three disciplines (computer, mechanical, electrical engineering), as predictors in the models aims to reveal the unique influences of both disciplines and demographics on variables such as career interests, health, and racialized experiences. This analytical approach allows for a nuanced investigation into how race, gender, citizenship status, and engineering disciplines collectively shape the outcomes under examination.

Career Interests/Goals: Regression models were conducted separately for each career sector (e.g., Faculty-Teaching emphasis, Postdoc, Join Startup, etc.), with race (URM=1; nonURM=0), gender (Female=1; Male=0), and US citizenship status (US Citizen=1; nonUS=0) considered as predictor variables for each model. The reference group for these analyses was computer engineering, allowing for comparisons between electrical and mechanical engineering with computer engineering. In summary, the results of the regression analyses reveal the following:

- *Nonprofit:* Females were significantly more likely than males to indicate interest or likelihood in pursuing a career in the non-profit sector. (β= 0.16, $p < .01$), regardless of engineering discipline. Likewise, mechanical engineering students were somewhat less likely than computer engineering students to pursue a career in the nonprofit sector (β= - 0.10, p=0.087, approaching significance).
- *Government:* US Citizens were significantly more likely than nonUS citizens to express interest or likelihood in pursuing a career in the government sector (β= 0.25, $p < .01$), regardless of engineering discipline. Additionally, electrical engineering students were somewhat more likely than computer engineering students to pursue a career in the government sector (β= - 0.10, $p< .10$, approaching significance).
- *K-12:* Both electrical engineering students (β= - 0.13, $p < .05$) and mechanical engineering students (β= - 0.14, $p < .05$) were *less* likely than computer engineering students to express interest in pursuing a career in the K-12 sector after graduating. No demographic variables were significant predictors in this model.

- *Entrepreneurship/Start Own Business*: URM students were significantly more likely than nonURM students to express interest or likelihood in pursuing an entrepreneurial path or starting their own business (β= 0.24, $p < .01$). No other variables were significant predictors in this model.

Detailed information on all significant regression models can be found in Appendix B. For Faculty with a teaching emphasis, Faculty with a research emphasis, Postdoc, joining a start-up, and industry, the model fits were not significant, and none of the predictors emerged as significant in predicting these career interests. This may suggest that the observed variability in participants' preferences for these specific career paths could not be reliably explained by the examined demographic variables and engineering disciplines.

Health: The results of the regression model for PROMIS-Physical Health suggest that, even after accounting for race, gender, and US citizenship status, electrical (β= 0.20, $p < .05$) and mechanical (β= 0.29, $p < .01$) engineering students scored significantly higher (indicating more severe physical health issues) than computer engineering students. See Table 4. This implies that students in computer engineering may experience less severe physical health-related issues. Additionally, URM students scored significantly higher on the PROMIS-Physical Health scale than non-URM students ($\beta = 0.23$, $p < .01$), suggesting that URM students experience physical health issues more severely than non-URMs. Overall, the results suggest that URMs in engineering encounter distinct challenges related to physical health issues. Acknowledging these disparities emphasizes the critical need for tailored interventions and support systems. Similarly, mechanical and electrical engineering students might face increased physical health challenges, highlighting the importance of targeted support initiatives. It is important to note that the regression model was not significant and revealed no significant predictors for PROMIS mental health. This may suggest that there are other factors influence mental health that may need to be explored within this context.

Table 4. Regression Results for PROMIS Physical Health

DV: PROMIS Physical Health; Scale: 1 (None) to 5 (Very severe)					
	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	β	t	Sig.
(Constant)	3.32	0.11		30.72	0.000
Electrical (vs. Computer)	0.23	0.09	0.20	2.50	0.013*
Mechanical (vs. Computer)	0.30	0.08	0.29	3.68	0.000**
URM (vs. nonURM)	0.29	0.09	0.23	3.19	0.002*
Female (vs. Male)	0.11	0.07	0.12	1.59	0.114
US Citizen (vs. non-US)	0.16	0.10	0.11	1.50	0.135

Note: ns = not significant; †p<.10; *p<.05; **p<.01. $F(5,166)=7.62$, $p<.01$, $R^2=.19$

Racialized Experiences: Looking at the regression results for Racial Activism, the data indicates that several predictor variables influence engagement in such activism. Specifically, electrical engineering (β= - 0.25, $p < .05$) students were significantly *less* likely than computer engineering students to participate in racial activism. By contrast, URM students (β= 0.20, $p < .05$) and US Citizen students (β= 0.25, $p < .05$) were significantly *more* likely than their counterparts to engage in racial activism. A similar pattern emerges when examining the regression model for Minority

Status Stress (MSS): electrical engineering students (β= - 0.17, $p < .05$) were significantly less likely than computer engineering students to experience MSS, while URM students (β= 0.24, $p < .01$) and US citizen students (β= 0.30, $p < .01$) were significantly more likely than their counterparts to experience MSS. See Tables 5 and 6 below. This pattern of findings suggests that electrical engineering students exhibit lower involvement in racial activism and experience less Minority Status Stress compared to their computer engineering counterparts. On the other hand, URM and US citizen students across disciplines are more likely to engage in racial activism and experience higher levels of Minority Status Stress.

Table 5. Regression Results for Racial Activism

DV: Racial Activism; Scale: 1 (very untrue of me) to 7 (very true of me)					
	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	β	t	Sig.
(Constant)	2.58	0.48		5.36	0.000
Electrical (vs. Computer)	-0.84	0.34	-0.25	-2.47	0.015*
Mechanical (vs. Computer)	-0.39	0.30	-0.13	-1.28	0.203
URM (vs. nonURM)	0.73	0.36	0.20	2.04	0.043*
Female (vs. Male)	0.21	0.26	0.07	0.84	0.404
US Citizen (vs. non-US)	1.46	0.57	0.25	2.54	0.012*

Note: ns = not significant; $^{\dagger}p<.10$; $^{*}p<.05$; $^{**}p<.01$. $F(5, 116) = 5.39$, $p<.01$, $R^2=.19$

Table 6. Regression Results for Minority Status Stress (MSS)

DV: MSS; Scale: 0 (not applicable) to 6 (extremely stressful)					
	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	β	t	Sig.
(Constant)	0.54	0.31		1.77	0.079
Electrical (vs. Computer)	-0.56	0.25	-0.17	-2.21	0.028*
Mechanical (vs. Computer)	-0.17	0.22	-0.06	-0.78	0.437
URM (vs. nonURM)	0.85	0.25	0.24	3.39	0.001**
Female (vs. Male)	0.09	0.19	0.03	0.46	0.643
US Citizen (vs. non-US)	1.15	0.29	0.30	4.01	0.000**

Note: ns = not significant; $^{\dagger}p<.10$; $^{*}p<.05$; $^{**}p<.01$. $F(5, 164) = 8.29$, $p<.01$, $R^2=.20$

DISCUSSION

This study delved into the landscape of engineering career preferences, health outcomes, and equity attitudes across three prominent disciplines within engineering— ME, EE, and CE. Overall, our findings reveal both shared patterns and distinctive characteristics among these disciplines, and provide valuable insights into the multifaceted landscape of doctoral students' experiences. Notably, the findings underscore the significance of demographic variables, with a particular emphasis on race/ethnicity, as influential factors shaping the journey of doctoral students within these dynamic fields. To date, this study represents the first systematic exploration of differences across these three engineering disciplines concerning critical issues related to career, health, and racial equity. A discussion of major findings follows.

Similarities across Disciplines: The outcomes of the analysis, as indicated by the ANOVA results, reveal notable similarities across the three engineering disciplines. For example, the preference for pursuing a career in industry was consistently high across all disciplines, aligning with recent research findings (Choe & Borrego, 2020). Similarly, the inclination towards academia, encompassing roles such as teaching, research, and postdoctoral positions, was consistent and uniform across the disciplines, corroborating existing literature that reports minimal variability in this aspect. Despite employing regression models and accounting for demographic variables, discernible patterns, or predictors for variability in industry and academia choices among the engineers did not emerge. This suggests that the propensity towards pursuing academia or industry may be influenced by variables not considered in our model, indicating a connection to more global economic considerations and trends.

Differences across Disciplines: In terms of cross-discipline differences, computer engineering students displayed distinctive patterns that differed from the other two disciplines. Even after controlling for demographic influences, they showed a proclivity towards careers in the nonprofit sector, a reduced likelihood of pursuing roles in government, and a greater interest in the K-12 sector compared to their counterparts in the other disciplines. Furthermore, computer engineering students reported fewer physical health issues than their peers, with no significant disparities in mental health. Intriguingly, irrespective of demographic variables, computer engineers displayed higher engagement in racial activism and reported experiencing more race-based stress than their electrical engineering counterparts. Furthermore, the composition of our sample revealed a higher proportion of females and URMs in computer engineering compared to electrical and mechanical disciplines. These findings suggest that historically underrepresented groups, including females and URMs, may exhibit a heightened attraction to computer engineering. However, caution is advised in generalizing these trends; additional research is warranted to ascertain whether these patterns are specific to our population or indicative of inherent differences between the disciplines. Overall, our findings seem to suggest that computer engineering stands out as somewhat different from the other two sectors, emphasizing the need for additional research to delve into the factors contributing to these distinctive trends. These findings add another dimension to recent research by Brawner and colleagues (2020) who found that CE disciplines are perceived as having less positive faculty relationships and a lower sense of belonging among Black students. Our results add complexity to this work and suggest that further research may be necessary to fully comprehend the nuanced dynamics at play within computer engineering.

Demographic Differences: Examining demographic variables in our models, consistent with existing literature (Monroe-White & McGee, 2023; McGee et al., in press), URM students exhibited noteworthy trends. Regardless of discipline, URM students displayed a greater inclination toward entrepreneurial paths or starting their own businesses. This aligns with the broader trend in STEM, particularly among Black students, which suggest a growing interest in entrepreneurship. Additionally, URM students reported more physical health issues, more experiences of minority status stress, and more involvement in racial activism compared to their non-URM counterparts. These findings may suggest that race-based discrimination plays a pivotal role in both exacerbating stress-related health issues and motivating proactive engagement in racial activism. This aligns with prior research indicating a reciprocal relationship between racial activism and entrepreneurship driven by race-based stress (Monroe-White & McGee, 2023). Once again, these consistent findings underscore the crucial role that discrimination may play in both *self-protective* (e.g., action that individuals adopt to shield themselves from the negative consequences, often in response to experiences of discrimination) and *self-enhancing* (e.g., positive actions individuals derive from experiences of discrimination, such as personal growth, empowerment, or contributions to social change) consequences (Jones, 2005). On one hand, it may lead to more stress and health-related issues; on the other hand, experiencing stress related to discrimination may drive the will to address racial equity issues, engage in racial activism, and promote change.

Interestingly, in our regression models, gender and US citizenship were not as predictive as race/ethnicity. The only areas of distinction in terms of gender and US citizenship were that females displayed a higher interest in nonprofit roles than males, and non-US citizens were less likely to pursue government positions than their US citizen counterparts. The most influential demographic predictors in the regression models were associated with URM status. This emphasizes the crucial role of race/ethnicity in shaping career choices, health outcomes, and attitudes toward equity engagement.

Limitations and Implications

It is important to acknowledge the limitations of our study, including the cross-sectional design and reliance on self-reported data. Likewise, exploring the intersectionality of gender and race as a distinct predictor variable could be pursued in future studies and add further complexity to our understanding of influential demographic variables. Additionally, employing a longitudinal design could be used to gain a more nuanced understanding of how career interests, health, and racialized experiences change over time. Further, investigating institutional characteristics, such as departmental diversity and learning environments, may provide valuable insights and may need to be included in a more complex regression model that accounts for institutional variations.

Despite these limitations, our findings hold practical implications for educators, policymakers, and practitioners in the field of engineering education. The observed similarities across disciplines, particularly the consistent high preference for careers in industry, suggest that overarching trends in career preferences may be influenced by global economic considerations rather than discipline-specific factors. This underscores the need for institutions and policymakers to recognize and adapt to these commonalities in career aspirations. Differences across disciplines, notably in computer engineering, indicate that tailored approaches are essential for understanding and supporting the unique patterns within each field. Computer engineering doctoral students seem to be distinct from their mechanical and electrical engineering counterparts in their greater proclivity towards pursuing nonprofit and K-12 sectors. These findings signal the importance of recognizing and accommodating the diverse career interests and pathways within the field of computer engineering, and providing career guidance that expands into nontraditional sectors.

Likewise, demographic differences, especially for URM students, reveal a strong inclination toward entrepreneurial paths, aligning with recent trends (Monroe-White & McGee, 2023). This may be a call to action to foster entrepreneurship skills and opportunities for URM students. Also, the reported physical health issues, minority status stress, and engagement in racial activism highlight the critical role that racial discrimination plays for URM. Acknowledging these factors is crucial for creating supportive environments that address the unique challenges and aspirations of URM students within engineering disciplines.

Conclusion

In conclusion, our study contributes to the ongoing discourse on engineering education by unraveling the complexities of career trajectories, health outcomes, and psychosocial attitudes within three engineering disciplines. The nuanced findings provide a foundation for future research endeavors aimed at fostering a more inclusive and supportive environment for all students pursuing engineering careers.

Appendix A. Demographics

Gender by Discipline

Discipline		Gender: Male	Gender: Female	Total
Computer Engineering	Count	82	84	166
	% within Comp.	49.4%	50.6%	100.0%
Electrical Engineering	Count	115	51	166
	% within Electrical	69.3%	30.7%	100.0%
Mechanical Engineering	Count	147	58	205
	% within Mechanical	71.7%	28.3%	100.0%
Total	Count	344	193	537
	% within Total	64.1%	35.9%	100.0%

Note: 310 students chose not to disclose their gender or left this item blank.

URM/nonURM status by Discipline

Discipline		Race/Ethnicity: nonURM	Race/Ethnicity: URM	Total
Computer Engineering	Count	96	92	188
	% within Comp.	51.1%	48.9%	100.0%
Electrical Engineering	Count	151	57	208
	% within Electrical	72.6%	27.4%	100.0%
Mechanical Engineering	Count	173	71	244
	% within Mechanical	70.9%	29.1%	100.0%
Total	Count	420	220	640
	% within Total	65.6%	34.4%	100.0%

Note: 207 students chose not to disclose their race/ethnicity or left this item blank.

US Citizenship Status by Discipline

Discipline		US Citizen: No	US Citizen: Yes	Total
Computer Engineering	Count	74	114	188
	% within Comp.	39.4%	60.6%	100.0%
Electrical Engineering	Count	108	100	208
	% within Electrical	51.9%	48.1%	100.0%
Mechanical Engineering	Count	83	162	245
	% within Mechanical	33.9%	66.1%	100.0%
Total	Count	265	376	641
	% within Total	41.3%	58.7%	100.0%

Note: 206 students chose not to disclose their race/ethnicity or left this item blank.

Appendix B. Regression Models, Career Interests/Goals

Regression Results for Career Interest in Non-Profit

Non-Profit			**F (5, 416) =3.50, p<.05 R^2=.04**		
	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	β	t	Sig.
(Constant)	2.18	0.11		19.34	0.000
Electrical (vs. CS)	-0.10	0.11	-0.05	-0.84	0.402
Mechanical (vs. CS)	-0.19	0.11	-0.10	-1.72	0.087†
URM (vs. nonURM)	0.02	0.10	0.01	0.16	0.874
Female (vs. Male)	0.30	0.09	0.16	3.18	0.002***
US Citizen (vs. non-US)	-0.02	0.10	-0.01	-0.20	0.839

Note: ns = not significant; †p<.10; *p<.05; **p<.01.

Regression Results for Career Interest in Government

Government			**F (5, 420) =6.37, p<.01 R^2=.07**		
	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	β	t	Sig.
(Constant)	2.14	0.12		18.34	0.000
Electrical (vs. CS)	0.20	0.12	0.10	1.72	0.086†
Mechanical (vs. CS)	0.18	0.11	0.09	1.64	0.101
URM (vs. nonURM)	-0.17	0.10	-0.08	-1.67	0.097†
Female (vs. Male)	-0.02	0.10	-0.01	-0.20	0.840
US Citizen (vs. non-US)	0.51	0.10	0.25	4.97	0.000***

Note: ns = not significant; †p<.10; *p<.05; **p<.01.

Regression Results for Career Interest in K-12 Education

K-12			**F (5, 417) =2.47, p<.05 R^2=.03**		
	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	β	t	Sig.
(Constant)	1.72	0.09		18.99	0.000
Electrical (vs. CS)	-0.20	0.09	-0.13	-2.17	0.030**
Mechanical (vs. CS)	-0.22	0.09	-0.14	-2.48	0.014**
URM (vs. nonURM)	-0.01	0.08	0.00	-0.07	0.946
Female (vs. Male)	0.09	0.08	0.06	1.18	0.240
US Citizen (vs. non-US)	-0.09	0.08	-0.06	-1.16	0.248

Note: ns = not significant; †p<.10; *p<.05; **p<.01.

Regression Results for Career Interests in Entrepreneurship

Entrepreneurship			**F (5, 339) =4.14, p<.01 R^2=.06**		
	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	β	t	Sig.
(Constant)	2.02	0.13		15.62	0.000
Electrical (vs. CS)	0.05	0.13	0.03	0.41	0.683
Mechanical (vs. CS)	0.00	0.13	0.00	0.01	0.993
URM (vs. nonURM)	0.50	0.11	0.24	4.36	0.000^{***}
Female (vs. Male)	-0.17	0.11	-0.09	-1.64	0.102
US Citizen (vs. non-US)	-0.02	0.11	-0.01	-0.17	0.867

Note: ns = not significant; $^{\dagger}p<.10$; $^{*}p<.05$; $^{**}p<.01$.

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