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TURNED OFF FROM AN ACADEMIC CAREER: ENGINEERING AND COMPUTING DOCTORAL STUDENTS AND THE REASONS FOR THEIR DISSUASION

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ABSTRACT

Aim/Purpose	We sought to understand factors that dissuade engineering and computing doctoral students in the United States from pursuing a career in the professoriate.
Background	Many PhD students start the doctoral process excited about the possibility of becoming a professor. After a few years of doctoral education, however, many become less interested in academic careers or even come to loathe the idea of a faculty position.
Methodology	Participants in a larger study (N = 744) completed a comprehensive survey about their educational experiences and career aspirations. This study focused on a subset of these respondents (n = 147), who indicated they did not want to pursue faculty positions and explained their reasoning with a brief open-ended response. We coded these open-ended responses.

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Contribution	We found a general lack of interest in the professoriate and disgust over the associated pressure-filled norms and culture; this aversion is the article's focus. Respondents were critical of institutional norms that emphasize research (e.g., stress related to grant writing, publishing, and promotion as junior faculty) and described their own experiences as PhD students.
Findings	Findings support rethinking the outdated faculty model and interchanging it with healthier and more holistic approaches.
Recommendations for Practitioners	These approaches might include advocating for and emphasizing the contributions of research, teaching, and professional excellence as well as removing the secrecy and toxicity of tenure and promotion that discourage individuals from becoming the next generation of engineering and computing educators and knowledge makers.
Recommendations for Researchers	Future researchers should explore in greater depth the extent to which junior faculty's experiences in the professoriate influence doctoral students' and postdoctoral scholars' attitudes toward working in academia. To the extent that this is the case, researchers should then explore ways of improving faculty experiences, in addition to improving doctoral students' experiences that are unrelated to their socialization.
Impact on Society	Having a deeper understanding of the reasons why some doctoral engineering and computing students are uninterested in the professoriate is critical for removing barriers toward becoming faculty.
Future Research	Researchers should explore the factors that would improve doctoral students' perceptions of the professoriate, and better understand how they might disproportionately affect members of historically underrepresented groups.
Keywords	doctoral programs, engineering and computing, academic careers

INTRODUCTION

When Ph.D. students begin a doctoral program in the United States (U.S.), they get an up-close look at academic faculty life. Doctoral students today are socialized to understand that most contemporary faculty positions require a wider array of capacities than what was expected of prior generations, because expectations for scholarly productivity have increased at a rapid pace (Gonzales, 2013; Gonzales, Martinez, & Ordu, 2014). The tenure-track research faculty path subjects new faculty members to persistent stress, grueling workloads, funding inequities, intense pressures to perform consistently at one's highest capacity, and tenure uncertainty (DeMillo, 2011; Larson, Ghaffarzadegan, & Xue, 2014). Given the strains on today's faculty, this paper explores the primary reasons why a group of engineering and computing doctoral students and postdoctoral researchers in the U.S. are not attracted to pursuing academic research and teaching careers.

Doctoral students' experiences across disciplines and around the world have been the focus of a significant body of research. In particular, scholars have investigated why some of the highest achieving and most successful doctoral students have such high dropout rates (Wollast et al., 2018). In fact, doctoral degree seekers in the U.S. have the lowest rate of degree completion (estimated at 50%) (Golde, 2000) compared to all other degrees (Ampaw & Jaeger, 2011). Investigations into these low completion rates have revealed variation by a number of factors, including demographic characteristics such gender, nationality, and age (Groenvynck, Vandevelde, & Van Rossem, 2013; Wright & Cochrane, 2000), funding (e.g., Ampaw & Jaeger, 2011), and prior academic achievement (Wright & Cochrane, 2000). Although this research has broadened prevailing understandings of doctoral stu-

dents' experiences, and in many cases transcends disciplines and geographic borders, important questions remain. Namely, less attention has been given to understanding the factors that influence doctoral students' career choices. Thus, in the current study we explore why doctoral students and recent graduates are disinterested in academic faculty careers. We explore the perceptions and observations that engineering and computing doctoral students and recent graduates have about being a faculty member that dissuade them from pursuing a career in the professoriate.

The context of this study is important. Although many science, technology, engineering and math (STEM) education researchers focus on mathematics and science education (Burt, Williams, & Palmer, 2018; Eglash, Gilbert, & Foster, 2013; Ladner & Israel, 2016; Niemann & Sanchez, 2015), we are part of an emerging group of researchers who focus more on the E (engineering) and T (technology/computing) in STEM. Although we explicitly discuss engineering and computing Ph.D. students and recent graduates in this paper, we are by no means suggesting that our findings are not applicable to most of the STEM and some of the non-STEM doctoral processes across U.S. universities. However, we desired to research two disciplines that have significant departmental and cultural overlap – engineering and computing – as computing disciplines are often housed in engineering departments and share similar curricula (e.g., computer science and software engineering, electrical engineering, and computer engineering). Engineering and computing fields are critical to solving some of the world's most urgent health, technological, and environmental problems. As a promising answer to many of these problems, these fields are fast-growing and face a great deal of international competition, meaning academic researchers today work in a culture of accelerated knowledge production and face increasing demands of producing greater quality output in less time (Müller, 2014). We are concentrating on trainees in engineering and computing fields in the U.S., the most popular destination for internationally mobile graduate students in science and engineering worldwide (National Science Board [NSB], 2018). Because this study focuses specifically on doctoral students in engineering and computing departments in the U.S., it is important to contextualize the environment this group of students face during and following degree completion.

Doctoral students in U.S. engineering programs face a markedly different job market than the landscape that greeted the aging majority of current tenured faculty when they began their careers (Wulf & Fisher, 2002). Over the past 40 years, the proportion of science and engineering doctorates of all doctorates earned has increased from 58% in 1974 to 75% in 2014 (National Center for Science and Engineering Statistics [NCSES], 2017) along with increases in the number of international science and engineering doctoral degree recipients trained in the U.S., who, in 2014, were 55% of engineering doctorate recipients in the U.S. (NSB, 2018). In the meantime, the proportion of full-time tenured faculty positions has decreased (from 90% of all types of faculty positions in the 1970s to 70% today), as academia has increasingly relied on non-tenure-track full-time or part-time positions (e.g., teaching practice faculty and adjunct faculty; NSB, 2018). Along with increased competition for faculty positions due to supply and demand imbalances, recent research shows that only one fourth of institutions – those considered the most prestigious and elite in the nation (e.g., Ivy League and flagship public universities) – account for 71% to 86% of all tenure-track faculty hires across disciplines (Clauset, Arbesman, & Larremore, 2015). Therefore, it is not unreasonable for a significant proportion of today's doctoral students and postdoctoral scholars to question the viability of a tenure-track research faculty career.

The competitive landscape of academe may explain why smaller proportions of doctoral recipients in the U.S. are employed in academia (and government), while greater proportions are employed in business and industry (NSB, 2018). The National Science Foundation's 2015 survey of doctorate recipients reported that only 14.4% of engineering Ph.D. graduates had definite employment commitments in academia, while 72.1% had definite commitments in industry or business (NCSES, 2016). Furthermore, a number of engineering doctoral recipients may find industry jobs more attractive because of the relatively higher pay. Based on the 2015 Survey of Earned Doctorates, the median

salaries for engineers who earned their doctorates in 2010 in industry and academia are $100,000, and $62,000, respectively (NCSES, 2018).

The competition for academic positions, the quality of other employment possibilities, and the skewed hiring process privilege certain applicants (e.g., from prestigious institutions) limit the diversity of life experience that is critical within engineering and computing education to drive cutting-edge creativity and innovation in the broader field. Still, research shows that many STEM doctoral students pursue their degrees with the intention or at least the possibility of becoming faculty members. In a study of 469 biomedical science doctoral students at a large research-intensive university in the U.S., Fuhrmann, Halme, O'Sullivan, and Lindstaedt (2011) found that 93.2% of the participants were strongly considering research careers (including academia, government, and industry), with 72% strongly considering a traditional academic faculty research path. However, 71% of participants were *also* strongly considering non-research-focused positions outside the university (e.g., policy, law, science writing). Thus, in many cases, doctoral students in engineering and the sciences enter graduate programs with strong interests in research faculty careers but express openness to other possible career paths. Although common explanations for Ph.D. students' discouragement from pursuing academic careers often focus on labor market constraints (i.e., a limited number of tenure-track research faculty positions are available), Roach and Sauermann (2017) found that declining interest in academic jobs is not due to expectations about the labor market, but rather a misalignment between students' preferences for specific job attributes and their perceptions of the academic careers. During their Ph.D. programs, students come to realize that academic "research" is less hands-on than they expected, and more time is dedicated to tasks such as administrative functions and communicating research findings to external audiences (Hackett, 2016; Tierney, 1997). Consequently, what doctoral students observe and experience during the Ph.D. process has great potential to shift their career goals from one path to another.

In a larger survey that we conducted on the career interests of engineering and computing doctoral students and recent graduates (from which data for the current study were drawn), about 1 in 5 respondents reported they were not open to the possibility of pursuing a career in academia at any point in the future. Considering the constraints of the academic job market, we do not argue that all doctoral students and postdocs should be interested in pursuing academic careers. At the same time, we suggest that it is important to understand why such a sizeable portion of engineering and computing Ph.D. students and postdocs in our study are uninterested in faculty careers. While some students may simply be attracted to alternative career paths or feel their personality does not "fit" into the academic lifestyle, others are turned away from academia after learning through their doctoral socialization process that it is in fact an undesirable career option. We found that of those individuals who were not interested in the academy, roughly 70% provided at least one reason related to negative perceptions of the academy, such as perceptions of stress and strain, a disdain for the "politics" of the academy, and compensation that is incommensurate with such stress and strain. To the extent that their reported perceptions reflect what is occurring on the ground, these concerns are important because they highlight toxic features of the academy that are unhealthy for all. Furthermore, our participants' concerns may also identify points during the doctoral process at which departments and faculty could do more to accurately reflect academic faculty life.

The Ph.D. Socialization Process

Despite the scarcity of tenure-track positions in many fields and the fierce competition for available positions, most doctoral programs in the U.S. continue to socialize students for careers in the professoriate (Golde & Dore, 2001). Many factors play a role in doctoral students' career aspirations and trajectories: background characteristics such as race, gender, and citizenship; institutional factors such as institution ranking and funding availability; and socialization aspects such as disciplinary norms, satisfaction and comfort in one's department, and faculty mentoring (Barry, 2013). An integrative framework for understanding doctoral student attrition developed by McAlpine and Norton (2006)

groups these factors into three nested contexts: the departmental/disciplinary context, nested within the institutional context, situated within the societal/supra-societal contexts. However, much of the research on doctoral education highlights the significant role socialization plays in determining graduate students' experiences, attitudes toward the professoriate, and postgraduate career aspirations (Austin & McDaniels, 2006; Gibbs, McGready, Bennett, & Griffin, 2014). We rely on literature centered on the doctoral socialization process to frame our study of the reasons engineering and computing doctoral students are dissuaded from careers in academia.

Weidman, Twale, and Stein (2001) describe graduate and professional socialization as "the processes through which individuals gain the knowledge, skills, and values necessary for successful entry into a professional career requiring an advanced level of specialized knowledge and skills" (p. iii). Weidman and colleagues continue, suggesting that students develop "knowledge, skills, and values" through four stages of socialization: anticipatory, formal, informal, and personal. Socialization begins prior to enrolling in a graduate program in the anticipatory stage. In the anticipatory stage, students develop awareness of what it means to be an emerging member of their chosen discipline (Austin & McDaniels, 2006); however, this awareness is not fully developed and may change once they are immersed in the discipline. The anticipatory stage can include academic, social, and professional experiences before graduate school as well as the application and admissions process.

During the formal stage, students gain exposure to the norms and expectations of the field. This might include learning about the tenure process, faculty roles and responsibilities, publishing guidelines and expectations (e.g., tier levels for journals), and what it takes to establish prestige as well as pre-eminence in the field. The formal stage is typically the most standardized stage of the socialization process and is heavily shaped by formal faculty-student interactions such as advising, institutional and program-specific requirements, and professional expectations and definitions of quality scholarship and prestige. The informal stage occurs when doctoral/professional students learn about the disciplinary boundaries. The formal and informal stages overlap in faculty-student interactions—particularly in the advisor-advisee relationship—and this is where a hidden curriculum may exist (Jones, Wilder, & Osborne-Lampkin, 2013).

According to Barnes and Austin (2009) doctoral advisors are responsible for developing students as researchers and professionals within the broader discipline, as well as helping students navigate the unspoken and unwritten institutional and cultural norms and expectations that impact degree attainment. These implicit rules and guidelines can be identified as part of a hidden curriculum, a term used by scholars to describe the social and behavioral expectations enforced in academic environments—such as dress code, modes of interaction, and the appropriateness of specific personal and academic identities—as a means of hegemonic cultural reproduction that goes beyond intellectual and professional development (Apple, 2004; Giroux, 1981, 1983; P. W. Jackson, 1968; Margolis & Romero, 1998; Margolis, Soldatenko, Acker, & Gair, 2001).

The idea of a hidden curriculum can help to explain the potentially conflicting messages within complex learning environments such as the academy. Institutions of higher education are a microcosm of the inequitable systems that govern the rest of the world: racism, sexism, classism, homophobia, ableism, and so on (Jacobs, Cintrón, & Canton, 2002). The hidden curriculum includes the range of messages that students receive during their daily interactions with faculty, peers, staff, and other university employees. These messages can establish a sense of belonging or alienation and influence how students perceive themselves in the professional environment (Margolis & Romero, 2001). Students receive varying degrees of exposure to the hidden curriculum during their graduate education, depending on the kinds of mentoring and advising they get from faculty and their interactions with other graduate students. Additionally, one's exposure to the hidden curriculum affects the personal stage of socialization. The personal stage of socialization entails integrating one's professional identity with one's self-identity and self-image (Weidman et al., 2001). According to Weidman and colleagues, whether or not an individual identifies with the social/professional group impacts the individual's personal-professional identity integration process. In particular, Gibbs and Griffin (2013)

report that individuals who do not integrate their professional identity of academic researcher with their own self-identity are less likely to go into academia.

Given current conditions for tenure-track faculty, questions remain about the extent to which the challenges and possibilities of faculty academic life influence career decision-making among computing and engineering doctoral students and recent graduates—who are nearing (or just past) the cusp of selecting their post-Ph.D. career pursuits as prospective faculty members, governmental and industry researchers, or choosing to apply their degrees in a different capacity. We contend that the doctoral socialization process is critical to students' reasons for not wanting to pursue traditional academic careers. Thus, we pose the following question: *What perceptions and observations about being a faculty member dissuade engineering and computing doctoral students and postdoctoral researchers from pursuing the professoriate?* To the extent that our findings permit, we link participants' reasons for their discontent with pursuing academic faculty positions to the various stages in the doctoral socialization process.

METHOD

This study is part of our larger National Science Foundation-funded project investigating the institutional, technical, social, and cultural factors that affect the current underrepresentation of Black people (i.e., any individual of African descent, e.g., African American) in engineering and computer science faculty positions in the U.S. In addition to a survey, which was distributed to a multiethnic group of doctoral and recent graduates (N = 744), we conducted interviews and focus groups between 2014 and 2017 with more than 170 individuals, including Black engineering Ph.D. students and postdoctoral scholars, Black engineering tenured and tenure-track faculty, minority engineering program directors, and engineering administrators (e.g., deans and other administrative leaders). The focal data source of the current study is an open-ended response on the survey, which was relevant to a subsample (n=159) of the 744 doctoral students and postdoctoral scholars we surveyed. We further describe the data source and subsample in the forthcoming "Data Source" section.

A specific aim of the current study was to understand factors that dissuade doctoral students from being attracted to or sustaining an attraction toward the professoriate. We approached this study from a constructivist point of view (Miles, Huberman, & Saldana, 2014), whereby our goal was to explore engineering and computing doctoral students' and postdoctoral scholars' perspectives on their discontent with the prospect of becoming professors and the reasons behind those negative reactions. We relied on code enumeration—counting and showing the frequency with which certain themes appear across the participants' responses—because counting is integral to recognizing patterns in the data and describing responses across the overall sample (Sandelowski, 2001). From a post-positivist viewpoint (Cohen, Manion, & Morrison, 2013), we believe there is value in enumerating code occurrences to show nuance among the many codes for a relatively small sample (about 20%) of the larger population of interest.

DATA SOURCE

We used data from our larger survey of engineering and computer science doctoral students and recent graduates (N = 744), who were queried about their education history, identity, future career plans, mentoring and support experiences, discrimination, psychosocial well-being, and background demographics. The survey included mostly quantitative measures; however, we asked several open-ended, follow-up questions asking respondents to explain particular answers on multiple choice questions. For this analysis, we were focused on understanding *why* doctoral students were not interested in academia. Therefore, we selected data from a subset of respondents who (1) answered "no" to the question "Are you currently open to the possibility of becoming a faculty member at some point in your career?" and who then (2) provided an open-ended reflection explaining their response in a contingency question for those not interested in this career path. Out of 744 survey respondents, 159 participants replied "No," and all except 12 individuals followed-up with an open-ended rationale for their response. Thus, we analyzed open-ended responses from 147 participants who were not open

to the possibility of becoming faculty at some point in their careers. We used demographic and education background questions from the survey to provide descriptive statistics for our study subsample (Tables 1 and 2). Due to missing data on some demographic and educational background questions, Tables 1 and 2 show n's and proportions for each individual variable rather than for the full sample in this analysis. Please note, however, that all 147 individuals did indeed respond to some of the background questions (e.g., first-generation student status, institution type).

Recruitment and Procedure

Our university's Institutional Review Board approved the study in February 2015. After approval, we used a multiple-mode recruitment strategy to solicit survey participants and to ensure a multiethnic sample: (1) we leveraged the principal investigators' existing professional connections, (2) we contacted administrative leadership at institutions with five or more Black engineering tenured or tenure-track faculty as of 2012 (according to the American Society for Engineering Education [ASEE] Data Management System), and (3) we recruited individuals directly at a national engineering and computing conference. This multiple-mode approach was appropriate because there is no pre-existing sampling frame containing the contact information of all engineering and computing doctoral students in the U.S.—including their racial and ethnic identification—from which to recruit. Key staff members at multiple institutions forwarded our study invitation to engineering and computer science doctoral students and postdoctoral researchers via email. Those interested in participating provided consent online and completed the survey in Qualtrics. We gave all participants the option to receive a $15 gift card for participating in the study. While we were mainly interested in current doctoral students and candidates, we also accepted responses from recent graduates, including postdoctoral researchers, who were still asked about their career plans.

Study sample

Demographic and education background characteristics of our sample are reported in Tables 1 and 2. To provide a sense of how similar or different our sample (N = 147) is to a comparable population of scholars in the U.S., we compared these groups on sex, race, citizenship status, and the Carnegie classification of their institutions using data from the National Science Foundation's "Women, Minorities, and Persons with Disabilities in Science and Engineering" report (NCSES, 2017). Based on Chi Square tests of homogeneity, we determined that our study's sample and all engineering doctoral degree recipients in 2014 have significantly different distributions on sex, citizenship status, several race categories, and Carnegie classification, at the $p < .05$ level (Campbell, 2007). The proportion of women in our sample (41%) is significantly greater than the proportion of women who were awarded PhDs and who were in postdoctoral positions in engineering or computing in 2014 (22%; NCSES, 2017). In terms of citizenship status, in our sample, 52% of participants self-described as U.S. citizens, whereas the NSF reported only 42% of all engineering and computing doctoral recipients and postdoctoral researchers were U.S. citizens or permanent residents, which is also a significant difference. In terms of Carnegie status, according to the NSF, 82% of all engineering doctoral recipients who were U.S. citizens or permanent residents in 2014 received their degrees from institutions classified as R1 or "very high research activity", whereas all comparable participants in our sample were enrolled at or graduated from an R1 institution. Finally, the NSF only disaggregates data on race for U.S. citizens and for doctoral recipients, but amongst comparable participants in our sample, we found that Black respondents and respondents who indicated more than one race were significantly overrepresented. The overrepresentation of women, Black and multiracial students, as well as doctoral students from Research I (R1) universities is likely due to our sampling technique as well as the interests of our research group which we described to respondents when seeking consent, i.e., that we are particularly interested in understanding the experiences of historically marginalized students. In interpreting these findings, it important to note how these characteristics of the sample might impact the frequency of particular emergent codes.

Table 1. Demographics of Survey Respondents

		frequency	%
Sex			
	Male	79	59%
	Female	55	41%
U.S. citizen			
	Yes	70	52%
	No	64	48%
Race			
	Asian	52	40%
	Black	13	10%
	Latino/a	3	2%
	Multiracial	10	8%
	Other	4	3%
	White	49	37%
Has children			
	Yes	7	5%
	No	140	95%
Family background income			
	Not enough	9	7%
	Just enough	28	21%
	Enough plus	69	52%
	Abundance	27	20%
First-gen. college student			
	Yes	26	18%
	No	121	82%

Table 2. Educational Characteristics of Survey Respondents

		frequency	%
Discipline			
	Engineering	119	84%
	Computing	19	14%
	Engineering education	3	2%
Institution Type			
	Private	7	5%
	Public	140	95%

		frequency	%
	R1 Status	146	99%
	R2 Status	1	1%
Status			
	Ph.D. students	123	84%
	Ph.D. graduates	24	16%
Years in Ph.D. program (mean)			2.98 yrs.
Primary funding source			
	Research assistantship	79	55%
	Grants and/or fellowships	36	25%
	Teaching assistantship	26	18%
	Other	2	2%
Has mentor			
	Yes	91	64.5%
	No	50	36.5%
Sufficient time with mentor			
	Yes	64	71%
	No	26	29%
Has publication(s)			
	Yes	97	66%
	No	49	34%

Analytic Strategy

We downloaded the 147 open-ended "faculty unattractive" responses from Qualtrics and exported them into an Excel spreadsheet for coding. Four out of six authors carried out the data analysis. First, three authors met and read through all 147 responses multiple times (Dey, 1993) while independently creating a memo for each emerging theme (Miles, Huberman, & Saldana, 1994; Strauss & Corbin, 1998). Second, the authors consolidated the emerging themes during iterative consensus-building discussions. Two of the three coders then tested the face validity of the preliminary code set on a random set of ten responses and further refined preliminary codes and definitions. Third, the two coders independently coded all 147 responses using the refined coding structure, and in another consensus-building discussion (with just the two coders) refined code applications and reconciled "Other" codes into existing or new codes. Finally, the four authors met to discuss the refined code set, clarify definitions, and reorganize the refined coding structure under key index/parent codes within the emerging theoretical framework. By key index or "parent codes," we refer to larger thematic categories (e.g., "general lack of interest in faculty careers") under which various sub-codes or "child" nodes fall (e.g., "disinterest in teaching" or "unfair financial expectations"). A single response fell under multiple child-nodes if the participant conveyed multiple, mutually exclusive reasons for their general lack of interest in faculty careers, and/or multiple parent nodes if the participant con-

veyed multiple, conceptually distinct reasons for their disinterest in faculty careers. We chose quotes to reflect the diversity of perspectives and opinions that emerged from the data. We present the codes and code frequencies in Table 3.

Positioning and Subjectivity of the Researchers

As a team of academic researchers (at the time of data analyses: one faculty, three postdoctoral researchers, two doctoral students), it is important that we acknowledge our positions and subjectivity (Berger, 2013) in our readings of engineering and computing doctoral students' and postdoctoral researchers' attitudes toward faculty careers. Indeed, the larger project was conceived out of our interest in understanding trends in the field and our own experiences and observations, particularly as 5/6 of the authors are members of racial groups historically underrepresented in the academy. However, for a variety of reasons, including differences in current discipline, race, age, and academic positioning, our experiences and aspirations differ from those of the study participants. Therefore, while we recognize that we might share some experiences with our participants, we were careful to focus on the doctoral students' and Ph.D. graduates' narratives while minimizing our own subjectivity. In order to minimize the influence of researcher subjectivity, during the coding and writing process, authors took notes about how their views and lived experiences paralleled and differed from those of the participants in the study. We also discussed these notes during research meetings. These notes and meetings forced us to continuously be aware of how our experiences might influence our interpretation of the experiences and feelings portrayed by the study participants. Throughout the research process (including project conception), we actively acknowledged the importance of dialogue between co-researchers to reduce the influence of researcher subjectivity. Our iterative, consensus-building discussions were intended to foreground participant experiences, thereby maximizing credibility of the findings by agreeing on interpretations of the participants' intended meanings.

Results

On our survey, the multiethnic (though largely White and Asian) group of engineering and computer science doctoral students and recent graduates offered a wealth of information about their doctoral experiences and career aspirations. The current study focused on a subset (n = 147) of the larger survey's respondents who expressed a lack of interest in the professoriate as a viable career option. It is important to note that individuals' open-ended responses varied in length and depth; some individuals provided a single reason/code, others provided multiple reasons that we categorized under a single code, and still others provided multiple reasons that fell under different codes. Thus, in our results, we report the number of individuals (n) for whom a code appeared at least once in their open-ended response. Moreover, wherever proportions are presented alongside n's in the forthcoming results, the denominator is 147.

Two main themes emerged from the data: (1) general lack of interest (n = 70, 48%) and (2) being put off by the stressful nature of academia (n = 101, 69%). Although we focus on the second theme in greater depth—as the overwhelming majority of participants identified norms and pressures of academe as a primary turnoff from pursuing a faculty career—we first summarize the "general disinterest" theme. Table 3 details the codes, code descriptions, and code frequencies that our coding team established in the data analysis process.

Table 3. Codes, Code Descriptions, and Code Frequencies

		n (%)
1. General Lack of Interest in Faculty Careers: Expressed disinterest in faculty positions for reasons other than the norms and pressures of the academy		70 (48%)
1a.	Simply uninterested: Expressed general disinterest in the academy	43 (29%)
1b.	Personal Reasons: Individual reasons such as personality, internal attributions (e.g., confidence), not related to the academy	21 (14%)
	i. Lack of preparation or confidence	12 (8%)
	ii. Personality mismatch	6 (4%)
	iii. Other: Citizenship/Language Barriers or geographical reasons	3 (2%)
1c.	Disinterest in Teaching: Teaching is described as unattractive and a barrier for faculty interest	17 (12%)
	i. Does not like teaching	14 (10%)
	ii. Not good at teaching	3 (2%)
2. Norms and Pressures of the Academy: Perceived norms and pressures associated with life as a faculty member. Includes practices, policies, and expectations that are normalized within academe, yet invoke feeling of stress and disdain, and (more often than not) are misaligned with the participants' personal and professional values		101 (69%)
2a.	Academic stress and emotional strain: The demands for working in, advancing in, and thriving in academia are too stressful	50 (34%)
	i. Too much work, stress, and pressure (i.e., dislike of being over-worked and over-stressed)	36 (24%)
	ii. What it takes to advance is not worth it (i.e., the tenure track system and publish-or-perish is too stressful; junior faculty are overworked)	17 (12%)
	iii. Lack of work-life balance (i.e., desire to have a life outside of the academy)	11 (7%)
2b.	Perceptions of Unfairness: Perceptions that the academy doesn't 'do the r thing;' it's deceitful or immoral	31 (21%)
	i The "political" nature of the academy: (i.e., Participant disagrees with power structure of academe; if they actually used the terms 'politics' or 'bureaucracy'; disliked quid-pro-quo interactions and how "it's about who you know, not what you know")	16 (11%)
	ii. Toxic work environment (i.e., descriptions of a super-competitive environment, faculty who are unpleasant to work with)	10 (7%)

		n (%)
	iii. Having the wrong priorities (i.e., typically that the academy prioritizes research over helping students, and quantity over quality of publishing)	8 (5%)
	iv. Discrimination (i.e., believes gender or racial discrimination will prohibit their success)	4 (3%)
2c.	The Grant Funding Scramble: The idea of grant-writing, finding funding	30 (20%)
2d.	Academic Research: Perceives academic research as divorced from practical applicability and/or has little impact.	20 (14%)
	i. Not applied/impactful/useful (i.e., research is not useful or applied)	14 (10%)
	ii. Not "hands-on" (i.e., faculty don't even get to "do" the research)	6 (4%)
	iii. Other (i.e., Mismanagement or lack of infrastructure)	2 (1%)
2e.	Practical Reasons: Reasons for not pursuing faculty positions that are due to problems with higher education	19 (13%)
	i. Competitive Job Market (i.e., too many candidates, not enough jobs)	9 (6%)
	ii. Insufficient Salary (i.e., doesn't pay enough for the amount of effort)	10 (7%)
2f.	Ph.D. Experience: Respondent explicitly stated they learned from Ph.D. experience that they do not want to become a faculty member	16 (11%)

General Lack of Interest in Faculty Careers

In line with Weidman and colleagues' (2001) personal stage of socialization, a subset of participants cited personal reasons for not wanting to pursue faculty careers. Within the "general disinterest" theme, participants reported they were uninterested in academia because of personal reasons, or reasons that had nothing to do with their experiences in graduate school, or their attitudes toward the academy. Their responses were further subdivided into the following sub-codes in order of frequency, counting the number of individuals who gave a particular response: a) simply uninterested (n = 41, 28%); b) personal reasons (e.g., personality mismatch, lack of confidence, citizenship/language; n = 21, 14%); and c) disinterest in teaching (n = 17, 12%). Within the "simply uninterested" subset it appears that many participants may have entered their doctoral programs with the understanding that faculty life was not for them, and their training experiences did not change their perspectives. Their responses included statements such as: "I am simply not interested in becoming a faculty member. I want to experience work life in industry."

A number of personal reasons, the second "general disinterest" subtheme, presented barriers to interest in faculty careers. Some personal reasons included perceived personality incongruence, as shared by an Asian male, first-year environmental engineering student: "I am not talkative enough. I [feel] nervous to talk in front of people. I just want to focus on the work." Language and citizenship also served as personal barriers for some, such as an Asian male student in civil engineering, who wrote, "Because I have no citizenship and my communication with English is uncomfortable." Geographic limitations due to family or spouse's employment was another personal reason shared. An-

other example of personal reasons was when participants attributed their lack of interest to internal factors, such as feeling unfit or unprepared for an academic research career (e.g., lack of publications).

Seventeen respondents reported they simply did not want to teach. In this "disinterest in teaching" subtheme, some participants expressed a preference for research in place of teaching, which suggests that they perceived teaching and research as incongruent with one another. We surmise that our respondents believed that teaching did not align with their personal identities. Thus, according to Weidman and colleagues (2001), this misalignment of personal and professional identity may have resulted in some participants' lack of interest in faculty careers that involve teaching.

Perceived Norms and Pressures of the Academy

A central finding of this study was that participants' explanations of the norms and pressures of the academy shaped their career trajectories away from pursuing faculty careers. More than two-thirds (n = 101, 69%) of our respondents said the academic norms and pressures under which they were socialized as doctoral students had dampened their interests in the professoriate. Specific reasons within this general theme included a) the perceived stress and strain of faculty (e.g., workload, promotion and tenure, and work-life balance; n = 50, 34%); b) perceptions of unfairness in the academy (e.g. a disdain for politics, the academy's toxic work environment, academia's prioritization of the wrong things, and discrimination; n = 31; 21%); c) a disdain for grant-writing (n = 30, 20%); d) rejection of academic (i.e., basic or theoretical) research; (n = 20, 14%); and e) practical reasons (e.g., an insufficient salary for the workload or the competitive job market; n = 19, 13%).

The "norms and pressures of the academy" theme most closely aligns with Weidman and colleagues' (2001) *formal* stage of socialization (when students learn about academic norms and expectations), and the *informal* stage (a less standardized stage when students learn disciplinary boundaries). As part of their formal socialization, norms and pressures are aspects of the academy that students became familiar with while interacting with faculty and colleagues. Informal socialization appeared in the participants' descriptions of academic politics, which at times overlapped with their formal socialization (e.g., experiences in lab). Indeed, we found that 16 (11%) of the respondents specifically stated they formed their understanding of what a faculty career would be like through their experiences in their doctoral programs. Additionally, participants whose responses fell within the "norms and pressures" theme cited reasons that appeared to emanate from an understanding that faculty life would be incongruent with their personal identities, thus highlighting the *personal* stage of socialization.

In the sections that follow, we detail our findings for the five subthemes under our central theme, "norms and pressures of the academy."

Academic stress and emotional strain (n = 50, 34%)

Participant narratives implied or provided examples of how heightened levels of stress and strain seemed to be normalized and expected for the academic life of a faculty member. In relation to other post-Ph.D. careers, the demands of the professorate and the associated impairments to their psychological health and work-life balance, seemed overwhelming. The participants had observed their colleagues' and professors' lifestyles and determined that the work-life schedules of faculty are seriously imbalanced, and they could not fathom having a high quality of life in the academy. One White second-year female student in mechanical engineering said, "I believe in having a work-life balance, and too often I see junior faculty members scrounging to get by, working incredibly hard. I enjoy my work, but I also don't enjoy working to the point of exhaustion." Many participants also associated the elevated concentrations of stress they were currently enduring as doctoral students with a career in the professoriate. A White male third-year mechanical engineering student wrote:

> Academia has been stressful and not very rewarding while I've been a Ph.D. student. In particular, the job of being a professor seems like a lot of work, and very high pressure. At the

> same time, many of the professors I've worked with have had gigantic egos and poor interpersonal/management skills, and have been demanding, without being pleasant to work with. I don't really want to work with people like that or feel the constant pressure to publish and impress.

In short, these participants noted their present stress and its potential continuation in the future was a major deterrent against the pursuit of academic careers.

Perceptions of unfairness (n = 31, 21%).

A significant one in five participants revealed themes associated with conveying unfairness in the academy, including a disdain for the "political" nature of the academy (n = 16, 11%), a toxic work environment, (n = 10, 7%), that it has the wrong priorities (n = 8, 5%), and that it breeds discrimination (n = 4, 3%). Among the participant responses were negative critiques of the political and bureaucratic climate, and 14 of 16 participants whose responses were categorized under this code used the phrases "politics" or "bureaucracy" to describe the academy. For example, a third-year Latino male in mechanical engineering, wrote:

> There is too much politics involved in academia that I did not anticipate when I was a new graduate student. I often find it more difficult to work with others because of competition than I do to actually conduct research. There is a tremendous amount of stress involved in becoming a professor and job security is not as high as working in industry.

Some participants described their negative reflections of the structure of power and decision-making in academe. To give an extreme example, one of those participants was a first-year, White male student in computer and electrical engineering who explained he was not interested in faculty, "because it's a broken system. It's a mess. It's still in the feudal ages [sic] a few bored and miserable old people control everything with no need to explain their decisions or actions." In contrast to what this student implies about higher education's resistance to modernize and improve, many institutions are in fact adapting to broader social changes, such as accommodating an expanding market by offering online courses, Massive Open Online Courses (Johnson et al., 2016), and accommodating more diverse student bodies by emphasizing multicultural competence for student affairs professionals (Pope, Mueller, & Reynolds, 2009). Nonetheless, many changes have not solved some of the systemic issues such as sky-high tuition rates and fee increases, student debt (including disproportionately higher debt for Black STEM doctoral students in comparison to their White counterparts; Zeiser, Kirshstein, & Tanenbaum, 2013), and the culture of elitism (fueled by U.S. news college rankings) that has creeped into the psyche of a great many 4-year institutions, beyond those traditionally considered private and elite (Craig, 2015). Regardless of the validity of this critical statement, this student—who is only in his first year of his doctoral program—seems to have already had negative experiences, indicating areas in which the institution could improve.

It appears that students had already been exposed to and in some cases personally affected by the politics of the academy and had therefore developed disdain for this aspect of academic life. For many, the anticipatory stage of socialization, in which students develop awareness of what it means to be a part of their chosen discipline (Austin & McDaniels, 2006), did not align with the reality to which they were formally and informally socialized during their training.

Other negative critiques of faculty life included a sense of the immorality embedded in the structure of the academy. Ten participants (7%) expressed that the academy was a toxic work environment, meaning that they witnessed excessive competition amongst faculty members and future colleagues who they characterized as egotistical and unpleasant to work with. For example, a 2nd-year White female engineering science and mechanics student stated, "I do not like the competitive environment of faculty undercutting each other and competing for grants, particularly with the way female faculty are treated."

Eight respondents (6%) conveyed that the academy tended to prioritize the wrong things, for example, prioritizing research and grant-writing over teaching and mentoring students and other social justice–oriented work. A White, female mining engineering student noted, "'I use[d] to think universities were these really great institutions and really they are just well-hidden pyramid schemes that aren't focuse[d] on the students at all." In other words, it appears this participant did not want to work for a system that she perceived profits off of students and the actual education being secondary. A fifth year, female electrical engineering respondent stated, "The emphasis to be put on quantity of research publications rather than quality in order to get a tenure is simply unacceptable to me and that's what happens in most of the cases. This is really frustrating." Along with several other respondents, this participant alludes to the oft cited "publish or perish" mantra considered as required for tenure-track academic success. This "publish or perish" ideology sometimes privileges quantity rather than quality of research output (Plaut, 2014). There have been some recent cases of academic fraud by faculty who face pressures to solve some of the world's most critical problems (Edwards & Roy, 2017). The students challenged what they viewed as the traditional model of research as the priority and suggested that altering the model could heighten their interest in pursuing a faculty career. A small number (n = 4) of participants described discrimination as a factor that turned them away, such as a third-year Black female student in engineering education who wrote:

> Honestly there appears to be too many unknown hoops and politics to jump through. Additionally, looking at demographics/statistics/and research related to my demographic group successfully entering tenure[d] faculty positions is discouraging. I feel my time would be better served pursuing interests outside of the academy.

In addition to learning about the difficulties facing her as a Black woman in engineering, this student further explained that despite "some fairly decent" mentorship on the hidden curriculum (e.g., what types of publications at considered as top tier; how to carve out your own research; how to navigate racism and sexism without losing your spirit; traversing the dreadful holiday/graduation academic parties as the "only one."). This same participant exclaimed that some of her mentors who had achieved tenure and promotion proclaimed that some elements of gaining tenure were still unknown to them, demonstrating mystifying practices within the hidden curriculum.

Grant funding scramble (n = 30, 20%).

One in five participants described the grant funding process as a strategy that departments employ as part of the tenure and promotion process to persuade faculty to vigorously pursue highly competitive grant applications to fund their salaries. These participants classified academic grant activity as unappealing and worrisome, because grants have diminished in quantity and the task of getting funding has become increasingly aggressive. A White, fifth-year, male, mechanical engineering student explained, "The misery of writing grants instead of getting to do the actual work does not sound enjoyable as a career." Furthermore, they said that constrained resources often caused faculty colleagues to fight over the limited grant funding pool. A third-year Asian male computer engineering student's response exemplified this problem: "Financial hardship. Research as a faculty member is mostly not very impactful. Resources are mostly very limited." Academic pay structures were especially troubling for participants when they considered other associated norms and pressures.

Dislike of academic research (n = 20, 14%).

Another major reason that participants listed for not being open to the possibility of becoming a faculty member was their perception that academic research was too basic, or not applied enough. Some participants wanted to have a more transformative impact and argued that the field of engineering and positioned the academy as being largely divorced from practical application. A first-year Black female mechanical engineering student described how she came to this realization: "My views and goals in life have changed. Now I want an industry-based job with emphasis on research. Applicability is becoming an urgent part of what I want in my career as a researcher." Those who cited a

desire to engage in more applied forms of engineering or computing did not appreciate practices and policies that disconnected university teaching/research from real-world applications. For example, a sixth-year White male student in electrical engineering was grappling to understand how professors who lacked industry experience managed sophisticated research labs, yet did not implement or teach to students the kinds of meticulous procedures required for cutting-edge research:

> I don't understand how some professors that have never worked in industry are allowed to manage a state-of-the-art lab. Industry meticulous[ly] logs usage, recipes, and processes. Our lab did none of those things, and process issues were rampant. Students were treated as technicians and not engineers. The university job is [to] teach engineers and prepare them for a future job. Instead they limited our interactions with tools in the lab and made it difficult at times to learn what went wrong and how to fix tool issues.

Through experiences such as this, these students had concluded that being an academic engineer or computer scientist has less impact for their fields than being an engineer or computer scientist in industry. However, students' perceptions of industry may be limited by their exposure to industry (e.g., internships, funding) based on short-term relationships. One participant, a fifth-year White male mechanical engineering student, described:

> I think that the funding structure of academic engineering research often results in investigators having to invent problems to solve, whether or not those problems actually exist. Fundamental research in the sciences is important, but engineering is necessarily an applied endeavor, and I think this distinction often becomes blurred, to the detriment of engineering research, in academic environments.

Students expressed a desire to engage in more transformational work in a much more applied sense than what they had seen in the academic environment. While academic researchers may have to think creatively to maximize their research output, numerous participants believed they would spend a majority of their time writing grants, conducting research and publishing not for the sake of doing whatever innovative and impactful research they were interested in, but to sustain their careers. As one participant described, "most of the research in academia is useless and faculty [do] it just for the funding." University research has led to a number life-changing inventions including the seat belt, the internet, the periodic table, GPS, televisions, and computers (OnlineUniversities, 2012), and the creation of various companies (e.g., eBay, Zillow, Hewlett-Packard Company, Instagram; Stanford's Office of Technology, 2018), however, participants who have been turned off of this career path suggest that the research faculty engage in is not impactful, and merely for the purpose of sustaining their careers.

Practical reasons (n = 19, 13%).

Finally, some participants described not being interested in academic careers, not because of the nature of the work necessarily, but rather, problems with compensation for the work (n = 10, 7%) and the overall job market (n = 9, 6%). Concerns about financial expectations surfaced in the responses. For example, one first-year, male, Asian mechanical engineering student simply stated: "Not a good payment/workload ratio." For a normative understanding of faculty compensation, we offer the survey data from American Association of University Professors in early 2018. In the 2017-18 academic year, the average professor salary (across disciplines) ranged widely, depending on rank: Full professors earned $104,820, associate professors made $81,274, and assistant professors took in $70,791 (Harmon, Hopkins, Kelchen, Persky, & Roy, 2018). We note, that obtaining the ever-elusive grant funding can significantly increase the yearly salaries of faculty members (e.g., most often in the form of summer salary), thus there is additional incentive to obtain grant funding. With respect to the competitive job market, respondents described it as "cutthroat" and the competition as "fierce."

DISCUSSION

In this study, we explored why faculty careers are unattractive to a multiethnic sample of current engineering and computer science doctoral students and recent graduates. Our inductive qualitative analysis reveals why some doctoral engineering and computing students might be dissuaded from a career in the academy, and links their reasons to various stages of doctoral socialization as put forth by Weidman and colleagues (2001). An overwhelming majority of respondents explained they were uninterested in a faculty career due to the "norms and pressures of the academy." This was indicated by their disdain for the obligations of writing grants and creating fundable research, the imbalance between workload expectations and financial compensation, and academic politics—some of which they had already experienced during the Ph.D. process. Their responses suggested they learned the disadvantages of being academic faculty through both formal and informal socialization, causing conflict between their personal identities and their identities as engineers and computing scientists.

Many of the participants in this study were likely disengaged from academic careers because, through personal socialization, they were unable to reconcile their own self-concepts, values, and beliefs with their perceptions of an academic faculty role. However, individuals who were disinterested in academia due to unforeseen norms and pressures of academia seemed to have lost interest, and experienced dissonance between what others told them (through anticipatory and formal socialization) and what they experienced (informal socialization). Less commonly, students who we categorized as expressing a "general lack of interest in faculty careers" seemed to have already known they would not become faculty, and often focused on preferences (e.g., dislike of teaching) and personal reasons (e.g., language barriers). Although further research is necessary to replicate such findings and explore the interactions between one's goals, doctoral socialization, and career aspirations, many participants clearly suggested that the norms they observed and experienced through socialization in graduate school led to their desires to pursue other options.

Our results coincide with findings from previous research on doctoral student socialization and career decision-making. As Fuhrmann and colleagues (2011) found, negative experiences during the doctoral process have a lasting impact on students' perceptions of academia and often push away promising scientists by their third year in graduate school. Indeed, the majority of participants in this study were in their third year of graduate school or beyond; thus, we surmise that participants had learned about academic norms and pressures during the informal and formal stages of socialization. For example, by speaking with and observing faculty and reflecting on their own experiences, participants made projections about what would be expected of them as faculty members. In many cases, these projections were enough to discourage them from pursuing a faculty career. In some cases, their informal and formal socialization experiences conflicted with their anticipatory socialization, causing them to change their career ambitions unexpectedly.

Prior research showed those who were and were not interested in faculty positions expressed similar concerns about academic pressures associated with faculty careers (McGee et al., 2016). Although our participants reported that they were not currently interested in academe, 51% said they had entered graduate school with an interest in pursuing a faculty career. Some stage of their doctoral journeys—either the formal, informal, and/or personal aspects of doctoral socialization—discouraged roughly half these students. Again, this phenomenon highlights the possibility that a mismatch between anticipatory and later stages of socialization led to these doctoral students becoming "turned off" from faculty positions. Although the socialization experienced by these students may be normative for their respective fields—and therefore could be considered "effective," unmet and mismatched expectations can have a discouraging rather than encouraging effect on faculty career aspirations. The socialization models posited by Weidman and colleagues (2001) and others are not explicit in problematizing the possible unintended consequences of normative doctoral socialization, but research on the *hidden curriculum* of the academy does offer some insights. Students expected their roles in academia to focus on innovation, solving real world problems, and/or directly impacting

their personal and professional communities. Instead, the "turned off" students encountered institutional and cultural norms that made their initial goals appear difficult, unattainable, and unreasonable to pursue.

For many doctoral students and recent graduates, the pursuit of a healthy work/life balance in academia seems like an impossible goal. In addition to being torn between juggling heavy workloads, managing relationships and family responsibilities, and squeezing in outside interests, these participants also suggested the politics of doctoral education drastically added to their lack of work/life harmony. Having more balance for doctoral students has been identified as helpful for successful degree completion and subsequent placement in the academic profession (Brus, 2006; Stimpson & Filer, 2011). For instance, Martinez, Ordu, Della Sala, and McFarlane (2013) found that doctoral students were successful in achieving greater work/life balance by (1) purposefully managing their time, priorities, and roles and responsibilities; (2) managing stress levels, maintaining their mental and physical health, and creating personal time; (3) finding support from various individuals and their institutions; and (4) making tradeoffs. Thus, doctoral programs could benefit from building infrastructure and programming specifically designed to alleviate the work/life imbalance. There are also external programs like the Faculty Success Program, which is designed to teach doctoral student and junior faculty how to increase research productivity, adopting proactive instead of reactive time management strategies, and to live a full and healthy life beyond campus (National Center for Faculty Development & Diversity, 2018)

Furthermore, our survey respondents also indicated that they perceived academic research was not applied enough. The statistics on the United States' 2016 research expenditures of academic scientists revealed that basic research accounted for 63% of academic research expenditures and in contrast, applied research and development was only 37% of academic research expenditures (NCSES, 2018) displaying the harsh divide between basic and applied scientific research. Scholars describe this divide as costly and harmful to scientific advancement (Anadon, Chan, Bin-Nun, & Narayanamurti, 2016; Narayanamurti & Odumosu, 2016). Under the traditional model, scientific discovery arising from basic research is prioritized, then the engineers and applied scientists eventually devise inventions that apply that new knowledge in useful ways. Thus, basic and applied scientists frequently work in silos, although we know that having diverse types of scientists researching together, sharing ideas and insights and sometimes even switching roles, creates more innovative designs (Page, 2008). Although this results-oriented, collaborative approach has been largely embraced by STEM industries, it has not significantly increased the racial diversity of its STEM employees, which leads to more diverse interests in the application of engineering (McGee & Bentley, 2017). Universities lack the interdisciplinary and collaborative relationship building across the scientific diaspora (including such fields as psychology, sociology, and STEM Education). The respondents in this study discussed the high stakes associated with creating technological solutions for pressing problems (e.g., climate change), coupled with their desire to be a part of organizations that encourage risk, curiosity, discovery, invention, and blur disciplinary walls to increase collaboration. An increased focus on applied research and development may be one way universities can be more primed to address real-world problems as well as out-of-world problems. Consequently, doctoral students may come to view the academy as an enterprise for exploring new and important scientific knowledge.

Institutions of higher education have historically been marketed as citadels for academic freedom and a robust expression of ideas. However, as several participants described, many departments stifle creativity, innovation, and diversity of ideas through outdated practices and policies tied to faculty employment (Baptista, Frick, Holley, Remmik, & Tesch, 2015; Brodin, 2018). Some participants perceived innovation as uncharacteristic of the university but something that is welcomed in industry. For example, some participants saw the demands of the tenure track as not only stressful but highly limiting to their academic freedom and suggested the ultracompetitive grant environment limits possibilities to conduct science for the sake of science by pushing researchers toward better-funded lines of research. Many of our respondents conveyed that they had often informally learned about the

preoccupation of seeking and securing external funding through their advisors. A majority of engineering Ph.D. students attend research-intensive universities (in 2015, 79% of engineering doctoral recipients graduated from "R1" universities, which are characterized by "very high research activity," and the remaining 21% graduated from "R2" universities, characterized by "high research activity" (NSB, 2018). Therefore, most engineering doctoral students today witness firsthand many of their professors and advisors being steered toward rapid publishing and securing research for funding. This finding points to the possible need for funding practices that provide room for scientific research project failure (and learning from those failures) as a pathway toward eventual success, as well as greater professional development that demystifies the grant funding process.

While it is widely believed that academia grants its faculty research freedom (Roach & Sauermann, 2010), the traditional tenure-winning model may be more limiting. Advancements in engineering and computing require taking significant risks, and early failure is almost inevitable (Cropley, 2015; Simpson & Maltese, 2017). However, the traditional tenure-winning model is antithetical to the vulnerability entailed in exploring and developing new areas of technology. In reality, faculty are heavily influenced by pressure to maximize academic publications and limited by priorities of funding agencies and possibilities of failure due to risk-taking. Applicability is further decreased because publications are often hidden behind pay-walls and because their focus on specific publication audiences can create firm boundaries between research and praxis (Björk, 2017). As our participants suggest, the means for faculty advancement as well as the disconnect between the academy and the real-world applicability of engineering and computing restrain possible output, translating to less impactful research and their disinterest in academia.

Participant responses revealed that several stakeholders seem to perpetuate the perceived norm of suppressed innovation in the academy. University administrators might ask what protections their institutions offer to members of the campus community to guarantee a diversity of perspectives are represented in its discourse. For example, greater diversity in professors' experiences (e.g., past industry experiences) would expand doctoral students' sense of future possibilities and better prepare them to apply their training with the greatest impact. Funders seeking to encourage broad scientific innovation might ask how the grant award structure could incentivize creativity and diversity of thought. In 2007, the National Science Foundation made a move in this direction by emphasizing "transformative research" as a criterion for all grants regardless of their foci (NSB, 2007); we hope that ongoing diligence in this area will normalize such commitments to transformative, innovative research in academe and through other grant-making institutions.

Finally, a number of respondents said they were deterred from pursuing a career in academia because they were uninterested in teaching. This could be because engineering doctoral programs largely focus on preparing students for research activities and ignore socialization and preparation for other faculty responsibilities, such as teaching and service (Mars, Bresonis, & Szelényi, 2014; Wulf & Fisher, 2002). Particularly at research-intensive universities, external funding is the principal guarantee of promotion and tenure, while teaching and service are undervalued (Tierney & Bensimon, 1996). How might research and teaching be integrated so that they are mutually reinforcing rather than mutually exclusive (Anderson et al., 2011; J. Jackson, 2004)? Research has the potential to impart new knowledge, and teaching is an avenue to impart established knowledge. Professors tend to be most comfortable teaching what they know best, and the system offers few incentives for developing new teaching methods (Felder, 1994). This situation could be addressed by changing the reward system to encourage innovation in engineering teaching. Departmental and university cultures often do not adequately value, support, and reward effective innovation in engineering and computing education, and spaces for legitimate dissent and intentional departure from traditional pedagogies remain on the fringes of academia. Findings from engineering and computing education research and the comments of our participants suggest that innovation in research universities is severely disadvantaged in many regards and that a number of organizational and structural factors must be addressed systemi-

cally to bolster the prospect of improving engineering departments at research universities (Lyons & Ebert, 2005; Porter, Roessner, Oliver, & Johnson, 2006).

Participants highlighted several organizational and structural issues in this study that researchers and practitioners have been aware of prior to this study. This awareness has led to the development and implementation of several programs that aim to not only make academia more favorable to students but also to train professors to innovatively integrate research, teaching, and learning. For example, the Center for the Integration of Research, Teaching and Learning (CIRTL) is a network that was established in 2006 to enhance STEM education by integrating learning, education, and research (Linsenmeier & Woods, 2017). More specifically, CIRTL trains STEM faculty in modern evidenced-based teaching practices to work with diverse STEM undergraduates and graduates. The goals are to positively change the culture of STEM academia by encouraging healthy work-life balance, preparing to teach students effectively, and improving the teacher-learning process for current faculty by evaluating, enhancing, and successfully implementing effective teaching skills (Linsenmeier & Woods, 2017).

Furthermore, advances have been taken to help increase diversity in STEM fields for both graduate students and faculty members of color. Several programs and initiatives have been implemented both locally and nationally to assist with the socialization process of racially diverse computing and engineering doctoral students. For example, the Alliances for Graduate Education and the Professoriate (AGEP) is a program that was developed to improve pathways to the professoriate for underrepresented minoritized (URM) doctoral students, postdoctoral fellows, and faculty members, including African Americans, Hispanic Americans, American Indians, Alaska Natives, Native Hawaiians, and Native Pacific Islanders. With efforts to increase the number of URMs in STEM disciplines and STEM education research fields, AGEP supports the development and implementation of innovative models of doctoral education, postdoctoral training, and faculty advancement while advancing the knowledge of the underlying issues, policies and practices that impact career trajectories of URMs in the STEM disciplines (Tull, Rutledge, Carter, & Warnick, 2012).

Implications and Future Studies

This study is useful to practitioners who are invested in doctoral training, and these findings could provide STEM doctoral programs with direction for assessing and improving their doctoral students' experiences (Allum, Bell, & Sowell, 2012). We have mentioned a number of implications this research has for various stakeholders in making the engineering and computing professoriate an innovative and attractive career path. Students who do not choose to enter academia upon completion of doctoral training can continue to be innovative in other positions and have more options available to them than doctoral graduates in other disciplines (Langdon, McKittrick, Beede, Khan, & Doms, 2011). However, it is critical to remove barriers that make academia an unviable career path, as colleges and universities are important sites for producing scientific knowledge, innovation, and training. Removing barriers to entering academe is especially important for creating and maintaining diversity among faculty, as this is crucial for creativity and innovation in STEM.

Our respondents' perceptions and observations highlight aspects of academic work that are endemic to the role (e.g., heightened levels of stress) that institutions could better prepare students for, but they also indicate other aspects (e.g., perceptions of unfairness) that are highly problematic and may differentially dissuade students from academia depending on their demographic characteristics (e.g., race, gender, sexual orientation, and age). As such, departments and institutions should conduct in-depth audits of their doctoral programs to unpack the factors that produce differential job placement (e.g., students' research experience and collaborations with industry). To invigorate students' perceptions of teaching, we believe that all tenure-track faculty could benefit from a semester focused on professional development in teaching, in which they would learn new technologies to incorporate in their classroom teaching and get the latest research and pedagogy on teaching, learning, and advising. Faculty, and therefore their students, could also benefit from instating awards and named professorships recognizing outstanding teaching and advising. Such structures might alter the view that doc-

toral students have of the professoriate and thereby remove barriers stifling the flow of budding engineers and computing scientists into the academy.

Future researchers should explore in greater depth the extent to which faculty's experiences in the professoriate influence doctoral students' attitudes toward working in academia. This should happen within and beyond STEM fields, as some of these findings are applicable to the generalities associated with the doctoral processes and experiences. To the extent that this is the case, researchers should then explore ways of improving faculty experiences, in addition to improving doctoral students' experiences. Nonetheless, the responsibilities of being a faculty member at most institutions are growing increasingly heavy, and, as indicated by our respondents, doctoral students seem to look to the experiences of junior faculty as an indicator of what a career in the professoriate would be like. Therefore, we propose several additional steps institutions of higher learning could take to improve the climate for junior faculty specifically. These include (1) giving assistant professors seed money for the first three or four years of the professorship to ease the grant funding crisis; (2) encouraging senior faculty mentors to coach, protect, and guide new faculty through the academic terrain, with additional support systems to manage their own stress and to avoid overburdening their doctoral students; and (3) assessing junior faculty members' training to prepare doctoral students for faculty positions, to name a few.

Further advances are needed to improve pathways to the professoriate, and further research is necessary to improve the engineering and computing Ph.D. socialization process. Future studies should further explore which contextual factors are most related to engineering and computing doctoral students' disinterest in faculty careers, with a focus on whether these factors disproportionately impair the career trajectories of members of historically underrepresented groups. Engineering and computing doctoral students from historically marginalized groups in particular would profit from such an analysis, since they have been found generally more likely to follow nonacademic career pathways than those from well-represented groups (Gibbs & Griffin, 2013; Turk-Bicakci, Berger, & Haxton, 2014). It is especially important that initiatives seeking to improve doctoral students' perceptions of and preparation for faculty life do so within broader contexts that improve faculty well-being. For example, women of color faculty who have obtained prized faculty positions continue to confront situations that limit their authority even when tenured, and as they address these situations, they experience more stress and strain (Gutiérrez y Muhs, Niemann, González, & Harris, 2012; J. Jackson, 2004; Turner, 2002).

This study highlights the myriad reasons for U.S. engineering doctoral students' dissuasion from entering the engineering and computing professoriate, and how various stakeholders (e.g., administrators and funders) might address students' reservations. First, future research should examine how representative these findings are to engineering and computing doctoral students in the U.S. and whether or not they are generalizable across other populations and places. The experiences of doctoral students in the U.S. are likely different from the experiences of their counterparts in other countries, who may be subject to different tuition costs, academic experiences required for admission, and time pressures for completion—all of which could impact perceptions toward remaining in an academic setting for one's career. Second, future research should focus on differences in reasons for disinterest in academia between STEM doctoral students and postdoctoral researchers. Ph.D. graduates are increasingly extending their training into postdoctoral positions, which have absorbed many demands of academic science, technology, engineering, and math (STEM) research as tenure-track academic positions have declined (Andalib, Ghaffarzadegan, & Larson, 2016; NSB, 2018). Similar to doctoral students, research has shown that some postdoctoral scholars become significantly less interested in pursuing research faculty positions over the course of their postdoctoral tenure (Grinstein & Treister, 2018); however, it is unclear why this is the case. Characteristics of doctoral students and the expectations associated with the positions they fill and those of postdoctoral researchers differ in significant ways, which would have different implications for how these roles are structured to make academia more attractive. Finally, while some of the reasons cited in this study, such as general disin-

terest, a perceived lack of fit, or stress and strain, are common to all fields, future research should explore the degree to which doctoral students in other fields have similar reasons for their disinterest in academia. Engineering and computing are significantly less diverse fields than other fields, which could mean that certain reasons for disinterest in the academy (e.g., discrimination) could be amplified in these fields. Furthermore, the variety and quality of the overall job-market and non-academic career alternatives vary across fields (e.g., STEM and non-STEM), which means these findings likely vary across disciplines (Langdon et al., 2011). Approaches to improve conditions and improve the perceptions that doctoral students and postdoctoral researchers in engineering have of academic careers should be as tailored as much as possible to maximize successful change.

CONCLUSION

Undoubtedly, there are fewer research faculty positions available than there are doctoral students, so not all interested individuals can become faculty. However, faculty are powerful forces in shaping engineering and computing education—the profession's basic source of training and skills—and so the preparation of a diverse set of potential faculty members is critical to scientific enterprise as a whole. The respondents indicated the very real and systemic norms and pressures of the academy that not only make it appear unattractive to them but also lead to their perceptions of it being a toxic and hostile working environment. With recent pushes to diversify the U.S. engineering professoriate, this perception of the academic culture runs contrary to those goals. By tolerating environments that turn away individuals who would be well-trained professors and who could mentor and encourage all students, engineering and computing departments run the risk of threatening innovation and creativity in the field by creating a narrower professorial pool during the doctoral process. At a time marked by dramatic social changes stemming from climate change, globalization and the explosion of technology, the "half-life" of engineering knowledge will only decrease (Wulf & Fisher, 2002). Status quo engineering and computing education practices at the doctoral level have the potential to do a disservice to humanity, because all of us benefit from engineering and computing. Furthermore, the responses from our survey participants revealed that if these practices, including the professional development of faculty, continue 'as is' then groups of talented individuals may be turned away from a viable means of ensuring well-rounded and robust developments impacting the engineering and computing fields and its world-impacting outcomes. The recommendations outlined in this paper are prospective starting points to initiate beneficial institutional change.

The results of this study challenge academicians—especially in engineering and computing departments—to continue to improve on doctoral student socialization and training to increase the attractiveness of faculty positions. Although some participants cited a general lack of interest in faculty positions (which in some cases was not directly linked to poor experiences), most participants turned away from the academy because of their experiences, perceptions, and observations of norms that misalign with their goals to make utilitarian contributions to society, live balanced and adequately compensated lives, teach the next generation of scientists, and contribute to making the world more equitable and innovative.

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BIOGRAPHIES

Ebony McGee, associate professor of diversity and STEM education at Vanderbilt University's Peabody College, investigates what it means to be racially marginalized in the context of learning and achieving in STEM. In particular, she studies the racialized experiences and racial stereotypes affecting underrepresented groups of color. Her research also focuses on the effect of racialized experiences and bias on STEM education and career by exploring the costs of academic achievement through problematizing traditional ideologies of success. She investigates how marginalization undercuts STEM experiences through psychological stress, interrupted STEM career trajectories, impostor phenomenon, and other debilitating issues. Education is McGee's second career; she left a career in electrical engineering to earn a Ph.D. in mathematics education from the University of Illinois at Chicago. With funding from five National Science Foundation (NSF) grants, McGee co-founded the Explorations in Diversifying Engineering Faculty Initiative (EDEFI; pronounced "edify"). Visit EDEFI's website at blackengineeringphd.org.

Dara Naphan-Kingery is an interdisciplinary social psychologist and postdoctoral researcher at Vanderbilt University with the Explorations in Diversifying Engineering Faculty Initiative (EDEFI) group. She is interested in understanding the racialized and gendered experiences of historically marginalized engineering scholars. She is particularly interested in how mental health and identity management strategies mediate the relationship between discrimination experiences and academic and career outcomes, and the role that social responsible engineering and social justice in engineering can play in attracting and retaining underrepresented students to the field.

Dr. Faheemah N. Mustafaa is a postdoctoral researcher in the Department of Psychology (Social-Personality area) at the University of California, Berkeley. Her research primarily focuses on K-12 educators' racial attitudes and classroom practices, and students' perceptions of their teachers' classroom practices. Currently, she manages research partnerships to address racial inequalities in disciplinary, academic, and attendance outcomes in several school districts around the U.S. in collaboration with Dr. Jason Okonofua, assistant professor of psychology. She is committed to work that provides equitable access to education and wellness opportunities for all children. Dr. Mustafaa earned her doctorate in the Combined Program in Education and Psychology, and master's degree in Higher Education at the University of Michigan, and a bachelor's degree in Biobehavioral Health at Pennsylvania State University. She is a Ford Foundation fellow and Co-PI on a Jobs for the Future Student-Centered Learning Research Collaborative grant with Dr. Okonofua.

Stacey L. Houston II, Ph.D., is an Assistant Professor in Sociology at George Mason University. He received his B.A. Sociology from Davidson College in 2013 and his M.A. and Ph.D. in Sociology from Vanderbilt University in 2015 and 2018 respectively. His major research interests are health disparities, criminal justice, race/ethnicity, and education. His specific research projects highlight the intersections of these broad fields. In his dissertation study, Stacey explored the link between education, interactions with the criminal justice system, and well-being. He investigated how disciplinary practices in early education contribute to involvement with the criminal justice system, which, in turn, leads to health disparities across racial groups. While at Vanderbilt, Stacey worked on the EDEFI project for four years.

Portia K. Botchway is a doctoral student in the Department of Learning, Teaching, and Diversity at Vanderbilt University's Peabody College where she studies mathematics and science education. Portia received her A.B. in Organismic and Evolutionary Biology from Harvard College with a secondary field in Classics. Between her undergraduate and graduate studies she taught middle school science and high school biology and chemistry for four years at a charter school in Boston, MA. She is currently a graduate research assistant on EDEFI and additional research projects investigating how elementary students use spatial reasoning and awareness to make sense of angle, length, area, and volume measurement and teachers interpret student work as assessment evidence. Her research interests include how elementary teachers interact with disciplinary perspectives in mathematics and how teacher learning in the context of professional learning communities impacts instruction and supports student learning.

Jeremy Lynch is a postdoctoral researcher at Vanderbilt University with the Explorations in Diversifying Engineering Faculty Initiative (EDEFI) group. He received his Ph.D. in Counseling Psychology and has worked at various universities in the area. In addition, he has practiced as a psychologist serving the underrepresented community for 3 years.

His research interest include; exploring the interactions of vocational identity, multiculturalism, and mental health stigma in STEM students, in addition to underrepresented populations.