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RESEARCH ARTICLE

Professorial intentions of engineering PhDs from historically excluded groups: The influence of graduate school experiences

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Abstract

Background: In addition to the benefits of a diverse faculty, many institutions are under pressure from students and administrators to increase the number of faculty from historically excluded backgrounds. Despite increases in the numbers of engineering PhD earners from these groups, the percentages of Black/African American and Hispanic/Latino tenure-track faculty have not increased, and the percentage of women remains low.

Purpose: The purpose of this study is to identify how experiences in graduate school encourage or deter PhD earners from historically excluded groups in pursuing an engineering academic career.

Method: We conducted 20 semi-structured interviews with engineering PhD students and recent graduates, with half of participants interested and half disinterested in pursuing an academic career after graduation.

Results: Three key factors emerged as strongly influential on participants' desire to pursue an academic career: their relationship with their advisor, their perception of their advisor's work–life balance, and their perception of the culture of academia. Participants extrapolated their experiences in graduate school to their imagined lives as faculty. The results illuminate the reasons why engineering PhD earners from historically underrepresented groups remain in or leave the academic career pathway after graduate school.

Conclusions: The findings of this study have important implications for how graduate students' and postdoc's relationships with their advisors as well as perceptions of their advisors' work–life balances and the culture of academia affect future faculty. We make recommendations on what students, faculty, and administrators can do to create a more inclusive environment to encourage students from historically excluded groups to consider academic careers.

KEYWORDS

diversity, faculty, graduate education

1 | INTRODUCTION

People from historically excluded groups continue to be underrepresented in engineering faculty positions (e.g., women; people who identify as Black/African American, Hispanic/Latino, American Indian, LGBTQ+, first-generation college students, and people with disabilities). Increases in the numbers of PhD earners from these gender and racial/ethnic groups have not translated to an increase in faculty representation (Roy, 2019). If current hiring trends hold steady, faculty diversity will not significantly increase through the year 2080, even with a hypothetical exponential increase in underrepresented minority (URM) PhD graduates (Gibbs et al., 2016).

A diverse engineering faculty is important for a multitude of reasons. Not only do faculty serve as the gatekeepers for graduate students and the next generation of faculty, but their personal backgrounds influence what scientific questions are pursued and how results are interpreted and disseminated (Leggon, 2010). Having a diverse faculty improves all students' intercultural competence (capacity and comfort level to interact with others in a culturally aware manner), which can help with the postgraduate's transition to the workforce (Madyun et al., 2013).

There are many benefits to having women faculty. Women science and engineering PhD students with women advisors are more likely to complete their PhD than women students with men advisors (Main, 2018); and across fields, women PhD students with women advisors publish 8.5% more than women students with men advisors (Pezzoni et al., 2016). Both men and women PhD students in the biological sciences have reported higher quality of advising when their advisor was a woman (Blaney et al., 2022).

Similarly, faculty from historically marginalized racial and ethnic groups serve as important mentors and role models to students from similar backgrounds. Same-race instructors and faculty mentors have been shown to increase undergraduates' self-efficacy (Santos & Reigadas, 2002), confidence in their ability to be successful in their fields (Newman, 2015), and the overall number of engineering bachelor's degrees earned by women of color (Main et al., 2020). Women and URM PhD earners are more likely to pursue academic careers when they have same-gender or same-race/ethnicity advisors (Hofstra et al., 2022). In addition to serving as role models (Newman, 2015), students may perceive same-ethnicity mentors as more "helpful" than mentors from other groups (Santos & Reigadas, 2002).

STEM graduate students from marginalized backgrounds are motivated to enter academia by job characteristics such as autonomy (McGee et al., 2016), opportunities to mentor students (Gibbs & Griffin, 2013; Mendez et al., 2021), and the ability to serve society and marginalized people through their research (Gibbs & Griffin, 2013; McGee et al., 2016). Yet, engineering graduate students lose interest in faculty careers as they progress through their degrees (Choe & Borrego, 2020; McGee, Naphan-Kingery, et al., 2019). By the end of their PhDs, URM men, all women, and URM women in biomedical science report lower academic career interests than men from well-represented groups (Gibbs et al., 2014). Engineering and computing graduate students were found to lose interest in academic careers after observing the norms and pressures of the academy, such as a toxic, hyper-competitive work environment; the pressure to publish quantity over quality; the difficulty of finding funding; and too few available jobs for too little pay (McGee, Naphan-Kingery, et al., 2019; Woolston, 2022). Finally, a competitive faculty job market can deter all but the most confident researchers (Mendez et al., 2020; Roach & Sauermann, 2017).

It is healthy for graduate students to consider the benefits and drawbacks of different careers and exercise their agency in choosing a career. However, it is problematic when PhD earners from marginalized groups are dissuaded from academic careers at higher rates. From a social justice perspective, people should have equal access to their desired career paths. The results of this study help explain how experiences in graduate school contribute to individuals' decisions to abandon professorial intentions. While existing literature often focuses on deep exploration into a single factor, this article considers multiple factors and how they compound to influence individuals' career intentions.

1.1 | Notes on scope and terminology

There are many terms for race and ethnicity, including "Black," "African American." "Hispanic," "Latino," "Latina," and "Latinx." URM is a commonly used term to refer to people who are Black/African American, Hispanic/Latino, and/or American Indian. We acknowledge the complex histories and nuances around these terms and people's preferences for using them (Agyemang et al., 2005; Martin Alcoff, 2005; Sigelman et al., 2005; Strayhorn, 2020). In this article, we use the participants' own self-described terms and the language from cited publications. While this may come across as disjointed, it is important to us to be clear to readers, participants, and the historically marginalized groups we seek to support through our research.

2 | LITERATURE REVIEW AND THEORETICAL FRAMEWORK

Engineering graduate education research has few well-established theories (Fleming et al., 2023a). Here, we build a theoretical framework from the ground up to guide our study of influences on the professorial career intentions of graduate students and postdocs from historically excluded groups.

2.1 | Faculty prototype

A useful starting point for conceptualizing the professorial intentions of graduate students and postdocs is faculty prototype (Burt, 2019) or schema (Bieber & Worley, 2006). Faculty prototype is a student's idea of what it means to be a professor and is largely based on their interactions with their research advisor. Thus, advisors/supervisors serve as the primary source of developing a faculty prototype (Bieber & Worley, 2006). In Burt's (2019) 13-month ethnographic study of a single research group, the 12 graduate student group members witnessed their advisor's research, teaching, entrepreneurship, time management, family, and home, and got the idea of what it was like to be a professor. Faculty prototype and social comparisons, or "how members made sense of their chances of becoming a professor relative to their group's members and faculty prototype" (p. 314), are central to Burt's (2019) resulting Theoretical Model of Engineering Professorial Intentions (TMEPI). For example, one of Burt's participants remarked that he could live up to his faculty prototype of someone who worked long hours due to being unmarried and not having children. He also spoke with his group mates and advisor's spouse to determine his career trajectory compared to those of his peers or his advisor at the same stage in his career. Burt's illustration of the TMEPI model (Figure 1) shows the relationships between components. Burt's description emphasizes that TMEPI is not linear, and as such does not indicate which of the six components, if any, have more influence than others. Indeed, Burt calls for future research

> to understand the range of prototypes and their characteristics. Further, because prototypes provide cues—both positive and negative—related to faculty careers, which in turn influence interpretations of what faculty careers might entail, a better understanding of the cues members see and hear would provide clues to individuals' concerns about and interests in the professoriate. (p. 323)

The current study addresses this needed extension of TMEPI.

2.2 | PhD student/postdoc–advisor relationship

As Jenny Lee summarized, decades of graduate education research indicates that one's advisor can "make or break a PhD student" (Lee, 2008, p. 267), and a students' faculty prototype cannot be separated from their relationship with their advisor. In addition to learning how to conduct research (Saddler, 2009), students learn from their advisors that

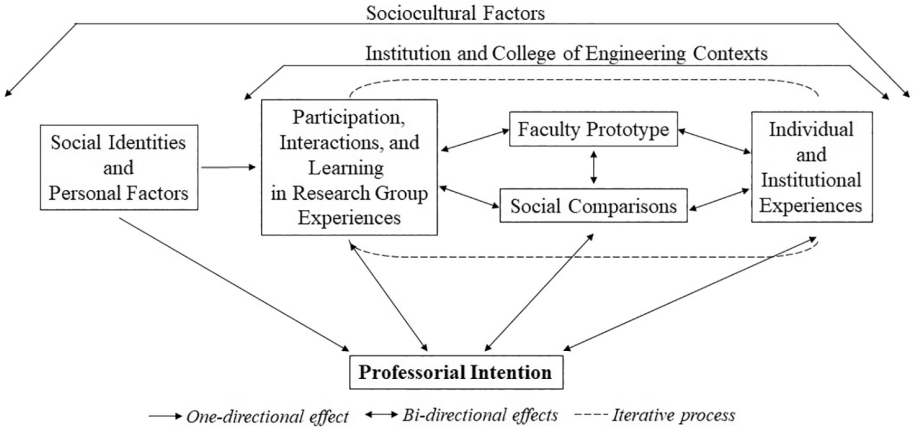

FIGURE 1 Burt's Theoretical Model of Engineering Professorial Intentions. *Source*: Reprinted with permission (Burt, 2019). American Educational Research Journal, 2019.

there are non-research and non-teaching aspects of a faculty position, which take up significant portions of time, such as professional service, grant-writing, and outreach (Saddler & Creamer, 2009). While a student's advisor is their primary faculty prototype, only half of STEM PhD students considered their research advisor a mentor (De Welde & Laursen, 2008).

Students from diverse backgrounds can have different advising needs (Mondisa, 2018). For example, first-generation students, who comprised 30% of PhD earners in 2015 (National Science Foundation, 2017), feel the need to learn how to do research the "right" way, looking to their advisors for guidance on skills, while continuing-generation students expect to be treated with more independence and individually tailored support (Wofford et al., 2021).

Although a student's advisor plays a very specific and highly influential role in their graduate school experience, for many it can be the "most disappointing aspect of their graduate experience" (Katz & Hartnett, 1976, p. 8). Poor advisee–advisor matches can lead to students' early degree departures (Berdanier et al., 2020). Compared to White students, students of color (and especially women of color) reported that their advisor is less respectful of their ideas (Noy & Ray, 2012). Advising experiences can feel racialized and demoralizing (Burt et al., 2018), and microaggressions between Black men engineering graduate students and their advisors caused students to question their ability to engage with and feel less comfortable in engineering (Burt et al., 2019). Asian women engineering PhD students' low scientist interest scores have been attributed to negative relationships with their advisors (Perkins et al., 2020).

However, when they receive good advising, graduate students can flourish. Supportive advisor relationships lessen emotional exhaustion (Hunter & Devine, 2016), improve sense of belonging and self-perception of academic competence (Curtin et al., 2013), and reduce students' intentions to leave academia (Hunter & Devine, 2016). Positive advisor–advisee relationships have resulted in better academic performance and degree progress for Black women STEM PhDs (Bryson & Grunert Kowalske, 2021). Latinx postdocs also had stronger STEM identities when their advisors were cognizant of the racial/ethnic power dynamics in their research groups (Mendez et al., 2021). URM PhD students maintain positive long-term relationships with advisors who are accessible to them, trust them, and communicate effectively with them (Bryson, 2021). Students who were satisfied with their mentors were more likely to accept tenure-track positions and be satisfied with their offers.

2.3 | Work–life balance

Perceptions of work–life balance (WLB) also dissuade engineering and computer science graduate students and postdocs from pursuing academic careers (McGee, Naphan-Kingery, et al., 2019; Mendez et al., 2020; Woolston, 2022). As suggested by Burt's (2019) findings, but not explicit in TMEPI, is that an advisor's WLB may be an important part of the faculty prototype formed by students and postdocs. Women report less interest in becoming professors, rate parenting and mobility as significantly more relevant to their career interests, and cite academic lifestyle as a more negative influence on their career decisions than men do (van Anders, 2004). The lack of role models who successfully balance faculty responsibilities with having children is discouraging for STEM PhD students who want both, but having a role model with such balance helps students to perceive they will successful (De Welde & Laursen, 2011).

Much of the existing literature around WLB is centered around White nuclear families, particularly the role of women with children in heterosexual marriages, including their negative perceptions of long work hours, women's disproportionately large contributions to household duties and childcare compared to men, negative perceptions of pregnancy and maternity leave, and difficulty traveling after having children (Beddoes & Pawley, 2014). For women interested in raising children, personal age and PhD/postdoc completion lead many to feel the pressure of competing biological and tenure clocks (Beddoes & Pawley, 2014; De Welde & Laursen, 2011).

Despite all of the research on White women faculty's WLB, most of it overlooks the needs of underrepresented minority faculty or, intersectionally, women faculty of color (Zambrana, 2018). Many URM faculty are dissatisfied with their WLB (Szelényi & Denson, 2019; Zambrana, 2018), but African American women reported the lowest WLB satisfaction among all gender and racial/ethnic groups (Szelényi & Denson, 2019). The same study found that working at a university with high or very high research activity was negatively correlated with WLB for African American men and women (Szelényi & Denson, 2019). A commonly recommended strategy for faculty unable to maintain their desired WLB is outsourcing domestic labor, such as childcare and other household responsibilities (Castañeda et al., 2015). However, this is not a solution available to all people, especially for Black and Hispanic Americans, who have significantly less generational wealth than their White counterparts (Taylor et al., 2011). In terms of family care responsibilities, URM faculty report high levels of taking care of non-children family members (Zambrana, 2018). The strongest

predictor of WLB satisfaction was perception of institutional support for WLB (Szelényi & Denson, 2019). While institutional policies may, on paper, be equally available to all, they are not always equally accessible to URM faculty. Many faculty learn about such policies informally from other colleagues, and a person's race/ethnicity can limit their informal professional networks, decreasing spread of knowledge (Castañeda et al., 2015). Additionally, many URM faculty are reluctant to take advantage of policies such as parental leave for fear of negative consequences for tenure and career progression (Castañeda et al., 2015). While we know that WLB concerns dissuade women from pursuing faculty positions, it is likely an important consideration for other URM PhD students and postdocs.

2.4 | Research group climate

Another important influence identified by Burt (2019) is "Participation, Interactions, and Learning in Research Group Experiences," which encompasses individuals conducting research in the laboratory or research group, group meetings, and non-research-related group tasks such as lab maintenance. In Burt's study, the professor actively contributed to research group climate by giving feedback during group meetings and creating the expectation of performing non-research group service. Crede and Borrego (2012) similarly found that interactions and communication within a research group, as well as expectations set by the advisor, can positively or negatively influence graduate student learning. There is a nuanced difference between culture ("norms, values, beliefs, traditions") and climate (how people experience an environment) (Stolp & Smith, 1995, p. 13). While the TMEPI discusses research group culture and its influence on group members' "learning of research and development of professional identities with regard to faculty careers" (Burt, 2019, p. 321), we focus on climate, as we are investigating participants' experiences in their research groups and resulting feelings.

Just a few studies have focused on research-group-level experiences of graduate students from historically excluded backgrounds. When research labs are diverse in terms of gender, race, and ethnicity, they can be welcoming spaces where students feel a sense of family (Rodriguez et al., 2022). Yet women STEM PhD students can experience sexual harassment from lab mates and faculty, feel tokenized due to their gender, and face double standards such as being thought of as less knowledgeable and feeling pressure to act agreeably, rather than assertively argue a point like a man colleague (Fabert et al., 2011).

2.5 | Department climate and beyond

Burt (2019) and others recognize the influence of broader contexts on professorial intentions. For example, one context relevant to faculty career intentions is the culture of academia, including pressure to publish (McGee, Naphan-Kingery, et al., 2019) and pressure to win large grants to support graduate students and their research.

There is considerable research on the departmental and institutional experiences of PhD students from historically excluded groups, who unfortunately can have quite different graduate school experiences than their peers from majority groups. Engineering students of color report lower peer relationship scores (Perkins et al., 2020), and Black STEM PhD students report feeling the need to work twice as hard as their peers (Alston et al., 2017; McGee, Griffith, & Houston, 2019). Because of the isolated nature of research labs and pressure to prioritize research, rather than participation in diversity organizations (Perez et al., 2022), graduate students of color can have limited opportunities to build social support networks (Rodriguez et al., 2022). Feelings of isolation can also happen from feeling unwelcome in study groups (Burt et al., 2018).

While graduate students are all too aware of negative racial climates in graduate programs, faculty and administrators can be unaware of the role of structural racism and thus inadequately support graduate students of color (Perez et al., 2023). Furthermore, the often invisible labor of recruiting and retaining graduate students of color (e.g., "diversity weekends" for prospective students, DEI committees, mentoring programs) frequently fall to the students themselves, sometimes due to pressure from their departments (Perez et al., 2022, 2023). While students can be successful despite challenging environments, it comes at a cost. Black engineering and computing PhD students have been found to experience psychological, emotional, and physical stress and impostorism (McGee, Griffith, & Houston, 2019).

However, not all of these students' experiences are negative. Many graduate students find or create community in identity-based groups (Aguado & Porras, 2020; Campbell-Montalvo et al., 2022). Similarly, Latinx STEM postdocs

increase their own sense of belonging by bringing together scholars of color in their field at discipline-based conferences and mentoring undergraduate and graduate students (Mendez et al., 2021). More recently, a number of STEM preparing future faculty (PFF) professional development programs have targeted students from historically excluded groups (Diggs & Mondisa, 2022).

2.6 | Culminating framework and research question

To summarize, faculty prototype is a useful way to conceptualize how graduate students and postdocs form their ideas of what it means to be a faculty member and compare themselves with this prototype. Advisors have an outsized impact on a students' faculty prototype, and the student/postdoc–advisor relationship directly and indirectly influences whether one will pursue and be successful in a faculty career. One unexplored aspect of faculty prototype is the perceived WLB of one's advisor. We and others acknowledge the additional importance of graduate school contexts, including research group, department, and academia. To extend this prior research, we explore the following research questions:

> Of advisor relationship, advisor work-life balance, research group climate, and department climate, which are the most salient for engineering PhD students and postdocs from historically excluded groups when discussing professorial intentions? How do positive and negative perceptions of each relate to whether participants are interested or disinterested in a faculty career? What, if any, additional influences on professorial intentions do engineering PhD students and postdocs from historically excluded groups identify?

3 | METHODS

3.1 | Positionality

As researchers, we recognize that our own experiences shape our worldviews and can influence the lens through which we view the data. We conduct this research from an interpretivist paradigm focused on individual realities of graduate students and postdocs within the context of higher education and their research groups. Our epistemology is subjectivist (Kivunja & Kuyini, 2017), which recognizes that our understanding of the phenomena was socially constructed through our interactions with the participants and with each other, informed by our own experiences in engineering education and research group settings. The first author was a multiracial woman of color postdoctoral fellow who, in addition to her engineering education research, completed her PhD in a technical engineering research group. She has also worked at a predominantly White institution, managing preparing future faculty workshops for graduate students from historically excluded groups and serving on college of engineering-level committees on DEI for graduate students and faculty. The second author is a Black woman PhD student with a technical undergraduate degree from a Historically Black University conducting engineering education dissertation research in a technical department. The third author is a White woman who is a professor and first-generation college student. She completed her PhD in a technical engineering research group, has experience serving on graduate admissions committees, and previously served as an associate dean in a graduate school. Having two members of the research team with technical PhDs contributed to our understanding of how influential the student–advisor relationship is to the engineering graduate student experience. These lived experiences also contributed to how we designed the interview protocol. When analyzing the data, the three authors frequently questioned each other about how their own experiences might bias interpretation of the data to ensure that they would not project their own experiences onto those of the participants.

The first author conducted the interviews, sharing her background at the start. Participants may have felt more comfortable speaking to a peer and may have felt more comfortable with the interviewer due to shared technical background and demographic characteristics, as one participant commented. It is possible that participants may not have been as candid with an interviewer from a majority group. Additionally, several participants were recruited to the study from either participation in the first author's previous future faculty workshops or snowball sampling from such participants. Having long-term relationships with and showing care for participants can have profound effects on both participants and research outcomes (Ong, 2005).

3.2 | Participants

To be selected, participants were required to be (i) a fourth-year or higher engineering PhD student or have earned their engineering PhD within the last 3 years and (ii) from at least one group historically excluded in engineering graduate education, including gender (women or gender non-conforming), race/ethnicity (Black/African American, Hispanic/Latino/a/x, American Indian or Alaska Native, or Native Hawaiian or Other Pacific Islander), first-generation students, low-income students, students with disabilities, or who identify as LGBTQ+. We chose to include both current graduate students and postdocs to widen the pool of potential participants and examine how graduate school and postdoc experiences could contrast each other or reinforce participants' professorial intentions. Many participants had multiple historically excluded identities, as seen in Figures 2 and 3. While we recognize that there can be vastly different experiences for people from these different backgrounds, we chose to include them together in this study because universities' conversations around increasing faculty representation commonly group together gender, racial/ethnic, and other historically excluded identities. Furthermore, sampling a diverse population complements prior literature focused on specific individual groups, and allows for additional consideration of intersectional identities.

Participants were recruited via social media and recruitment emails shared through graduate program coordinators and managers of graduate student programs for historically excluded students. Most recruitment emails were sent to R1 institutions, as the majority of engineering faculty come from those institutions (Wapman et al., 2022); furthermore, no

Pseudonym	Participant Gender	Participant Race/ Ethnicity	Participant Other Identities	Advisor Relationship	Advisor Work-Life Balance	Research Group Climate	Department Climate
Malik	Man	Black: African-American descent		I, +	I, +	+	+
Lorena	Woman	Hispanic/ Latina (Puerto Rican)	Disability	+ +	+ +	+ +	+ +
Rosa	Woman	Latina (Colombian)	Disability	+	+	+	+
Brad	Man	White/ Caucasian	First-gen student, Married, Father	N +	N +	+ +	+ +
Ahmed	Man	Black/African American (refugee & naturalized U.S. Citizen)	First-gen student	+	I, +	+	–
Juan	Man	Latin, mixed-race	Married	N +	+ +	+ +	L –
Candice	Woman	Asian (Korean)		+ + + +	+ I, + – +	– + + +	– + + +
Brianna	Woman	African American		+	–	+	–
Jamal	Man	African American & Caucasian	Married, Father	– +	– +	N +	N N
Ana	Woman	Latin descent (Colombian)		–	–	+	–

FIGURE 2 Heat map of participants *interested* in faculty careers. "L" represents participants who indicated that they had limited interactions with their research group or department.

Pseudonym	Participant Gender	Participant Race/ Ethnicity	Participant Other Identities	Advisor Relationship	Advisor Work-Life Balance	Research Group Climate	Department Climate
Amy	Woman	Asian, White	Married	+	+	+	+
Christine	Woman	White	Married, Mother, disability	+	+, –	+	+
Enam	Man	African (Ghanaian)		+	+	–	N
Santiago	Man	Hispanic/ Latino	First-gen student	N	–	+	L
Cruz	Non-binary (he/they)	Guatemalan-American	First-gen student, first-gen American, queer	–	+	+	–
Camila	Woman	Hispanic/ Latino	First-gen	+	–	–	N
Steve	Man	White	Bisexual, disability	– +	– –	L +	N N
Monique	Woman	Black American	First-gen grad student, low-income	– +	– –	– +	+ +
Maria	Woman	Mexican-American	First-gen, low-income	–	–	+	–
Naomi	Woman	White & Native		+	–	–	–

FIGURE 3 Heat map of participants *disinterested* in faculty careers. "L" represents participants who indicated that they had limited interactions with their research group or department.

participants signed up from the R2 schools included in our recruitment efforts. As such, we center our literature review, discussion, and implications on such positions.

Snowball sampling was also used. Using a screening survey, we intentionally selected participants so that one half were interested in faculty careers and the other half were not. Participants were chosen to meet our criteria for a balanced sample (by career interest and personal demographics). Interviewing PhD earners about their experiences is most important around the time they are graduating, as this is when they are making career decisions to pursue or not pursue an academic career.

We interviewed 20 participants: 10 who were interested in pursuing a faculty career after graduation and 10 who were not. We call these the *interested* and *disinterested* groups of participants to reflect how the participants' career interests changed over time. Of the 10 *disinterested* participants, all but one (Amy) had previously been interested in a career in academia. *Disinterested* participants were often pursuing non-academic careers as the alternative choice to an academic career. Eight out of 10 *interested* participants were interested in academic careers at the beginning of graduate school. One *disinterested* participant (Santiago) was a postdoc, while three *interested* participants (Lorena, Brad, Candice) were postdocs.

Participants were in many fields across engineering, including agricultural and biological, bio/biomedical, chemical, civil and environmental, electrical and computer, industrial and systems/operation, mechanical, and nuclear engineering. They were students and graduates from 11 R1 institutions. Fifteen participants were US citizens, three had international student visas, one was a permanent resident, and one was a naturalized citizen who had come to the United States as a refugee. Two participants had parents who were faculty members.

Many participants were hesitant to share information that could lead to their identities being discovered, despite assurances of confidentiality in their signed consent forms, at the beginning of the interviews, and, in some cases, multiple times throughout the interviews. Many participants were the "only" (woman, person of color, woman of color) in their department, which could lead to their identity being discovered. In order to protect the privacy and confidentiality of our participants, we have removed personal information such as linking participants' demographics with their fields of study.

Per our IRB-approved procedures, the interviewer explained to participants at the beginning of the interview that the results would be used in journal or conference publications. Prior to submission, we contacted all participants to share the Methods and Results sections of this manuscript, providing an opportunity to verify that their experiences have been accurately portrayed and to choose a different pseudonym. Ten participants responded giving their approval of how their experiences have been represented. Three participants requested further de-identification, one participant requested a different pseudonym, and one requested her perception of her advisor's WLB be changed to both positive and negative.

3.3 | Data collection

The 20 interviews were conducted virtually during the summer and fall of 2021 via Zoom, with the exception of one interview that took place in person. Although we do not believe COVID-19 poses a limitation to this study, it is important to note that participants' graduate and postdoctoral experiences happened in that context (see Discussion). All interviews were audio-recorded and professionally transcribed. Most interviews lasted around one hour. The semi-structured interviews included sections about career interests, participants' advisors, and the climates of their research groups and departments (see Appendix). We designed the interview protocol informed by our literature review to ask about professorial intentions in relation to advisor relationship(s), advisor WLB, research group climate, and department climate.

The methods of this study align with Alessi and Kahn's (2023) guidelines for conducting trauma-informed qualitative research to ensure participants' safety and promote their resilience. These five steps and how we enacted them are shown in Table 1. We largely followed Sochacka et al.'s (2018) process-oriented model of ethical validation: particularly, reflecting on our motivations for embarking on this research project; the impacts of our interests, biases, preconceptions, and intentions; and how to do justice to our participants and their lived experiences through the construction and dissemination of our findings.

3.4 | Data analysis

We completed three rounds of inductive coding of transcripts, using open and axial coding techniques (Strauss & Corbin, 1998). During the first round of coding, we identified the major codes of participant–advisor relationship,

TABLE 1 Alessi and Kahn's (2023) guidelines for conducting trauma-informed qualitative research and their implementation in this study.

Alessi and Kahn's guidelines (2023, p. 121)	Implementation in this study
"1) Preparing for community entry: Learning about the impacts of traumatic events and historical trauma on individuals and communities"	The first author conducted a thorough literature review about traumatic experiences of graduate students from historically excluded groups, including racism, sexism, and discrimination.
"2) Preparing for the qualitative interview: Establishing safety and trust in the research environment"	Before the interview, the interviewer (first author) assured participants that great lengths would be taken to protect their identities. The informed consent form was shared with participants in advance so they could review it prior to the interview.
"3) Extending safety and trust into the qualitative interview"	At the beginning of the interview, the interviewer shared her identities and reiterated her commitment to protecting participants' anonymity and that the interview could be stopped at any time.
"4) Knowing when to change course to avoid re-traumatization in the interview"	During interviews, the interviewer allowed participants to share as much or as little as they wanted. When participants did not want to elaborate on a topic (e.g., racism from a faculty member) and relive trauma, the interviewer thanked them for sharing what they were willing to and moved onto the next question without further probing.
"5) Committing to regular and radical self-reflection and self-care in the research process"	During weekly discussions about coding, the first and second authors took time for collaborative self-reflection, discussing how the emerging themes impacted them personally and how these themes aligned or contrasted with their own experiences in their PhD programs or postdoc.

participant's perception of their advisor's/s' WLB(s), research group climate, department climate, and culture of academia. The first four were asked in the interview protocol, and the fifth was an additional influence identified by participants. During the second round of coding, we identified sub-codes in each of the first four major codes, as discussed below. In the third round of coding, we looked at the relationships between codes using axial coding techniques, including early drafts of the heat maps in Figures 2 and 3. The first author completed the first round of coding, the second round of coding for advisor relationship and advisor WLB, and the third round of coding. The second author completed the second round of coding for research group climate and department climate. The first and second authors met weekly to discuss coding, and the first and third authors met weekly to discuss results. We also categorized each participant's experiences (advisor relationship, perception of advisor WLB, research group climate, and department climate) as positive (including improved over time), negative, or neutral. We categorized three cases where participants indicated that they did not interact much with their group/department as "limited interactions." These scores are presented in heat maps. All three authors evaluated each other's coding, discussing differences and collaboratively achieving consensus when necessary.

3.5 | Limitations

We considered both concerns about anonymity and participants' past trauma resurfacing during these interviews and used a trauma-informed approach to try to combat some of that. Showing respect and validating the experiences shared with us built rapport with participants (Alessi & Kahn, 2023). We attempted to create an environment where the participants felt safe and comfortable sharing the more difficult parts of their stories. Some participants were still reluctant to share details that they thought would lead to them to being identified.

Our findings emphasize graduate students' experiences and perceptions of their advisor's WLB. Had we interviewed advisors, we may have heard different perceptions. What one person deems a "healthy" WLB may appear to be overworking to another. When talking about their advisor's WLB, it was not uncommon for a participant to give an example of something the advisor had done followed by how they themselves would react (in a more "acceptable" way) to the same situation. We did not provide participants with a definition of the phrase "work–life balance," which is highly personal, nor did we ask them for their own definition.

We interviewed participants at one point in time, which limits our analysis to how they are currently making sense of their graduate and postdoc experiences. The meanings they provide might not be how they interpreted events as they were happening, which may have implications for early degree departures, and is a possible area for future work. Their understanding may also continue to evolve over time, especially for those who depart academia and gain life experiences in other contexts, such as government or industry. The four postdoc participants may have had more time to process their graduate school experiences than the graduate student participants. Additionally, postdocs may make self-select to stay in academia to further their chances of obtaining a faculty position. This may explain why there were more postdocs in the *interested* than *disinterested* group. As all of the participants in this study attended R1 institutions, and nearly all talked about faculty careers being tenure-track positions at R1 institutions, our findings may not be generalizable to PhD students from non-R1 institutions.

Recruitment materials advertised the study as investigating how the graduate school experience, including student–advisor relationship, research group climate, and program climate, affects people's career choices. It is possible that participants with very strongly positive or negative experiences were more likely to participate in this study than those with neutral experiences. In order to mitigate this and incentivize participation, it was advertised that participants would be paid for their time.

4 | RESULTS

How do positive and negative perceptions of advisor relationship, advisor WLB, research group climate, and department climate relate to whether participants are interested or disinterested in a faculty career?

To overview our findings and provide a visual summary of the participants' experiences, Figures 2 and 3 present heat maps that compare the experiences of *interested* and *disinterested* participants, and Tables A1 and A2 in the Appendix are screen-reader-accessible versions. Each participant's gender, race/ethnicity, and other salient identities are included in the figures to contextualize their experiences. We show participants' *Social Identities and Personal*

Factors together with the results, as they provide the underlying context and cannot be removed from their experiences. In tandem, all of these experiences influence graduate students' professorial intentions (or lack thereof). Participants extrapolated their graduate school experiences onto how they would experience life as a professor. As seen in Figures 2 and 3, participants in the *interested* group had mostly positive experiences in graduate school, while the *disinterested* participants had notably more negative and neutral experiences. Given this trend, it is difficult to argue that these factors, particularly the advisor as a faculty prototype, do not substantially influence students' professorial intentions.

Of advisor relationship, advisor WLB, research group climate, and department climate, which are most salient when discussing professorial intentions?

In parts of the interview protocol, we directly asked participants how their advisors, perceptions of their advisors' WLBs (AWLBs), and research group, and department climates influenced their career interests. Table 2 reports the number of participants who said each of these influenced their professorial intentions. Three participants also additionally identified the culture of academia as a negative influence on their professorial intentions. The most common factors impacting participants' professorial intentions were their perceptions of their advisors' WLBs, relationships with their advisors, and the culture of academia.

In addition to the high frequencies in Table 2, participants spent significantly more time, went into more detail, used more descriptive language, and used more non-verbal expressions (facial expressions, tone of voice, laughter) when describing their advisor relationships and AWLBs, which we interpret as indicating that their advisors were more influential on overall graduate school and postdoc experiences than their research group or department climates.

What additional influences on professorial intentions do engineering PhD students and postdocs from historically excluded groups identify?

One sociocultural factor that participants identified as influencing their professorial intentions was the culture of academia. Although the interview protocol did not contain questions regarding the culture of academia, three participants—all in the *disinterested* group—commented on it as negatively impacting their professorial intentions.

In the sections that follow, we expand on how participants described advisor relationship(s), AWLB, research group climate, department climate, and the culture of academia and their influences on professorial intentions.

4.1 | Advisor relationship

4.1.1 | Overall advisor relationship

Some participants had strongly positive or strongly negative relationships with their advisors, while others had more neutral or "professional" (Santiago) relationships. Some participants with multiple advisors had vastly different experiences between the two. Monique changed groups and compares her two advisors:

> [My second advisor] is like my hugest champion. Every time we have a meeting, she's like, "[Monique], you're very good at this. I hope you know that, and there are people who will want you," and it's ... very nice to hear after my last group who literally sent an email to our department, he was like, "[Monique] is trash, and these are the ways that she's trash." So, having her after that experience and literally telling me that I could do whatever I want career-wise and that I can is really heartening. (Monique)

Monique's experience with her first advisor was highly negative, and she was fortunate to have found her second and more supportive advisor who had faith in her career goals.

TABLE 2 Number of participants reporting each factor's influence on their professorial intentions.

	Advisor relationship	Advisor work–life balance	Research group climate	Department climate	Culture of academia
Interested participants ($n = 10$)	5	7	0	0	0
Disinterested participants ($n = 10$)	6	6	0	0	3
Total	11	13	0	0	3

Participants had more positive relationships with advisors who met frequently (weekly or biweekly), regularly gave research advice, and were responsive to emails. Participants tended to have negative relationships with advisors who did not meet frequently and did not communicate via email. For example, Enam met with his advisor only three times in the previous year, saying that due to his advisor's lack of involvement in the project, he thought the advisor's name should not be included on his project's manuscript.

4.1.2 | Advisor and advisee social identities and personal factors

Shared (or unshared) demographic identities played important roles in how participants viewed and interacted with their advisor. Participants with same-race or same-gender advisors felt that these similarities positively impacted their relationship by contributing to the advisor's understanding of the student's experiences and struggles. Brianna, an African American woman with an advisor who was an African American man, said:

> I'm sure a lot of my outward acceptance of our relationship has a lot to do with mutual ability, in the fact that he's an African American male. So, I feel like there's always an understanding. We have an understanding regardless of what it is. Regardless of the experiences I have. There's mutual lived experiences, and I think that that really enhances our dynamic [...] not having to explain where the feeling is coming from. You're not talking to someone that can only empathize with you. You're talking with someone that 100 percent gives that sympathy, or at least give that as, "I know where you're coming from 100 percent." I'm not saying that at all to diminish all the other qualities of a good advisor that he has, but that, I believe, has been nothing but a benefit. (Brianna)

The African American identity Brianna shared with her advisor was an important and positive aspect of her graduate school experience. Even when participants had a negative overall relationship with their advisor, demographics could still benefit the participant. Ana, a Latina with a White woman advisor, said because her advisor "is also a woman and an engineer, that has some impact on how I see myself in the future. You know? She's kind of my role model even though our relationship is not the best" and "It would be really cool to be something like this—something like she is."

Even when participants did not share the same background as their advisor, there was a benefit to having an advisor from a historically excluded group. Cruz, a non-binary Latinx student with a White woman advisor, could relate to their advisor being a woman in a male-dominated department and recognizing her struggles. They said, "I know that's something. Like, not me trying to walk in her shoes, but me just being within proximity of that, and like making sure that she has space to share, and then also for me to share, as well."

Conversely, many *disinterested*—but notably zero *interested*—students felt tokenized by their advisor. Maria, a Mexican-American woman unwilling to disclose her woman advisor's race/ethnicity, said:

> [My advisor] had these ideas in her head based on my gender and my ethnicity, and she just passed those down onto me through this advice of like, you have to be perfect or else. So, there was a lot of that ... I felt like a token a lot of times. I cannot even list all of the times where she received some sort of diversity award. She filled out the NSF broader impacts section. It was me blasted all over her statements. I almost felt like she could apply to those things because of me, because there was nobody else that was a minority student in our lab. So, a lot of that. A lot of like, oh, yeah, look at my Mexican student. And then there were some instances of blatant racism, but they were less frequent. (Maria)

Maria felt tokenized by her advisor, as the only minority student in the lab, experiencing racism and microaggressions, and in the hypocrisy of the diversity awards her advisor receives. Tokenizing students happens in different ways with possibly different intentions. In cases like Maria's, advisors sought to take advantage of having a student from a historically excluded background. In other cases, the advisors' intentions were less clear, but participants felt tokenized because of being heavily featured in the photos on their groups' websites or feeling included in a project to "check a box" for federal funding.

4.2 | Advisors' impacts on faculty prototypes and professorial intentions

All but two *interested* participants said that their relationship with their advisor positively influenced their decision to pursue an academic career; conversely, five *disinterested* participants said that relationship dissuaded them, and two said that relationship positively impacted their career interest in national labs. Malik felt encouraged because of his positive advisor relationship, stating, "I see her hard work and her mentorship, and the great work she does definitely has influenced me to help to continue to pursue a professorship." In contrast, Maria's negative relationship with her advisor deterred her from becoming a professor because of her fear of negatively impacting her own potential students:

> The sort of negative role that she played in the picture that I drew in my head about what it means to have power as a professor. And then just never wanted that to be me. So, I sort of realized that although it could be impactful and I could do a lot of good, I could also do a lot of harm without even noticing it. So, that's a little scary for me to think about ... I think she had a lot of power over my emotions, over my work, over my mental state, without having any accountability for it [...] you have an impact over somebody's life. And it could be really, really negative and you don't even know it or you don't even care. (Maria)

Maria intends to be very careful as an advisor not to abuse the power she has over her students, as she has observed in her own advisor.

In addition to professorial intentions, advisors influenced what type of advisor participants would like to be in the future. Ahmed's advisor carefully worked to cultivate an inclusive environment in her research group, which when interviewing for faculty positions, he "pitched as who [he] would be as an advisor," creating a research group climate that is a "family" and "safe space." Even though it did not affect their professorial intentions, *interested* participants also described research group climate (generally, not influenced by their advisor) as shaping their views on how they would run their own research groups.

4.3 | Advisor work–life balance

4.3.1 | Overall perception of AWLB

We coded participants' overall perception of AWLB as positive, negative, or improved over time. The "improved over time" code (three participants in the *interested* group) was unexpected and was primarily associated with advisors who were new assistant professors when the participant began graduate school and had children during the participants' PhD. Participants observed that after their advisors had child(ren), not only did perceived AWLB improve but advisors also encouraged participants to set more boundaries for a "healthy" WLB themselves. When asked about her PhD advisor's WLB (but not specifically about how AWLB influenced her career interests), Lorena succinctly stated: "I want to be like him." Participants with negative perceptions of AWLB were highly negative, including concerns about the number of hours worked as well as the times of day, as previously described. Brianna said, "My perception is that he doesn't have a life."

As participants developed their faculty prototype, their observations of AWLB became part of their picture of life as a faculty member. WLB became a key component of their faculty prototype, the same as observations of how faculty conduct research or teach classes.

4.3.2 | Social identities and personal factors: Family responsibilities

When we asked about their perception of their AWLB, participants frequently mentioned family and children as examples of what "healthy" or "unhealthy" WLB looked like. Participants had both positive and negative impressions about their advisors' family responsibilities (i.e., childcare). Amy perceived that her (man) advisor had a good WLB and took advantage of his flexible schedule to take his children to important appointments. However, Camila and Ana felt that their (women) advisors' childcare duties impacted their advising, canceling, and not rescheduling meetings due to childcare needs or having Zoom meetings but not fully paying attention.

The way that participants spoke about their advisors' family situations was notably gendered by participant (but not by the gender of the advisor). Women participants used the terms "child(ren)" and "kid(s)" more frequently, while men participants favored "family." Participants were asked on the pre-interview questionnaire to indicate whether their advisors had children; we confirmed that the trend is not due to the men advisors less frequently having children. Many women participants anticipated difficulty balancing the responsibilities of a faculty career with having children (only one woman participant had a child). Ana pointed out differing expectations between fathers and mothers, stating that there is no "requirement"—but pressure nonetheless—that the mother is the parent "who provides the help." Even though this has not deterred Ana from pursuing a faculty career, she views it as a future stressor in her life.

4.4 | Perception of AWLB's influence on faculty prototype and professorial intentions

Perception of AWLB was the most common influence on a participant's faculty prototype and desire to pursue or not pursue a career in academia ($n = 13$). Participants who witnessed their advisor maintaining a healthy WLB while having a successful faculty career felt that they could also achieve the same. As Ahmed said

> I think seeing her strike a balance has really helped me realize that I can also strike a balance, and that's influenced me a lot. Because I've always been the type that, I wanna make sure I have family time. I don't wanna go into any career where I have to jeopardize family time. And so, seeing how she's able to sort of manage that has made me feel like I can also manage. (Ahmed)

Ahmed's advisor has what he perceives as a healthy WLB, which gives him optimism that he can achieve the same in his future faculty career. Women participants were especially dissuaded from academic careers when they had an advisor with a negative WLB. As Camila put it, "I think [seeing my advisor's work-life balance] solidified not wanting to be a professor. I wanna have kids ... the clock is ticking ... I feel like it's harder for me to picture a life as a professor with the whole family shebang, too." Steve was the most blunt about how his perception of his advisors' WLBs affected his career interests, stating "Seeing the lives of both of my advisors has dissuaded me from wanting to go into academia." Importantly, seeing their advisor's WLB set participants' expectations about what the WLB must be like for all faculty, even though it was usually only one or two examples.

The single most commonly cited reason that dissuaded participants from academic careers was a lack of boundaries on their advisor's time. Eight of the 13 participants with negative perceptions of AWLB reported that their advisors worked extra hours, including on holidays or vacations, and emailed students outside of normal working hours. Santiago shared multiple incidents where

> if I was working at 2 a.m. and I sent an email out to an advisor, or another professor, or something, I would get a response at like 2 a.m. I would be like, "What? Why aren't you sleeping? You have a family." So I didn't want to put myself in that position professionally. (Santiago)

Receiving immediate email responses from an advisor in the middle of the night was disconcerting for Santiago, who thought that once a faculty member had children, they would not be obligated to work all hours. While Santiago did not comment on why he was working at 2 a.m. as a graduate student or how he felt about doing that, he made it clear that it was not something he wanted to do for the rest of his career. We note that some advisors set clear boundaries by emailing only during business hours and taking vacations. Other advisors who worked a lot acknowledged that even though this was their own standard, they did not expect their advisees to do the same.

4.5 | Research group climate

4.5.1 | Overall research group climate

Participants described the overall climate of their research group as either positive, negative, or neutral, or their groups were too small or not close enough to make a judgment, as shown in Table 3. When looking at what factors are consistent throughout all of the responses, the research climate was most impacted by how welcome, included, and supported

the participants felt in their groups. Things like freely sharing information and resources with peers were mentioned a few times as a positive aspect of their research group, while negative responses were centered around participants feeling like they were not included or supported by their peers.

4.5.2 | Advisor influence on research group climate

Four participants mentioned their advisor's influence on the climate of the research group. Steve spoke about how his advisor set research group expectations for his students to "work together, and do your best, and prioritize your mental health, and take care of yourself." Candice also spoke about how one of her advisors "rigorously" interviewed prospective students and postdocs "both technically and in terms of personality. So, they handpick their students and postdocs. And if they think the candidate will not get along with the group, they don't hire them." As previously described, some *interested* participants' advisors' cultivation of a positive research group climate informed how they wanted to lead their own future research groups.

In contrast, Enam explained how not holding research group meetings led to a negative climate and a complete disconnect from his peers in his research group. He did not agree with the way his advisor managed his group and thought "it would be beneficial [for his advisor] to have some sort of relationship with all [his] students." He also felt like there was a need for his advisor to "foster relationships between students where they could help each other, or hear what other people are working on, and give input ... as opposed to having students all siloed up, and not interacting with each other."

4.5.3 | Research group climate and participant identity

Participants' personal identities played a major role in how they were affected by their research group climate. A number of participants felt that the group climate created a space where some aspects of their identities were not welcome. Monique, a Black woman and low-income, first-generation graduate student, who "would have been the first woman to graduate from that group and definitely the first Black person or maybe the first person of color generally" felt "tokenized." In her case, the lack of a feeling of belonging evolved into a climate of racism and sexism.

> There was an incident where I didn't wanna go to a conference, and one of the research scientists said something to the effect of like, "Well, you're Black and a woman. We wanna be able to show you off at this conference," which might have just been like he was conveying himself poorly and [meant] to say something else. I didn't take it that way, and I was very offended. (Monique)

Interactions like these draw attention to situations when students from historically excluded groups are "the only" one and make tokenizing intentions explicit. These situations were not isolated incidents. Naomi spoke about her time in the labs dealing with "science bros" that she knew "would give [her] a problem" and were a reason she was "dreading the job." She spoke about them being members of her research group who were intimidating and unapproachable for help. Malik won a national fellowship, and a peer made him feel like he only got the award because of his identity. He felt like he was "really pressing on [his] resources, trying to make sure [he] could combat this stereotype," but was encouraged by his advisor to not dwell on "outside noise." Enam was in the minority of students in his research group

TABLE 3 Sample quotes for positive, negative, and neutral research group climates.

Positive	Negative	Neutral
"Inclusive and open" (Malik)	Feeling like an "outsider" (Naomi)	"Fine" (Santiago)
"Supportive" (Juan)	"Didn't feel like I fit in" (Candice)	"Cordial" (Jamal)
"Everyone's aware of all the different projects going on" and everyone knows "whom to reach out to if there's a resource or a question that [they] have within [their] lab." (Brianna)	"Hard to navigate," "tense" (Camila)	

who did not speak the same (non-English) language, so he felt like he could not build relationships with his peers and advisor when they excluded him from conversations.

Candice felt disconnected from her peers in her research group and felt like that was due to close-mindedness centered on her being in a male-dominated department and group.

> I think I was the only woman in the group. So, I didn't feel—except for talk[ing] to my advisor, I didn't feel as connected to my labmates in the beginning of my grad school. And I think engineering students can be very rigid if they wanna be, or not open-minded. (Candice)

Being the only woman in her research group was isolating enough, but Candice suggests that the men in her group were so used to being in the majority that they lacked open-mindedness to other ways of interacting and doing research. Stories like these affected a number of the women participants, and especially women of color. Participants who felt excluded culturally spoke a lot more negatively about their research group, while minoritized participants who were in research groups with minoritized advisors or diverse peers spoke more positively about their research group even if they were not part of the same identity group.

4.6 | Department climate

A graduate student's or postdoc's primary interface and context to their institution or college of engineering is through their department.

4.6.1 | Overall department climate

Department climate had substantially less impact on participants than direct interactions with their research groups and advisors. Most descriptions of their department climate were vague, with most participants referring to interactions with peers during coursework or interactions with faculty and staff outside of their research. Monique had a positive experience with her department head when changing research groups, but "never really got the feeling of what [her] department's culture was." Christine called her department "overall ... healthy" but said the two programs in her department were "disjointed." Steve felt "pretty accepted" and had "pretty good relationships with almost all of the students" from his department. Rosa described her department as "super nice" and "a good place to talk about what [she and other students] want to do, and [her department] will always look for tools for [them] to achieve those things."

Santiago was working in a more specialized area of research and felt like he did not necessarily belong in his department. He described the climate as a place where students "exist outside of the department" and "kind of do [their] own thing." Ana emphasized that the separation and competitive climate seen at her department level led to missed opportunities to improve their research.

> I think they are very competitive ... So, it's more like each group does whatever each group is doing. And sometimes you can tell that the research is overlapping between the groups. And I am sure that it will be much [quicker] if we work together and if we unite and put some of the methods that we use together. But you don't see that much cooperation between the professors in the department. And I think that's something that could be improved. (Ana)

The competitive department climate was not only isolating to Ana but it was also unnecessarily inefficient and missed opportunities for innovation. Candice transferred departments for her postdoc because of the negative environment she experienced.

> As I had alluded to, it's not as friendly as other departments in terms of I think towards women, and also towards people doing work that's not traditional. So, I would say [my previous] department is very traditional. So, if anything is out of the tradition, people are very uncomfortable with the idea ... I think [those in my new department are] relatively open-minded, and positive, compared to the [previous] department. (Candice)

Candice was much happier in a department whose climate was more accepting of her less traditional research area. Camila also spoke about her department culture not being supportive of some research areas. She said, "I can see amongst the faculty, there is a lot of tension," with her takeaway from that tension being "I don't think that I like that culture." Juan mentioned that the culture in his second department led to some students leaving their groups. He also spoke about the lack of faculty diversity, saying that it was a "bit challenging to find support within that department."

4.6.2 | Department climate and social identities and personal factors

When speaking about department climate, a number of participants referenced diversity initiatives and issues they experienced in their departments. Naomi, a White and Native woman, perceived that "the [qualifying exam] failure [rate] of non-White, non-male people is much higher than it should be" in her department. She noted that the statistics were not tracked, but she saw a trend and heard similar perceptions from her peers.

Monique spoke about not making connections with others in her department. She felt "alone" and "like the only" Black woman in her department. When asked if his department climate influenced his desired career path, Steve acknowledged that he benefits from being a White man:

> Not really. I don't think so. I guess also for me, I'm White and a male, so the climate is kind of beneficial for me. I don't have to face some of the different barriers other people have. So, I could see how some people might be discouraged from pursuing a career. I mean, [my field] also is a very White and male career field. So, I could see us being like a woman in STEM or a non-White person in STEM, how it could be more intimidating, and might discourage somebody. But I don't think it's really affected me personally at all. (Steve)

Notably, he did not describe his bisexuality or disability status as having any impact on his perceived benefits from being a White male in STEM.

Ahmed, a Black man, described his department's attempt to have a dialogue in the aftermath of the murder of George Floyd as "done in a weird way ... an unnatural, uncomfortable conversation" because "no one really talks about the fact that I'm the only Black student in the whole department, or why that is, or what we can do to be better about that." Malik, another Black man, similarly interpreted his department's reaction to the George Floyd murder as "performative allyship." He felt like they had an outward appearance of caring, but he had some "doubts" about their authenticity.

Some participants found community outside of their departments in identity-based groups. This included professional organizations, such as the National Society of Black Engineers (NSBE); organizations for graduate students from specific countries, such as one institution's Colombian grad student association; and internet-based groups, such as the LatinXinBME Slack group.

4.7 | Culture of academia

One additional influence that participants identified was the culture of academia. Through their interactions with their advisors and others in their field, participants formed an idea of what academia is like and decided that it was not a system of which they wanted to be a part. This was mentioned by three participants. As Enam put it,

> I don't like the nature of academia. I think a lot of emphasis is put on academic bean counting, if you would. Your h-index has to be this, you have to produce these many papers to graduate. I think that that pressure sometimes tends to get in the way of good research, and that there isn't a lot of room for design-based research, which could take a lot more time than going to a lab and running an experiment and getting results. So, that definitely is one reason why I'm leaning the other way from academia. (Enam)

To Enam, the culture of academia was not consistent with what he most enjoyed about research.

Christine, who strongly identified with being a mother, was initially the most interested in a faculty career of all the participants in the *disinterested* group, going as far as attending a preparing future faculty workshop and applying to

and interviewing for faculty positions. However, once the COVID-19 pandemic began, she saw that nearly everyone in a nationwide online support group for mothers in academia felt unsupported by their institutions.

> I feel like I watched first-hand the academic system just completely shit on parents everywhere ... I just watched these glaring inequities. And not just caregivers' issues in academia, but all sorts of things just grow what felt like exponentially, and watching people suffer and complain about how the academic system is not doing anything to help them. (Christine)

Christine's faculty applications were derailed by the COVID-19 pandemic, with interviews canceled and a verbal offer rescinded as a result of hiring freezes. Despite encouragement to re-interview, she has decided to pursue a career at a national laboratory.

Though not dissuaded from faculty careers, *interested* participants were aware of DEI issues in academia and how their identities would impact their future experiences as faculty members. Lorena spoke about how applying to faculty positions, especially writing her diversity statement, caused her a lot of anxiety. She felt that candidates from "diverse backgrounds" should not have to write a diversity statement, going as far as calling diversity statements "trauma porn." Faculty members from historically excluded groups are often called upon to do service at higher rates than their peers from majority groups (Griffin, 2012; Trejo, 2020; Wimsatt et al., 2009). *Interested* participants were aware of this "diversity tax," and it was one of the common concerns about becoming a faculty member. Malik said the diversity tax was the "number one" obstacle he perceived he would face as a faculty member, as service is not as highly valued as research in the tenure and promotion process of his targeted institutions, and while he wanted to do service and outreach, he needed to do it in a way that allowed him to balance his research and teaching.

5 | DISCUSSION AND IMPLICATIONS FOR RESEARCH

We used prior research to build a theoretical framework focusing on four influences on professorial intentions: advisor relationship, advisor WLB, research group climate, and department climate. Three participants additionally identified the culture of academia as an influence. When asked directly, participants credited only their advisors and culture of academia, but not their research groups or departments, as influencing their professorial intentions (or lack thereof). Yet, summary Figures 2 and 3 show that participants in the *interested* group had mostly positive experiences in graduate school, while the *disinterested* participants had notably more negative and neutral experiences. Given this trend, it seems that these factors, particularly the advisor as a faculty prototype, are correlated with students' professorial intentions. What is less clear is why, for the *disinterested* participants, there was such a high co-occurrence of negative or neutral experiences, although arguments can be made for the climate at one level influencing other levels. As mentioned, all but one of the *disinterested* participants (Amy) were previously interested in an academic career, and their experiences in graduate school dissuaded them from pursuing one, causing them to leave the academic career pathway. Notably, Amy was the only one of the *disinterested* participants who had positive experiences in all four categories. When asked whether her positive experiences had made her rethink an industry career in favor of an academic one, she replied, "Being in graduate school has reaffirmed that I do not want to be a professor at all." In contrast, several of the *interested* participants had positive experiences in all four categories. The one postdoc in the *disinterested* group, Santiago, was completing his postdoc with the same advisor and research group as his PhD to continue the work that he was doing. The three postdocs in the *interested* group all changed advisors; two of the three changed institutions. It is not surprising that the *interested* group contained more postdocs than the *interested* group, as postdocs have become an unspoken requirement for a faculty position and receive significantly less pay than an engineering industry job.

This study found ample support for the concept of faculty prototype (Bieber & Worley, 2006; Burt, 2019). Study participants extrapolated their experiences, both positive and negative, in graduate school and postdoc to how they expected to experience life as a tenure-track faculty member. The most influential factor for participants' professorial intentions is their advisor, who serves as the primary—and in several cases, only—role model for their faculty prototype. Since graduate students often have just one advisor, they closely observe only one example of what it may take to be successful in academia. Then, these graduate students envision that they must emulate their advisor's professional and personal behaviors to attain the same level of success, a perception that heavily influences their professorial intentions. Advisor relationship had additional influence beyond a student's professorial intentions. *Interested* participants

noted that their experiences in graduate school, particularly their relationships with their advisor, have influenced their future advising style, in agreement with previous studies (Delamont et al., 2000; Lee, 2008).

While we expected to find that one's advisor would influence professorial intentions, we were not expecting the degree to which perception of advisor's WLB did. WLB was one of the most influential components of faculty prototype development. This is in contrast to TMEPI, which did not find that WLB informed one's faculty prototype but is rather just a part of the social identities and personal factors less central to that model. Our graduate student participants tended to define WLB as not working all the time. We realize the COVID-19 pandemic had played an important role in our participants' experiences in graduate school, as we conducted these interviews during the summer and fall of 2021. Not only did the pandemic affect how participants conducted research and interacted with their advisors, peers, and other colleagues, it also affected how their advisors managed their own time in terms of work and family care responsibilities. The pandemic's influences on graduate students and faculty parents exacerbated already existing difficulties in maintaining a healthy WLB, with junior faculty and women faculty with young children reporting higher work and home stress than senior faculty and men faculty without children (Kotini-Shah et al., 2022). An interesting direction for future work might be a more direct comparison of faculty and graduate student perceptions of WLB in faculty careers post the pandemic.

The next most influential factor on professorial intentions was participants' perceptions of the culture of academia, which prior studies have found (McGee, Naphan-Kingery, et al., 2019). No interview questions directly probed this; nevertheless, three participants still indicated that a negative perception of the culture of academia directly and negatively influenced their professorial intentions. The participants who commented on the overall culture of academia as "bean counting" and not family-friendly were all in the *disinterested* group. Additionally, although not an influence on professorial intentions, *interested* participants were aware of the "diversity tax," or disproportionate service burden, on faculty from historically excluded groups and perceived this as a challenge they would have to address in their careers.

In contrast with Burt's (2019) study that led to the development of the TMEPI, we found little direct evidence that research group influenced professorial intentions. This may be due to the perspectives of Burt as an ethnographer and experienced education researcher versus students experiencing one or a few research groups. Additionally, our participants perceived that their advisors had little influence on the climate of their research group: only four participants mentioned their advisor affecting the group climate. We note that, as illustrated in our heat maps, there are only a few instances of advisor relationship and research group climate not aligning as both positive or both negative. It is possible that the students were unaware of faculty efforts to cultivate research group climates, and that some advisors themselves were unaware of how they influenced group climate through their actions and expectations. Nonetheless, our participants reported a wide range of inclusive, exclusive, and non-cohesive research group climates, including some individuals who discussed contrasting climates of multiple groups of which they had been members. While it did not appear to be a key factor in career interests, we note that nearly all *interested* participants reported positive experiences in their research groups.

The sexism, racism, and tokenization frequently mentioned in our interviews are unfortunately not new for graduate students from historically excluded backgrounds (Burt et al., 2016; Fabert et al., 2011; McGee, 2021; McGee, Griffith, & Houston, 2019; Perkins et al., 2020). In engineering education research, such negative experiences are often discussed in the context of student retention or early degree departures (Crede & Borrego, 2013; Litzler et al., 2005). Here, we extend the analysis of these experiences to the workforce by examining the relationships between a student's advisor, research group, and department to their intention to pursue or not pursue an academic career. Our participants with one historically excluded gender or racial/ethnic identity discussed the ways in which that single identity impacted their experience, often negatively. Participants with multiple marginalized identities, such as women of color (including first-gen and/or low-income), first-gen men of color, and a queer student of color, reported ways in which single identities (being a woman, being Latinx) impacted their experiences as well as how having intersectional identities compounded an already difficult experience. The diversity of participants' backgrounds enabled a more intersectional examination of how their professorial intentions are shaped by their social identities and how these influence their graduate school experiences.

It was not our intention to compare the responses of postdocs to graduate students, and most of the interview protocol focuses on graduate school experiences. Owing to the nature of many postdoctoral positions being in a different research group to learn new skills, three of the four postdocs we interviewed were in a better position to compare various advising styles, AWLB situations, and research group climates. They may have a better sense of the possible variations in how they advise their future students and run their future research groups. Although postdocs have more opportunity to experience more research environments, we note that only those with at least partially positive graduate

school experiences will persist to the postdoc stage to prepare for a faculty career. Santiago, the only postdoc we interviewed who was disinterested in a faculty position, was continuing his same line of research in the same group, which he described as having a "professional" research group climate that was "fine."

International students reported unique experiences as compared to domestic students. In our study, the participants on international student visas were from Africa and Latin America. As found in our previous work, high percentages of Black/African American and Hispanic/Latino PhD earners hold undergraduate degrees from a non-US institution (29% and 55%, respectively), and there is a need to discuss how these students fit into conversations about DEI as it relates to recruiting diverse faculty (Fleming, Patrick, et al., 2023). When considering what "counts" as representation, where do these students (and, later, faculty) belong? Does seeing a professor who "looks like them" (Newman, 2015) help students envision themselves as a professor if the professor shares a skin tone but not the same lived experience? This answer might be different for non-US-born Black/African American or Hispanic/Latino engineers. Black/African American students may have had ancestors forcibly brought to the United States as a part of the slave trade, and therefore their connections could be different than they are for Hispanic/Latino students, whose parents or grandparents might have willingly immigrated to the country. International students from African and Latin American countries, like Enam, Rosa, and Ana, occupy a unique place in engineering graduate education. While their experiences in their countries of origin were much different, non-US-born Black engineering graduate students experience some of the same feelings (racialized impostorism, feeling "othered") as those who are US-born (Burt et al., 2017). While less has been written in engineering about Latino/a/x graduate students experiencing complex racialized dynamics upon immigrating to the United States, research on Latin American international undergraduate students shows that they experience acculturative stress (psychological distress due to adjusting to a new cultural environment; Constantine et al., 2004; Wilton & Constantine, 2003). Future research is needed to understand the experiences of Latin American international graduate students in engineering.

In sum, this work identifies several directions for future research. Given the strong influence of perceived AWLB and the single perspective of our participants, future research should compare faculty and graduate student perceptions of faculty WLB. Highlighting possible disconnects between what advisors think they are conveying to their students and the implicit messages these students receive might uncover new strategies for advisors to be more intentional about the expectations of a faculty career. Although not directly related to faculty careers, we were unable to connect our findings to prior research on the experiences of Latin American international students in engineering, a gap in the research. The racialized experiences of international students of African descent are much better understood. Future research is also needed to explore how multiple factors contribute holistically to the professorial intentions of engineering PhDs from historically excluded groups. Our participants were interviewed at one point in time while still completing their PhDs or postdocs. It is possible that, if interviewed a few years after graduation, PhD graduates will have had more time to reflect on their graduate school experiences and effects on their decisions to pursue or abandon previously held professorial intentions. Furthermore, there is an opportunity to further investigate the postdoc experience by conducting postdoc-centric research on this topic.

6 | IMPLICATIONS FOR PRACTICE

The results of this study have implications for graduate students, faculty, and departments. A key takeaway for students is the importance of finding a supportive advisor who will help them thrive during graduate school. Many students consider program reputation (Bersola et al., 2014), their funding offer, and "fit" in a department when considering where to attend graduate school (Kennedy et al., 2016). While these are valid considerations, we urge students to carefully consider the advisor they select, given this person's tremendous influence on many aspects of a student's career including whether or not they pursue a faculty position. Students should speak with a prospective advisor's current or former students, particularly those with similar backgrounds, to learn about group culture, WLB for the advisor and group members, and how the advisor treats their students. For students choosing between advisors at a given institution, we recommend considering factors beyond common research interests. Rotational programs in which first-year graduate students spend time in with a few different research groups is one potential mechanism mentioned by a participant.

Faculty advisors are the most important factor for PhD students developing a faculty prototype against which to compare their own desire and ability to pursue a faculty career. However, there is often little oversight by departments or institutions on how faculty mentor graduate students or training for how to be an inclusive mentor. In one study,

the most common skill early career faculty reported feeling lacking in preparation for was how to mentor graduate students (De Welde & Laursen, 2008; Laursen & Rocque, 2009). More open conversations among faculty of how they advise graduate students may be a good first step to begin ongoing discussion about inclusive mentorship. Inclusive mentorship involves centering the mentee and their goals (which is sometimes at odds with the advisor–advisee relationship in graduate education); getting to know mentees as people with identities, experiences, and goals beyond academic and career success; growing as a mentor and a person as you learn more about different people and their backgrounds and experiences; and being dynamic and flexible to the needs of the protege. Faculty can demonstrate a high degree of care for their advisees by cultivating a nurturing relationship, caring about their students outside of the classroom and research lab, and advocating for students when talking with other faculty (Burt et al., 2021). Departments should research on how to inclusively mentor students, especially women (Chesler & Chesler, 2002), students of color (Griffin et al., 2020), and first-generation students (Wofford et al., 2021). In addition to having good communication with students, advisors should be accessible, interested in their students' projects, and adaptable to their students' needs (De Welde & Laursen, 2008).

Advisors and other faculty need to be aware of how their actions may come across as tokenizing to their students. Our participants reported a range of experiences that made them feel tokenized, including being singled out in an advisor's grant proposals as evidence of broadening participation, featured in all of the photos on a research group's website, and expected to speak on behalf of a racial/ethnic group at department events about racial injustice. First, faculty need to realize that DEI efforts go beyond advising a student from a particular background. When looking for items to include for broadening participation in grant proposals, faculty should consider joining existing activities in their department or institution. At the very least, these proposals should be shared with the students who are being written about for transparency and to negotiate respectful descriptions. Second, in order to make students feel less like the "poster child" of the research group, faculty should make an effort to feature all group members equally on group websites and allow them to choose where in the photo they are located; photographers should not actively position people front and center who do not wish to be featured that way. Third, rather than expecting a student to speak at a DEI event, administrators should consider hiring an external speaker or facilitator who is a subject-matter expert. This is not an exhaustive list of recommendations to avoid tokenizing students, and faculty should reflect on their own practices of how highlighting their students might be inadvertently tokenizing them.

Faculty who advise graduate students should be more aware of how their work habits and WLB may be perceived by students. They should set working hours and communicate to their students how to contact them and how soon they can expect a response. Advisors should refrain from emailing or texting students after business hours; if necessary, they should learn to use tools to schedule messages to be sent at more reasonable times. If they must work at odd hours, such as when children are sleeping, faculty might focus on projects that do not include a lot of correspondence. Even disclaimers that one does not expect people to respond immediately may not be taken at face value by those over whom the writer has power, including graduate advisees. Faculty can be open with their students about how they navigate work travel, such as taking an afternoon off from a conference to explore the city or bringing family along to enjoy a few days of vacation. They can mention how other faculty colleagues at different career stages and with different family situations handle these considerations, especially if they take more time off than the advisor does. Even when students are told that they are not expected to work the same hours as their advisor, advisors must recognize that this may or may not affect graduate students' perceptions of their expected working hours and thus influence their faculty prototype and career decisions.

Departments also need to be aware of the impact that they have on the student and faculty DEI experiences, which are important to PhDs from historically excluded groups' willingness to stay in academia. DEI efforts at the department level impacted participants significantly more than those at the university level. Participants cited department-level DEI efforts, such as student involvement in admissions committees, undergraduate research opportunities for diverse students, and specific affinity groups, as having a positive impact. However, there can also be a negative impact if these efforts are not executed in collaboration with people from historically excluded backgrounds. Hiring more diverse faculty members will lessen the "diversity tax," or undue service burden, placed on faculty from historically excluded groups. Such faculty, particularly when they are the "only" in their department, end up disproportionately serving on diversity committees and providing largely unrecognized mentoring to students of color (Newman, 2015), a fact which *interested* participants were well aware of. Cohort hiring is an underused, but effective way for institutions to make positive strides to increase the number of historically excluded faculty in engineering (Tran et al., 2020).

7 | CONCLUSION

There is a persistent and alarming lack of diversity in the engineering professoriate, which can be traced in part to PhD earners from historically excluded groups being dissuaded from academic careers at higher rates while they are graduate students and postdocs. The current study bridges two distinct lines of research (persistence decisions of historically underrepresented graduate students and pressures of faculty life on parents of young children) to describe how graduate students' experiences and perceptions of their advisors' WLB influence their decisions to pursue or not pursue a faculty career. Participants extrapolated their experiences in graduate school to how they imagine their lives as faculty. Decisions to pursue or not pursue a faculty position were also influenced by the participants' relationship with their advisor and perceptions of the culture of academia. Given the wide variation in research group climates and advisor relationships, graduate schools and departments should increase oversight and training in inclusive mentoring of graduate students. If we are truly serious about diversifying the engineering faculty, those in leadership positions must look beyond the most immediate step in the faculty hiring process (recruiting and hiring) and examine how our graduate education practices contribute to the broader systemic issue of interested PhD earners leaving the academic career pathway, as well as the culture of academia which pressures faculty into WLB perceived by students as unreasonable.

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APPENDIX

Interview protocol

1. What are your current institution and status (graduate student/postdoc year)?
2. What are your gender and race/ethnicity identities? Do you have other salient identities (e.g., sexual orientation, physical/mental disability status, first-gen status, citizenship) you would like to share?
3. Where did you go to undergrad? What was your motivation to attend graduate school?
4. When you entered graduate school, what type of career(s) were you interested in?
5. How do you feel now about a faculty position/other career?
6. How has your thinking/enthusiasm/motivation for your career option(s) changed over time?
7. Why are you interested in your chosen career path?
8. Describe your relationship with your PhD advisor. Has this influenced your desired career path, and how so? Demographics of advisor?
   a. What is your perception of your PhD advisor's work–life balance? Does this influence your desired career path? Do you want the kind of job your advisor has? Why/why not?
   b. What advice does your PhD advisor give you about your suitability and preparation for your desired career path?
   c. Are there some aspects of your plans you don't feel you can openly discuss with your PhD advisor? (which ones)
   d. What other people have significantly influenced your desired career path during graduate school? (and how)
9. What is the climate like in your research group? How has this affected your desired career path(s)?
   a. Climate of your department/program?
10. How have aspects of your personal identity (e.g., race/ethnicity, gender, sexual orientation, disability status) affected your graduate school experience?
    a. How have they affected your interactions with other students?
    b. How have they affected your relationship with your advisor?
    c. How have they influenced how you feel you "fit in" with your department?
    d. How have they influenced your desired career path?

If not yet postdoc: do you plan to do a postdoc? Why?

Postdoc section (if applicable):

11. Why did you choose to do a postdoc?
12. Describe your relationship with your postdoc advisor. Has this influenced your desired career path, and how so?
    e. What is your perception of your postdoc advisor's work–life balance? Does this influence your desired career path? Do you want the kind of job your advisor has? Why/why not?
    f. What advice does your postdoc advisor give you about your suitability and preparation for your desired career path?
    g. Are there some aspects of your plans you don't feel you can openly discuss with your postdoc advisor? (which ones)
    h. What other people have significantly influenced your desired career path during your postdoc? (and how)
13. What is the climate like in your research group? How has this affected your desired career path(s)?
    a. Climate of your department/program?
14. Overall, would you say your experience in grad school or your postdoc has influenced your career interests more? Why?

For interested participants:

15. What are the biggest challenges you think you will face during the application process? Overall thoughts/feelings on the application process?
16. What obstacles do you perceive you will face as a faculty member?

Tell me about your experience with the faculty application process.

How did you decide which universities to apply to? Types of universities?

For disinterested participants:

17. Did you ever consider a career as a faculty member? Why are you not interested in it?
18. Was there a specific incident where you realized you didn't want to become a faculty member, or was it gradual over time?

If have applied for faculty position before:

19. Tell me about your faculty application process.
20. How did you decide which schools to apply to?
21. Did this experience make you change your mind about a faculty position? What factors led you to change your mind?

TABLE A1 Screen-reader-accessible version of Figure 2: Participants *interested* in faculty careers.

Pseudonym	Participant gender	Participant race/ethnicity	Participant other identities	Advisor relationship	Advisor work–life balance	Research group climate	Department climate
Malik	Man	Black: African-American descent		I, +	I, +	+	+
Lorena	Woman	Hispanic/Latina (Puerto Rican)	Disability	+	+	+	+
				+	+	+	+
Rosa	Woman	Latina (Colombian)	Disability	+	+	+	+
Brad	Man	White/Caucasian	First-gen student, married, father	N	N	+	+
				+	+	+	+
Ahmed	Man	Black/African American (refugee and naturalized US citizen)	First-gen student	+	I, +	+	−
Juan	Man	Latin, mixed-race	Married	N	+	+	L
				+	+	+	−
Candice	Woman	Asian (Korean)		+	+	−	−
				+	I, +	+	+
				+	−	+	+
				+	+	+	+
Brianna	Woman	African American		+	−	+	−
Jamal	Man	African American and Caucasian	Married, father	−	−	N	N
				+	+	+	N
Ana	Woman	Latin descent (Colombian)		−	−	+	−

Note: Positive (+), positive after improving over time (I, +), negative (−), neutral (N); "limited interactions" with research group or department (L).

TABLE A2 Screen-reader-accessible version of Figure 3: Participants *disinterested* in faculty careers.

Pseudonym	Participant gender	Participant race/ethnicity	Participant other identities	Advisor relationship	Advisor work–life balance	Research group climate	Department climate
Amy	Woman	Asian, White	Married	+	+	+	+
Christine	Woman	White	Married, mother, disability	+	+, −	+	+
Enam	Man	African (Ghanaian)		+	+	−	N
Santiago	Man	Hispanic/Latino	First-gen student	N	−	+	L
Cruz	Non-binary (he/they)	Guatemalan-American	First-gen student, first-gen American, queer	−	+	+	−
Camila	Woman	Hispanic/Latino	First-gen	+	−	−	N
Steve	Man	White	Bisexual, disability	−	−	L	N
				+	−	+	N
Monique	Woman	Black American	First-gen grad student, low-income	−	−	−	+
				+	−	+	+
Maria	Woman	Mexican-American	First-gen, low-income	−	−	+	−
Naomi	Woman	White and Native		+	−	−	−

Note: Positive (+), positive after improving over time (I, +), negative (−), neutral (N); "limited interactions" with research group or department (L).