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RISING MINORITIZED DOCTORAL STUDENTS IN ENGINEERING: WHO ARE THEIR MENTORS AND WHAT ROLES DO THEY FILL?

Carol Geary,[1,*] Mayra Artiles Fonseca,[2] Sarah Blackowski,[3] & Holly Matusovich[1]

[1]*Virginia Polytechnic Institute and State University, College of Engineering, Blacksburg, Virginia 24061, USA*

[2]*Arizona State University, Mesa, Arizona 85212-2180, USA*

[3]*University of Wisconsin Milwaukee, Engineering & Mathematical Sciences, Madison, Wisconsin 53706, USA*

*Address all correspondence to: Carol Geary, Virginia Polytechnic Institute and State University, College of Engineering, 667 McBryde Hall, 225 Stanger St., Blacksburg, VA 24061, USA; Tel.: +540-231-4205, E-mail: cpgeary@vt.edu

Mentors are key to the academic success of engineering graduate students, and particularly historically marginalized graduate students. To continue to enhance and improve mentoring experiences in order to support minoritized students to persist in their doctoral degrees, it is important to understand who is mentoring minoritized students regarding enrollment in doctoral programs and what expectations these students have for mentoring in graduate school. We used interviews and focus groups to explore who students cite as mentors and who they expect to fill this role once entering the doctoral pursuit. We used a theoretical framework organized around different support and challenge roles that dissertation advisors might play to understand the different roles these mentors played. We found various roles in which a variety of mentors influence minoritized students enrolling in doctoral programs, including family, informal undergraduate mentors, and peers, as those who support their decision to enroll. Our findings also detail the expectations of rising minoritized students for future advisors.

KEY WORDS: *mentors, doctoral students, mentor roles, engineering*

1. INTRODUCTION

Research shows that mentors are key to the academic success of minoritized students in engineering, both at the undergraduate (Smith and Paretti, 2015; Newman, 2015; Mondisa and McComb, 2015) and graduate levels (Holloway-Friesen, 2019). Doctoral students are more likely to persist to graduation and report higher degrees of satisfaction with their program when they engage in a meaningful relationship with a faculty mentor or advisor (Bair and Haworth, 2004). However, because minoritized students achieve PhDs at lower rates than their majority counterparts, there are fewer mentors from minoritized backgrounds (either faculty or advanced graduate students) available to mentor minoritized students pursuing a PhD (Johnson-Bailey and Cervero, 2004). Because fewer role models match minoritized students' demographic characteristics and

life experiences, it is important for the academic community to understand the mentorship of rising minoritized engineering doctoral students receive about pursuing a doctorate prior to commencing the PhD and their expectations of mentoring moving into the PhD process. Our research questions are:

- What roles do the mentors influencing minoritized students enrolling in engineering doctorates fulfill?
- What role expectations do these students have for future mentors in graduate school?

This study has implications for mentors, faculty, and administrators interested in changing the engineering landscape for minoritized students. Understanding how rising minoritized doctoral students perceive their mentors can help these stakeholders address systemic gaps in student support.

1.1 Defining Mentoring

Although the doctorate community sees the concept of mentoring as important, existing literature does not have an agreed-upon definition of what mentoring entails. In fact, for years researchers have called out the need to operationalize the mentoring relationship concept to strengthen mentoring research (Crisp and Cruz, 2009; Jacobi, 1991). Some of the seminal works in the mentoring literature originally described the functions of mentoring as providing (1) psychosocial support and (2) career or instrumental support that includes providing challenging work toward skill development (Kram, 1983). However, current literature has shifted more toward mentoring relationship dynamics (Pfund et al., 2016; Straus et al., 2013). Thus, a more current definition for mentoring by the National Academies of Sciences, Engineering, and Medicine (2019) has defined mentorship as "a professional, working alliance in which individuals work together over time to support the personal and professional growth, development, and success of the relational partners through the provision of career and psychosocial support" (National Academies of Sciences, 2019, p. 2). Our study builds on existing research and furthers calls to define and operationalize the mentoring relationship by using "mentoring roles" to conceptualize the mentoring that rising minoritized doctoral students receive and from whom they receive it.

1.2 Mentorship and Minoritized Students' Decisions to Pursue and Persist in Graduate Education

Mentors are critical in helping minoritized students consider and pursue doctoral education in ways that are consistent with the definition of mentoring as providing career and psychosocial support. In a study of minoritized undergraduate engineering students, Mondisa (2015) found that mentors can be a key force in helping students identify career opportunities of which they may not have been aware. Similarly, Gordon et al. (2015) examined minoritized graduate students involved in an enrichment program for

academic careers. They found that the students were more likely to pursue academic faculty-type jobs after graduate school and were more prepared for these careers. Specifically, relationships with faculty members can lead undergraduates to enrollment in graduate education as they help students harness their disciplinary passion and develop an autonomous path into a future career (McGee et al., 2016).

Beyond influencing the decision to pursue graduate education, mentoring is influential in helping students adapt to ongoing challenges within graduate education (Aikens et al., 2017; Lunsford, 2012). Multiple studies have shown that minoritized students strongly benefit from mentoring by helping them combat the transition isolation they face in doctoral programs (Mondisa, 2015; Redmond, 1990). Yet, finding appropriate mentors can be a challenge for minoritized students due to a lack of role models, especially in engineering (Davidson and Foster-Johnson, 2001). One possible relationship that could turn into a mentor relationship is the doctoral advisor, which, when combined with a mentoring relationship, can be very powerful to doctoral graduate students.

1.3 Nuancing the Concepts of Advising and Mentoring

While the advisor–advisee relationship is frequently touted as a cornerstone of the doctoral process, mentoring and advising are not the same. Not all advisors are mentors and not all mentors are advisors—although some people can serve the function of both, which we argue here. There is a difference between a doctoral advisor and a doctoral advisor who is also a mentor (Burt et al., 2021; Lunsford, 2012). Lyons et al. (1990) defined the role of the advisor as a faculty member acting in an official capacity who helps their advisees plan their course of study, evaluates their progress, and shepherds their pathway through the PhD. Advisors are graduate students' "official link to the university in matters of policy and planning" (Lyons et al., 1990, p. 277). In contrast, the authors describe the primary function of a mentor in the doctoral process as to "act as a guide in the rite of passage from novice to professional in all aspects" (Lyons et al., 1990, p. 278). Lunsford (2012) found this exact difference in the student experience by showing that, although students strongly value mentoring, not all students would consider their advisor to be a mentor. Lunsford (2012) argues that mentoring comprises two supports: (1) career support and (2) psychosocial support. Career support includes the ability to write publications and professional presentations, whereas psychosocial support is more closely related to a student's satisfaction with the advising relationship. Lunsford (2012) also found that students who are more satisfied with their advisors are more likely to take their career advice. From the faculty perspective, Titus and Ballou (2013) found that faculty members, whose primary responsibility is to educate PhD and MD PhD students, prefer to view themselves as advisors (54%) rather than mentors (38%). Therefore, for this work we define an advisor as a student's formal and primary guide through curricular progress toward degree attainment and a mentor as someone who can provide both career and psychosocial support. While a person can serve varying degrees of either type of support, we reiterate that not all advisors are mentors and not all mentors are advisors.

Yet, when advisor and mentor roles combine, they can help students' persistence toward degree completion. Through a meta-synthesis of research on doctoral education, Bair and Haworth (2004) found that having a meaningful relationship with their advisor increases the likelihood of doctoral students persisting and satisfied with their relationship. Many studies argue that this meaningful relationship develops when the advisor provides psychosocial support within the advising relationship (Bell-Ellison and Dedrick, 2008; Katz, 1997; Lechuga, 2011). An advising relationship that encompasses mentoring can be specifically beneficial to minoritized students and their persistence in the doctorate. Felder (2010) found that successful students, specifically Black students, who are successful in pursuing a PhD are those who responded positively to mentoring. This positive mentoring can often lead to research collaborations and idea sharing that can help enhance a student's sense of inclusion as well as acknowledgment outside of the classroom. This acknowledgment outside the classroom holds much value for students who do not feel like they belong in a place, and all those students appreciate having faculty relationships where they feel support and welcome support from across all races. Similarly, Espino (2014) found that when minoritized students engage positively in these mentoring relationships, these relationships become a source of cultural capital that benefits both the mentee and the mentor. The author argues that this capital can often be the difference between a student completing the doctorate and a student not completing the doctorate as these systems of knowledge help them fight the racial oppression they face in academia. Holloway-Friesen (2019) shows that possessing cultural capital shared with their mentor increases academic self-efficacy, fostering a sense of belongingness. However, if there is a lack of understanding of students' needs, these relationships can sometimes become sour. Artiles and Matusovich (2020) found an unintentional mismatch in the expectations between faculty and underrepresented students' beliefs in their ability to complete a doctorate in engineering. These misalignments in the motivation for pursuing the doctoral degree between the advisor and the student can ultimately impact how minoritized students receive an advisor's feedback. While all students can be prone to mismatches with their advisor (Devos et al., 2016), minoritized students specifically can have deeper implications regarding identity development (Barker, 2011).

Despite the benefits of mentoring and the potential positive impact on minoritized students' experiences, finding a mentor can be a difficult endeavor. Mentoring is time-consuming (Mollica and Nemeth, 2014), and both the mentor and mentee will only engage in it if they believe they will receive value and academic knowledge (Smith, 2007). For groups who are more isolated in higher education, mentoring can be an even more difficult endeavor. International students who are also undergoing adjustment to a new culture as they progress in their doctorate or students older than the traditional doctoral demographic are less likely to find mentoring (Le and Gardner, 2010; Rose, 2005). Women often seek both personal and professional mentoring; seeking acceptance and confirmation from their mentors as they progress in their discipline (Archie et al., 2015; Rose, 2005). Yet, the benefits of mentoring are clear, as mentoring in relation to

the PhD can help decrease isolation and increase degree progression, ultimately leading to retention (Mollica and Nemeth, 2014).

1.4 Beyond Advisors

Beyond the advisor, the process of entering graduate school and completing a doctoral degree involves receiving support through interactions with a variety of mentors such as peers, family, and undergraduate research mentors.

1.4.1 Peers

Research on doctoral students shows that much of the learning that occurs in the more informal stages of the doctoral degree occurs through peers, and studies have discussed the key importance of peers as mentors in student development (Lovitts, 2001; Weidman et al., 2001). Holley and Caldwell (2012) showed that peers can help students make the most of the doctoral experience while enhancing faculty mentoring. Peers are particularly instrumental in the writing phases of the doctoral degree, as they provide accountability toward goals and vicarious experiences through which students can make meaning of their own (Maher et al., 2013; Wilmont and McKenna, 2018). Development of peer groups, either formally or informally, provides social support to those in the early-career stage of postdoctoral researchers (Vekkaila et al., 2018). The role of peers can be particularly critical within engineering when considering the traditional organization of research groups (Crede and Borrego, 2012) and the collaborative nature of research in STEM fields (Zhao et al., 2007).

1.4.2 Family

Research in higher education demonstrates that family is also an influential factor in doctoral degree persistence, particularly for students of color. Many communities of color, particularly Asian/Asian American, African/African American, and Latinx, tend to place greater value on the overall well-being of the family and community over any individual's achievement (Mattanah et al., 2004). Thus, it concludes that the family influence over minoritized students entering their doctoral journey goes beyond the traditionally used markers such as parent education level, socioeconomic status, and gender to the active ties students maintain with these communities throughout their educational journeys (Garcia et al., 2020; Weintraub, 2020). While a number of studies report connections between the role of family and student persistence in undergraduate engineering (Huang et al., 2000; Matusovich et al., 2020; Villa et al., 2016), fewer studies demonstrate the role of family in the decision to pursue doctoral degrees. A notable exception is a study by McGee et al. (2016) that found family to be one of several distinct factors that influenced Black engineering students' decisions to enroll in an engineering doctoral program. To our knowledge there are no studies that explore the influences of family as mentors in the engineering graduate setting. However, some studies show

family as mentors of underrepresented minorized graduate students in STEM where all participants characterized their parents as supportive mentors (Yang and Gentry, 2022).

1.4.3 Undergraduate Research Mentors

Linn et al. (2015) often describe undergraduate research as an effective recruitment tool for doctoral students because it provides experiences similar to doctoral education. However, not all research experiences and interactions encountered by students are equal. In a study of undergraduate research mentors in engineering, Ahn and Cox (2016) found that students desired mentors who could establish positive relationships, acknowledge their individual needs, tailor their guidance to match those needs, demonstrate attentiveness to the students' daily tasks, and foster personal connections. However, research finds differences in mentoring structures and research outcomes along gender and racial lines, particularly concerning the interactions undergraduate students have with their fellow students, graduate student or postdoc mentors, and faculty advisors (Aikens et al., 2016). These differing interactions ultimately lead to disparities in students' scientific identity and lower intentions to pursue a STEM PhD. Thus, we cannot deem all undergraduate research mentors as equal or having similar impact across all students.

1.5 Summary and Purpose of This Study

In sum, mentors play a critical role in the experiences of minoritized students in doctoral programs. Yet, appropriate mentors can be hard to find, particularly for minoritized students. To remedy this situation, it is important to ask students what they need and then listen. Research shows that among underrepresented engineering students, when faculty and programs listen to the students' individual needs, they can adapt their graduate programs accordingly (Wood et al., 2016). Our study leverages existing research that shows the specific dynamics of mentoring for minoritized students to identify what types of mentoring students describe before and after going into graduate school and to support ways of promoting better mentoring and advising for graduate students, particularly for minoritized graduate students.

1.6 Theoretical Framework

We situated our research using the framework of support and challenge conceptualized by Spillett and Moisiewicz (2004). Spillett and Moisiewicz created this framework to give dissertation advisors strategies to facilitate a successful dissertation learning process. The support and challenge framework describes four possible roles a dissertation advisor (adapted for this study to include mentors more broadly) can fulfill: cheerleader, coach, counselor, and critic (4C). Within the 4C framework, cheerleader and counselor are supportive roles, while the coach and critic are challenge roles. Supportive roles function through the relationship or process, while the challenge roles function through the tasks or outcomes of the dissertation experience. The mentor who demonstrates

interest in the individual embodies the cheerleader role—the cheerleader believes in students' abilities and is willing to help. The counselor role assists students to become aware of psychological obstacles to completing the dissertation and to learn effective self-management skills. A mentor acting in a counselor role helps a student identify and remove roadblocks, focus on work progress, and normalize the experience (Spillet and Moisiewicz, 2004). A mentor acting as a coach will direct the student in completing the activity or dissertation. Specifically, the coach will break a large outcome into discrete, appropriate steps for the skill of the student and the timeline for the completion of the larger task while maintaining a holistic view of the overall research endeavor. The critic role is the one that Spillett and Moisiewicz (2004) say may be the most familiar to faculty. The critic evaluates a student's work to see if it meets specific standards while inspiring students to strive for higher and higher quality products. Spillett and Moisiewicz (2004) posit that a successful relationship will span both supportive and challenging roles.

Considering popular advice for students to have multiple mentors, we assert that multiple people outside the dissertation advising relationships could also be filling these four critical roles for graduate students. Thus, we sought to identify from the student perspective what people were filling what roles presently and their expectations for these roles in graduate school. We leverage this framework to understand the conceptions rising doctoral students have about the people in their mentoring networks upon starting a dissertation early-information intervention. Table 1 outlines the mentor roles, role categories, formal definitions from Spillett and Moisiewicz (2004), and how we operationalized the roles when coding the data for this research. Because the framework specially focuses on the advisor/student relationship, we operationalized the mentor roles to have a slightly broader scope that includes anyone serving as a mentor for the incoming doctoral student. We do not assume these are the only roles mentors may be fulfilling, but these four provide a theoretical and practical starting point.

A review of the literature found no direct research applications of Spillett and Moisiewicz's framework, although researchers have cited it when establishing arguments for and interpreting findings from studies on advising relationships (Barnes et al., 2010; Jimenez y West et al., 2011). As argued in the literature review, many but not all advising relationships are also mentoring relationships (Lunsford, 2012). Thus, the 4C framework described offers a general perspective on dissertation advisors (and mentors more broadly, as we argue) and all the possible roles they can play within a relationship, not accounting for disciplinary nuances. Prior work looking at advising relationships shows that within the sciences advisors are more than guides toward degree progress for students in STEM (Zhao et al., 2007). Rather, they operate on what is also known as the "science model of advising" where the advisor and student also are collaborators, coworkers, and coauthors, and they self-select each other into relationships based on these broader criteria (Joy et al., 2015). This closer relationship allows for more opportunities to engage in different aspects of mentoring beyond merely advising for degree progress. For this reason we believe this framework can both expand and operationalize the support students receive before entering the PhD and illustrate potential gaps in

TABLE 1: Definition of mentor roles based on the 4C framework

Mentor role	Role category	Definition (Spillet and Moisiewicz, 2004)	Operationalized
Counselor	Supporting	"Assists students to become aware of psychological obstacles to completing the dissertation and to learn effective self-management skills." (p. 252)	The counselor helps to normalize the graduate school experience and the feelings it evokes through conversation.
Cheerleader		"Demonstrates interest in students, belief in students' abilities, and willingness to help students through the dissertation process." (p. 251)	The cheerleader provides verbal support and encouragement for the student regarding their ability to succeed in graduate school.
Coach	Challenging	"Directs the entire activity necessary to complete the dissertation and breaks the myriad tasks into small steps that are concrete, specific, and do-able." (p. 254)	The coach knows the graduate school context and can provide measurable, actionable steps to help the student be successful.
Critic		"The advisor evaluates students' work according to appropriate standards and inspires students to strive for a high-quality product." (p. 256)	The critic challenges students by normalizing criticism and providing constructive evaluation of student work to help them improve.

their expectations for mentoring moving into the doctoral program, as indicated in the purpose of this study.

2. METHODS

This analysis is part of a larger exploratory case study (Artiles Fonesca et al., 2021) that involves the Rising Doctoral Institute and seeks to understand the experiences of minoritized engineering students entering doctoral programs. To characterize rising minoritized doctoral students' perceptions of their mentors while pursuing a doctoral education, we conducted a qualitative analysis of interviews and focus groups with rising minoritized doctoral students in engineering who participated in the Rising Doctoral Institute. We conducted this research in accordance with human subject research protocols.

2.1 Context

The Rising Doctoral Institute workshop was a one-week program designed to help minoritized students prepare for their doctoral degree programs. Funded by the National

Science Foundation (NSF), the Rising Doctoral Institute program recruited students nationally and paid travel expenses for their in-person attendance at the workshop. The Rising Doctoral Institute workshop included interactive learning sessions for students such as maintaining advisor relationships, time management, working with the literature, strategies for success in graduate school, among other similar topics focused on preparing students for doctoral programs. The workshop and data collection took place in summer of 2019. All workshop participants were to start their doctoral degrees in the fall term following the workshop in engineering at different primarily White institutions (PWIs) across the United States.

2.2 Participants

The Rising Doctoral Institute workshop enabled access to the participants through their participation. Our analysis includes a total of 17 participants who were all rising minoritized doctoral students enrolled in doctoral engineering programs. Participants self-selected into interviews or focus groups based on their individual preference. We interviewed six of the participants individually and conducted two separate focus groups to interview the remaining 11; one focus group included seven participants and the other included four participants. We aimed to elicit responses from all participants in the focus groups but allowed them to self-select when they were comfortable sharing. Ten participants self-identified as male, six as female, and one as nonbinary. Eight out of the 17 participants identified their ethnicity as Hispanic. Eight out of the 17 identified their race as Black or African American. To protect participants' identities, we provide demographic information separately, as indicating intersections could make participants identifiable. Moreover, we did not analyze differences by demographic characteristics and therefore refer to all participants using they/them/their pronouns and assigned gender-neutral pseudonyms to each of them.

2.3 Data Collection

We used semistructured individual interviews and focus group interviews as the primary data collection method. The main purpose of the interviews was to understand rising doctoral students' perspectives on their upcoming doctoral process, relationships with their advisor, and past experiences doing research. We conducted individual interviews over Zoom prior to the Rising Doctoral Institute workshop and conducted focus group interviews in person during the Rising Doctoral Institute workshop. The workshop and data collection took place in summer of 2019. Individual interviews and each focus group lasted approximately 1 hour. The last three authors collected the data. To ensure consistency across the execution of the data collection, we met to design the interview protocol and agreed on the questions we would prioritize for a response. The research team saved all interview and focus group audio files and later transcribed them for analysis by a professional service. The interview protocol intended to elicit responses that describe the typical activities and interactions of the participants in their academic ac-

tivities, as well as their perceptions of their upcoming doctoral process. Examples of the questions included in the protocol are "Why did you pursue a PhD?" "How did you [or plan to] select your advisor?" and "Who helped you decide to pursue graduate education?" The questions in the focus group were similar in nature but also included questions regarding what lessons they learned during the week of the intervention.

2.4 Data Analysis

Drawing on a constructivist worldview (Denzin and Lincoln, 2005), we first analyzed transcripts using emergent coding (Saldana, 2015) where we identified that students talked about different mentors pertaining to their attending graduate school (Table 2). Using the emergent codes, we identified groups of people whom participants identified as serving mentoring roles. After identifying all sources of mentoring articulated by the students, we leveraged the 4C (Spillet and Moisiewicz, 2004) framework to apply *a priori* codes (Miles et al., 2014) as shown in Table 1 based on participants' articulation of the roles served by their different mentors. The output of these two coding rounds results in a list of people who mentored the students or whom they expected to receive mentoring from, along with the specific mentoring role each person took or expects to take. One thing to note is that the researchers did not explicitly ask the participants about these mentor roles or about the 4C framework, and they applied the support and challenge framework as a lens after data collection.

We identified five groups as the most salient, including 1) informal undergraduate mentors, 2) future doctoral advisors, 3) peers, 4) family, and 5) colleagues. We had a sixth group that captured "other influential mentors" as people who had significant impacts on future plans but that did not fit into the other five categories. We did not see any patterns relative to who was in this group or what roles they served. Therefore, further analysis of this final category would potentially be fruitful for future work. Table 2 includes the definitions of the codes and examples from the data. It is important to note that not all participants had committed to their future doctoral advisors at the time of the interview. However, all participants did have a faculty advisor in mind when talking about their future relationships.

2.5 Quality and Researcher Positionality

As a research team, we did three things to ensure the trustworthiness and validity of our study: peer examination, inter-rater reliability, and clarifying researchers' potential biases. First, at key points during the study the team met to discuss the study's progress and the appropriate decisions required to move forward (Tracy, 2010). These meetings came after data collection to debrief our initial thoughts about the interviews and focus groups, and after researcher (Carol Geary) had read through all the transcript data to discuss initial emergent themes, to develop a codebook, and to discuss themes from the data analysis. Second, to ensure inter-rater reliability, this study went through two rounds of inter-researcher triangulation with the author team. In the first round, two graduate re-

TABLE 2: Codebook

		Definition	Operationalized
Sources of mentorship	Future doctoral advisor	Those faculty advisors the participants perceived as the faculty advisor they would choose for their dissertation.	"My advisor, they even talked about their own hardships when they were going through their PhD program and they were expressing, as an advisor, 'I don't want to be like that.'" – Blake
	Informal undergraduate mentors	People working in the university setting who advised or mentored the participant, including undergraduate research professors, academic advisors, participants teaching professors, and other professionals working in the college setting.	"They're a faculty member in a different department, engineering technology department, and they're one of the only ones that does engineering ed research at (university). So, we published a paper together, and I was able to go (to a conference) because of that." – Jesse
	Peers	People who lived through an experience now mentoring a person who is new to that experience.	"They were very helpful in terms of what classes to sign up for. Even helping me with finding housing, or at least how to go about it. They also, at the start, 2 years ago, gave me advice on what to expect as a graduate student, how they live a typical life as a graduate student." – Avery
	Family	People identified by the participant as family.	"As for my mom, I think she was more accepting of it at the beginning. What she did, she supported me by questioning what I was doing. She was trying to make sure that I was thinking ahead of time, in the big picture, and that I'm not doing something rash." – Avery
	Colleagues	Colleague is a person that participants work with in a professional setting.	"I had dinner with the vice president (of my internship company)… I don't know, they wanted me to be exposed to what my potentials were, and things I could strive for and just expose me to … the industry" – Blair

searchers (Carol Geary and Sarah Blackowski) coded three of the same interviews and came together to discuss similarities and differences. When there was a difference, they decided together upon the appropriate coding. In the second round, the same graduate researchers independently coded the rest of the interviews and came together to ensure that the results were also congruent within and among participants to ensure all salient themes were consistent. Upon conclusion of the coding process, our inter-rater reliability exceeded the recommended 70% (Stemler, 2004). Finally, we reflected on our roles as researchers through writing a detailed identity memo (Maxwell, 2009; Secules et al., 2021). Creswell (2009) suggests researchers take a look into their own backgrounds in order to help the reader see the context and setting for the researchers' decisions. Each author has included a positionality statement:

I (Carol Geary) am a cis, LGBT, mixed-race, female graduate student and worker who attended the same institution for my undergraduate degree and am now pursuing a PhD. As a person of mixed heritage, I found myself sharing a number of experiences that the participants described. While they were not identical, I did see myself in a few of the participants. My experiences as a minoritized student has shaped me to be the human I am today. I have little undergraduate research experience, but I have had a number of undergraduate mentors who held these different roles of coach and counselor from my third through the fifth year. As a graduate student, I see my faculty advisor as a combination of coach and critic as I step through the milestones of the dissertation process.

I (Mayra Artiles Fonseca) am a cis, Latinx, female faculty member in engineering with various years of prior engineering industry experience. Having had a master's degree prior to commencing my doctoral journey and researching doctoral education throughout this process, I had an understanding of the many hats my advisor would wear during my doctoral journey, aligning the process with my expectations. As a faculty advisor who researches doctoral education, I strive to make myself aware of my students' expectations and make them aware of mine in the negotiation that is advising.

I (Sarah Blackowski) am a cis, White, female graduate researcher and I attended a PWI with a special focus in a few topics for my undergraduate degree in engineering. Currently, I am at an urban research university completing my PhD while working as an early-career faculty. As a result of my undergraduate and graduate settings, I have not had the same minoritized experiences as the participants. However, I can see some of the same experiences around the perception of the undergraduate and graduate faculty mentor. My undergraduate research mentor acted as a cheerleader throughout my third and fourth years, while coming into graduate school I saw my faculty advisor as someone to strictly coach me through my experience. Since I do have experience as an undergraduate researcher and now a PhD candidate, I can see some of my background intersecting with my participants, but due to the discrepancy in our demographic backgrounds there is potential for some bias, as is likely in most empirical research.

I (Holly Matusovich) am a cis, White female faculty member in engineering education with significant prior experience in consulting and industry. I had no undergraduate research experience and earned all three of my degrees (bachelor's, master's, and doc-

torate) at different universities some years ago. I was a first-generation doctoral student in my family, and as such elements of participants' stories resonated with me, though I recognize that my majoritized identities also grant me privileges as a graduate student and today as a researcher.

As a research team, we have a diverse collection of social identities and experiences that inform our education, careers, and ultimately our research interests. All authors have a background in engineering education, including qualitative data collection and analyses. All authors identify as cis-gender women who are able-bodied but have differing experiences and views related to mentorship and the role faculty have in mentoring graduate students. These varying perspectives and roles we each had participated in, as well as our differing racial/ethnic identities, helped us work through possible interpretations of the participants' statements. It also allowed us to maintain precision in our assessments of the data by interpreting them from the multiple vantage points each of us brought to the analysis until we reached consensus of what the participant intended in context. Overall, our beliefs and backgrounds allowed us to approach this research informed by our unique experiences and positions as researchers, which at its core has been beneficial to this body of work.

2.6 Limitations

Our study relied on volunteers who participated in a workshop related to success in graduate school and who were willing to share their perceptions of the upcoming graduate process and their perceptions of their mentors. They participated in such a workshop and were willing to participate in the interviews related to common personality traits that motivated them to seek help in beginning their degree and share their experience in the process. Additionally, the sample participants attend different institutions and pursue doctoral degrees in different engineering disciplines. We believe these variations should have minimal influence on the results. However, these variations may have contributed in ways not easily visible to us in a one-hour phone interview and subsequent analysis. Another limitation of this study is that we applied the support and challenge framework as a lens after data collection did not explicitly ask the participants about these mentor roles based on the support and challenge framework. Therefore, our results represent a range of responses rather than the only set of responses.

2.7 Statement of Protection of Marginalized Populations

To protect participants who are members of marginalized populations, we held interviews with participants separately and ensured that no one participant knew the other interviewees. In the case of the focus groups, we disclosed to all participants our inability to protect their anonymity and participation due to the nature of focus groups and advised them to share with that information in mind and agreed as a group to not disclose information outside of the group. To protect their identities,

we do not disclose racial/ethnic groups of individual participants, nor do we use any identifying features of participant identity. To differentiate between individual participants in the results, the research team assigned gender-neutral pseudonyms to each of them.

3. RESULTS

Our research questions were, What roles do the mentors influencing minoritized students enrolling in engineering doctorates fulfill? and What role expectations do these students have for future mentors in graduate school? In answer to our research questions, we have three primary findings, summarized in Fig. 1. First, participants described a range of mentors who we interpreted as filling the counselor, cheerleader, and coach roles delineated by the 4C framework before graduate school. Second, when talking about expectations for graduate school, participants talked mainly about the future doctoral advisor and described ways that person would meet counselor, cheerleader, and coach roles. Third, the role of critic was largely absent from the data for both before graduate school and their expectation for during graduate school mentoring. The codes appeared in our data as follows: coach appeared a total of 52 times, counselor appeared a total of 19 times, cheerleader appeared a total of 18 times, and critic appeared a total of 9 times.

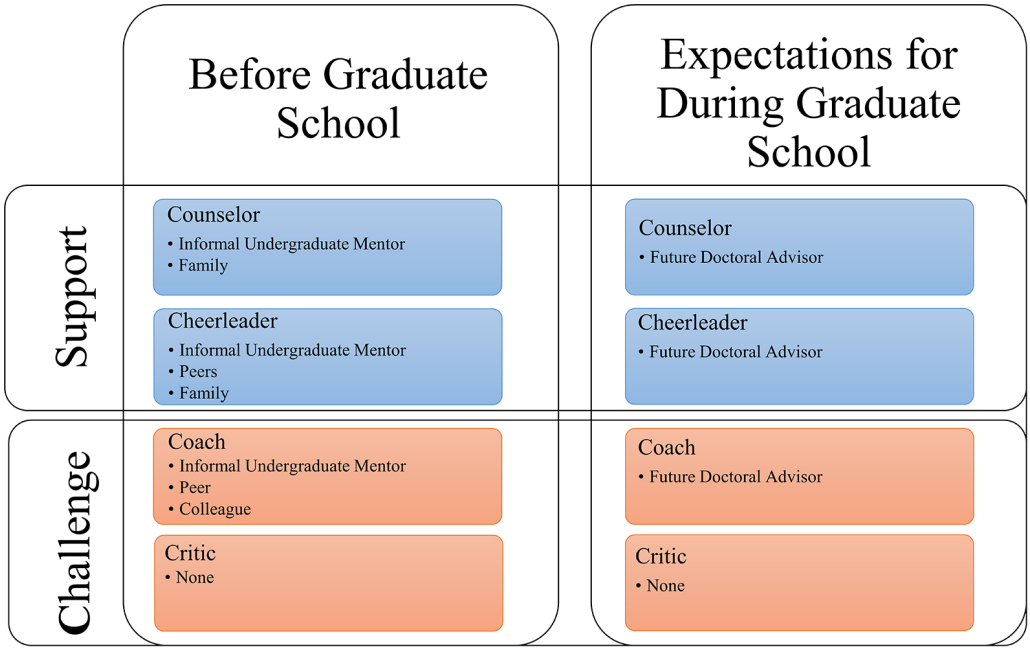

FIG. 1: Summary of mentor roles described before graduate school and expectations for during graduate school

3.1 Mentoring Experiences with Past Influential Mentors before Graduate School

When considering the people participants identified as mentors prior to graduate school and our interpretation of the roles they fill within the support and challenge framework, our results revealed several patterns. First, participants identified four distinct groups of mentors, including informal undergraduate mentors, colleagues, peers, and family. Second, in combination, these mentors filled three of the four possible mentoring roles we considered for participants: coach, cheerleader, and counselor. Notably, two are support roles (cheerleader, counselor) and one is a challenge role (coach). Finally, within these roles the different mentor groups often served different purposes. For example, as coaches, informal undergraduate mentors taught students about research processes, whereas as coaches, peers, and colleagues explained application processes. Similarly, mentors could serve across multiple roles, such as informal undergraduate mentors serving as coaches, cheerleaders, and counselors. The research team did not identify the role of critic with the four mentor groups.

3.1.1 Coaches

Our results showed that students mostly discussed mentors taking on the role of coaches in the decision of applying to doctoral education. These mentors were either informal undergraduate mentors who taught students about research, or people categorized as peers and colleagues who helped students understand the more organizational aspects of graduate education.

Informal undergraduate mentors are a combination of research advisors, influential professors, and other individuals working in the undergraduate context. Specifically, informal undergraduate mentors were often described as teaching students research procedures that gave them a clearer idea of what graduate school work could look like:

> *They are someone who actually cares about mentoring their students and teaching their students, and having their grad students grow as researchers and as people. […] Even last week when they were like, 'Oh, write the Result section,' I was like, 'I don't think I can do that. That's not going to happen, I'm sorry, you can't trust me with this.' [Undergrad Advisor] working with me now, they're like, 'No, just write it, just do it and we'll talk about it later,' I'm like, 'Okay, I guess this sounds good.' – Robin*

> *They had me shadow for a month or two, and then they had interviews that were [in our research topic]. I just jumped into qualitative research and now I'm writing the result section this week. – Sam*

Robin felt ill equipped to complete the task of drafting their research results. However, the undergraduate research advisor pushed them to pursue the task regardless and

provided feedback and support after the student made the first attempt. This promise of "We will talk about it later" gave the student confidence, despite feeling unprepared to complete the task. Sam's quote demonstrates how this participant also describes how their undergraduate research mentor coached them to gradually increase their ability to research and complete research tasks. In both examples, the undergraduate research advisor fulfilled the role of coach by allowing a space for the participants to build their research skills and facilitated their individual growth by providing a structured space for feedback.

Participants also described peers and colleagues who pursued PhDs previously as coaches. In this case we have grouped these distinct groups of mentors together because they provided the same types of coaching that was distinct from informal undergraduate mentors. As coaches, peers and colleagues were key in describing the benefits of a graduate education and the application process. For example, in Blair's internship one colleague who was the same race/ethnicity and had pursued a PhD motivated them to pursue this education:

> *I still didn't know what a PhD was. I thought it meant that you're a genius, and people call you doctor. That was my first exposure, and I saw how it was applicable in life and what you could do with it. This one guy every time I saw them at the gym they would pester me about what I was going to do after college. They would always talk about like, 'Oh, go to grad school.' I sat down with them at Chipotle one day for 2 hours and they really laid out everything about their experience, why they chose to get a PhD, how they got there, the route they took because they went into industry first, and they was trying to convince me that it'll be better in the long term to just stick it out and go through with whatever postsecondary education I wanted to get. – Blair*

This quote shows that this student had not considered the option of graduate school until this colleague encouraged them but also explained to them the process and benefits of obtaining a doctoral degree. While the encouragement overlaps with the cheerleader role, we note that the subsequent guidance in combination with the encouragement present a holistic approach of coaching. A second participant had a similar experience with graduate students (i.e., peers) in the institution where they practiced undergraduate research:

> *The students, the PhD students, they were very helpful in terms of what classes to sign up for. Even helping me with finding housing, or at least how to go about it. They also, at the start, 2 years ago and even last year, they gave me advice on what to expect as a graduate student or at least how they live a typical day in their lives as a graduate student. I was able to talk to them in person, through text, or email. They were quite accessible. – Avery*

Finally, a peer at the same educational stage offered coaching as well:

> *Part of the main reason why we did it together was 'cause we went away on study abroad, and so while we were there they were like, 'Oh we should study for the GRE together.' And I was like, 'I wasn't planning on taking the GRE 'cause I didn't know it was needed.' And I was like, 'Okay.' Then they're like, 'Yeah, if you do really well you can get fee waivers and stuff.' And so we have a whole plan our whole senior year, what we do together and how we would check in. And it was really helpful. They gave me all of these tips I didn't know about, about who to reach out to, what to say to people. And they helped me do interview prep. So them being there for me was really, really huge. – Sam*

Thus, we can observe that these peers and colleagues gave participants a front-row view of what their day-to-day could look like and the logistics of pursuing a graduate education. Peers and colleagues can encourage students to pursue graduate education by making the process of obtaining a doctoral degree clearer with defined tasks and goals specific to graduate education, and helping structure the tasks to make it manageable for the participants.

3.1.2 Cheerleaders

Participants also shared about having multiple cheerleaders supporting their decision to go to graduate school. Cheerleaders included informal undergraduate mentors, family, and peers.

Informal undergraduate mentors served in the role of cheerleader when encouraging the student to pursue doctoral education. The following example summarizes the interaction that pushed one of our participants to seriously consider graduate education: "My [undergraduate research] mentor's like, 'Hey, it's been 2 years, so you're ready to start grad school.' And I was like, oh. Yeah. I guess I am." – Blake. For this participant, hearing from their informal undergraduate mentor that it was time to pursue graduate education encouraged them to believe they were ready to do so. This experience resonated similarly across other participants as well: "As I was getting close to finishing up, they convinced me to keep going to the PhD, so they said it was a good career option, said there's lots of maneuverability. All that stuff. They gave me the whole spiel." – Finley. Both these participants leveraged the words of encouragement they received from these informal undergraduate mentors to drive their decision to ultimately apply, and once admitted, enroll in a doctoral program.

Participants also described their families as playing a role in encouraging them to take this career option: "I had my cousin, they've always been in my corner, and then several mentors. Just a variety of mentors, saying, 'Yes, yes, go do this. Yes, yes, yes.'" – Blake

> *My dad's been really supportive and I know my mom is supportive, but they also were upset when I didn't take my full-time offer, because it was a pretty good offer, in terms of the salary, benefits. […] Overall, they've been really*

supportive. I talk to them about stuff, but it's more of me telling them, 'Okay, this is what I'm doing,' versus me saying, 'Oh, what do I do,' if that makes sense. – Robin

Finally, participants also described cheerleader roles for peers:

So my best friend who I was doing it with was like 'Oh, I'm applying to grad school. You should apply to grad school too. You're really good at research.' And I was like, 'Oh, I never really thought about it, but yeah, I guess it seems really cool.' – Taylor

Undergraduate research mentors, families, and peers were all identified as serving a cheerleader role in encouraging participants to pursue a PhD. Thus, encouragement being a key component of mentorship relationships was present in our participants' past experiences, leading them into pursuing further education.

3.1.3 Counselors

Informal undergraduate mentors often filled the counselor role. These individuals served as a resource of support to the participants. Sam describes their experience with a faculty advisor who helped give a community and a sense of belongingness to the student:

There was one professor at my undergrad institution who was our faculty advisor for (student organization), and I'll never forget some of the work they did for our organization showing us how, you know, we're meant to be here, we're supported, and no matter what, you know, despite what others think, we are going to get in the program. And so one of the things they set up, when it was a really hard time in my undergraduate career, just like my first few years, they had this thing called Pretty Tuesdays, and it's where the women of color, we could go to their house after, after all our classes…having these Tuesdays where we could share and they could just be like a shoulder to listen to and to give us advice. – Sam

This participant later shares the importance the faculty advisor had on their mental health support and how crucial the faculty advisor's support was as a counselor, especially when it came to normalizing the difficulty of the undergrad institution:

'You guys can come eat, I'll make you dinner once a week.' And so things like that, a lot of people don't think they're needed in both higher education and graduate. But that type of emotional support is critical. And to see someone where you want to be in like 15 years, you know, it's not just the role because if you don't see someone like you getting to that place, you don't think you belong there or that you could make it. – Sam

The words of encouragement and emotional support from the informal undergraduate mentor highlight a key type of mentorship support that is lacking in the participant interviews.

3.2 Mentoring Expectations from Future Mentors

Throughout the data set, participants mainly described future doctoral advisors serving as future mentors in their doctoral journeys. Participants described some key expectations they anticipated for their future doctoral advisors regarding their mentoring roles once they began graduate school. When discussing these expectations, students predominantly described their expectations relevant to their doctoral advising relationship and did not describe ongoing mentorship from other mentor groups. Participants anticipated future doctoral advisors to serve in roles as coach, counselor, and cheerleader. One key finding is that the role of critic was again absent from our data set. We elaborate on it further in the Discussion section.

3.2.1 Coach

The main mentor role we saw for future doctoral advisors was as a coach. Through the following selected quotes, participants share that their experience with their future doctoral advisors will be mostly about talking through the mechanical parts of completing the doctoral degree (credits, course selection, etc.):

> *I'm more of like a hands-on type of person, and they understand the type of background where it comes from. I need a little bit more support. So we came up with a plan for my first semester where they're going to check in with me on my goals. And so I have both like academic, professional goals, so like professional goals relate to being like actively involved in professional societies. – Sam*

In this quote, Sam shares that they need a more "hands-on" support, such as planning out a timeline with tangible professional and academic goals for the semester. Having a structured and interactive support that specifically breaks down the overall undertaking of the semester helps hold Sam accountable. The doctoral advisor, acting as a coach, has discipline-specific knowledge of the tasks and can help Sam parse out what is important and appropriate for Sam's skill in the discipline. Similarly, Jesse shares:

> *But my advisor and I right now we're setting up goals. So the first few meetings we had we talked about like the goal that I want for the first semester, how to assemble a committee, and also like reading through the handbook and learning about places where I can get support. – Jesse*

Jesse shares their current advisor/advisee meeting agenda. They set goals for the semester, which include ideas about being successful in graduate school.

3.2.2 Counselor

The second-most-common role participants talked about regarding their future doctoral advisors was as a counselor. Our minoritized participants sought out advisors with whom they could relate to on a personal level. The following participant describes the relatedness factor they seek in an advising relationship:

> *If I look at my advisor, as my advisor, yes, but also as a mentor, I should want to feel comfortable being able to approach them with successes and the hardships without feeling like I'm stupid, or I'm not smart. I don't want to have that feeling towards my advisor, because I know how attached I'm going to have to be to writing my dissertation and focusing on my project. I really was just looking for a personable person who was human, honestly. – Blake*

Some participants, but not all, found comfort in selecting a future doctoral advisor of the same race or ethnicity because they believed this could foster a shared understanding of what it means to experience minoritization in graduate school. A participant shared the relationship they expect from their future advisor who is also Black:

> *I guess I talk to her, I built a connection with her, and I hate to say it, but they're Black and they seemed like they were relatable, and I know that the relationship between your advisor and you, it's not supposed to be super social or anything. It's a professional relationship, a professional working relationship, but I feel like they could help me in ways that other professors wouldn't be able to. – Blair*

In sum, our student participants described desiring a faculty advisor who would provide guidance through the doctoral process but also be human—an advisor who would understand and validate some of their struggles of pursuing a PhD and experiencing minoritization throughout the process.

3.2.3 Cheerleader

The least common role participants talk about regarding their advisors was as a cheerleader. A focus group participant, Sam, shared the following quote about their advisor:

> *I worked with my advisor in the past and they were like, 'Hey, this is a good topic that you publish a paper on at ASEE. You should really come back and think about pursuing this whole topic as part of your PhD. You're very motivated about it and it would be good to... I would love to support you, give you grant money, funding, whatever it is, because we work well together.' And they wanted to see me succeed. – Sam*

This quote shows that the student sees the advisor as willing to make time and financial investment in the student by offering time and access, which leads to building trust. Blake talks about how they want different mentors for different situations and that they wanted an advisor to be there for them as a whole person, not just as a boss:

> *What I was looking for in an advisor was the same things that I look for in someone as a mentor, where it's like... because I know that's how I am. I'm more successful when I have a mentor in that, and my mentors, they don't all serve the same purpose. If I look at my advisor, as my advisor, yes, but also as a mentor, I should want to feel comfortable being able to approach them with successes and the hardships without feeling like I'm stupid, or I'm not smart. I don't want to have that feeling towards my advisor, because I know how attached I'm going to have to be to writing my dissertation and focusing on my project. I really was just looking for a personable person who was human, honestly. – Blake*

Thus, we anticipate the role of cheerleader, i.e., encouraging the student's efforts, in future doctoral advisors, but not notably.

4. DISCUSSION

Our findings show that students describe mentors in the roles of coach, cheerleader, and counselor as undergraduates and as they look forward to graduate school. At the same time, despite students mentioning a variety of mentors during their time as undergraduate students, they talk mainly about their future doctoral advisors when looking forward to graduate school. This shift from multiple mentors to a single source of mentoring notes a key expectation mismatch with the graduate school experience (given that prior research shows the importance of multiple people beyond advisors serving as mentors). However, we are cautious in labeling this shift to be definitive in participants' view of graduate school, as it is possible it was a function of the workshop context influencing the responses. Noticeably absent from our data set is the mention of the role of critics, which we elaborate on further in this discussion. Nonetheless, it is important to consider what does and does not emerge from the interviews and focus groups, as the knowledge can still inform recommendations for future research and practice.

4.1 Who Are the Mentors?

Our results are consistent with the literature in that students identify advisors, peers, informal undergraduate mentors, and family as mentors (Burt et al., 2021; Lunsford, 2012; McGee et al., 2016; Villa et al., 2016; Wilmont and McKenna, 2018). However, our findings also provide some nuance: (1) we added a group identified as

colleagues, and (2) our informal undergraduate mentors category is broader than the undergraduate research mentor often captured in existing literature. We believe our results support making this distinction as these groups served different roles. Our participants did not see their colleagues as cheerleaders, although they served in the similar role of coach by educating students on the doctoral process. Our data also supports broadening the category of undergraduate research mentors to informal undergraduate mentors, as the people named were more than undergraduate research mentors.

Looking toward graduate school, our data show students' expectations for their future doctoral advisor to be a counselor, cheerleader, and coach but not a critic. Because these students did not describe having critics in their experiences prior to graduate school, it is natural to not consider the possibility of having an advisor (or any other person) fill that role. However, as we note in our literature review, not all advisors play the role of mentor. Many play the role determined by the curricular part of the doctoral degree, which is monitoring degree progress that will inevitably lead to the role of critic on multiple occasions (Lunsford, 2012). We discuss the nuances for each role and the perils of this mismatch in detail.

4.2 Coach

As undergraduates, our participants described the role of a coach in their lives as those people who explained the doctoral degree process, the craft of pursuing research, and the nuances of choosing and applying to doctoral programs. These definitions are consistent with the literature, as the advisor often acts as the master in an apprentice relationship, teaching the student the craft of the research in which they endeavor in—both in undergraduate (Adams et al., 2013; Ahn and Cox, 2016) and graduate research (Austin, 2009). The presence of mentors as coaches in the decision part of pursuing graduate education is unique, as many of these students started the doctorate immediately after completing their undergraduate degrees, and most were actively involved in undergraduate research. This prior experience also allows the likelihood of these students having access to the cultural capital needed to take the decision to pursue further education with adequate support (Espino, 2014). These experiences in undergraduate research also likely provided direct exposure to what an advisor should be (Adams et al., 2013; Ahn and Cox, 2016; Gilmore et al., 2015) and, to an extent, the potential dynamic they can expect for their own doctoral advisor relationship.

Students also anticipated a coaching role for their future advisors. Because research has shown that learning in graduate school occurs through advisors but also across other sources such as peers, faculty, and counterspaces in the case of minoritized students, we suspect that students do have additional people in mind as serving coaching functions in graduate school (Austin, 2009; Twale et al., 2016; Weidman et al., 2001). However, it could be important to openly communicate with students about different kinds of mentors in order to avoid what research has identified as disappoint-

ment in the advising relationship by having expectations too great for an advisor to meet (Devos et al., 2016, 2017).

4.3 Counselor

Our participants also describe the role of a counselor as something they hoped their advisor could serve as once they were in graduate school. This expectation is not surprising, as participants saw informal undergraduate mentors in this role as well. This expectation of a counselor type of mentoring from their advisor could be concerning, as much work has shown that this counselor role is often better met through peers, especially those who are also minoritized and have been or are going through the process (Artiles et al., 2018; Holmes et al., 2010; Wilmont and McKenna, 2018). While minoritized faculty could likely fill this role, they are already an overburdened population, and many minoritized students do not have minoritized faculty as mentors (Barker, 2011; Martinez et al., 2017; Ong et al., 2011). Moreover, choosing an advising relationship based on shared race and/or ethnicity could ultimately be a disservice for a student, as they could be better served by matching their research interest and working style (Aikens et al., 2017; Barker, 2011; Newman, 2015). We note that students also indicated family members occupying this role as occurred during their undergraduate degree, but they rarely mentioned peers acting as counselors. It may be that many minoritized students are also first-generation PhD candidates and therefore family roles as counselors may be limited to family and other close contacts (Holley and Gardner, 2012; Roksa et al., 2018).

4.4 Cheerleaders

Prior to graduate school, students saw families, peers, and informal undergraduate mentors in the cheerleader role. This observation aligns with the work of Burt et al. (2019) that demonstrated how families, faith communities, and undergraduate mentors helped Black men in the process of graduate education resist and persist. Our research supports and expands the findings of Burt et al. (2019) by demonstrating this finding to also be true for other groups also minoritized in engineering.

Looking ahead to graduate school, participants also anticipated their advisor serving in the cheerleader role. Because prior research has shown that this type of support plays a critical role in persistence (Artiles and Matusovich, 2020; Berdanier et al., 2020), it is important to ensure that students have multiple sources of such support. Moreover, Lewis et al. (2017) show that students of minoritized identities select a research topic that—beyond meeting their individual interests—helps them serve their community and works toward improving society. Thus, it is advisable for students to maintain their connections to their undergraduate mentors once they begin graduate school, as this would help them persist when the doctoral process becomes difficult. Again, considering that many minoritized doctoral students are also first-generation PhD candidates, students may miss out on support from family (Holley and Gardner, 2012; Roksa et al., 2018).

4.5 Critic

A key missing mentoring role in our participant interviews was the role of a critic, despite Spillett and Moisiewicz (2004) noting this as the role faculty may be most comfortable with. Prior work has demonstrated the essential nature of critic in the advising relationship, as it is integral to the doctoral training process. Correcting is key to forming well-developed independent researchers (Austin, 2009). The students in our sample did not discuss having someone in that role, which can be common for undergraduate students, and did not discuss any specific expectations of their advisor playing this role throughout the doctoral process. This lack of discussion reflects the transition from the prescriptive course-taking nature of undergraduate studies and some master's pursuits to the more critical and iterative nature of the doctoral process, where constant revision of one's work driven by critical feedback is the norm (Maki and Borkowski, 2006). Not being aware of this transition can be commonplace in the early stages of the doctorate, which is where our participants were at the time of this interview (Lovitts, 2001). However, long-term success in the doctorate will depend on a student's ability to transition into an apprenticeship relationship with the advisor quickly. This apprenticeship involves continuous critique (Austin, 2009) that may or may not happen alongside the aforementioned and expected mentoring aspect of the relationship (Lunsford, 2012). This misconception can have an especially detrimental impact on engineering graduate students because this field practices the "science model of advising" (Zhao et al., 2007), where the advisor and student possess a relationship that extends beyond advising to employee-supervisor, coauthors, and collaborators. When there is a prolonged mismatch between the expectations of the advisor and advisee, they can perceive the critic's role negatively, even when the advisor intends to provide assistance (Artiles and Matusovich, 2020). However, as students may not be expecting the role of critic, it could push the advising relationship into the dangerous territory of misunderstanding, having a detrimental effect on their degree completion (Devos et al., 2016).

4.6 Implications for Research and Practice

These findings suggest several potential areas for future research. What was markedly lacking in the results was the minoritized students' anticipation of the critic role of their future doctoral advisors. Future research aimed at understanding why this is not a consideration by rising minoritized doctoral students could lead to better advisor–advisee relationships. With regard to practice, early conversations with students about the different roles an advisor will eventually play and how these roles may not always be encouraging (either from the faculty advisors themselves or from other mentors) can help students adapt their expectations accordingly (Devos et al., 2016) and prepare for the changing stages of the advising relationship (Twale et al., 2016). At a systemic level, establishing faculty training programs that highlight the diverse roles faculty may need to adopt while advising students could effectively assist faculty in recognizing and under-

standing how they can support students in different mentoring roles. Moreover, the development of interventions for students could help raise their awareness of the specific type of support they need and provide guidance on accessing those resources through the Rising Doctoral Institute.

Additionally, using the doctoral advisors' perceptions of the responsibilities and roles they play as an advisor could be an important crossover of understanding. Findings from this study may inform policymakers about how to support potential minoritized students in pursuing a PhD. Such support may include investing funds to allow informal undergraduate mentors more time to interact directly with engineering students because they serve various roles in influencing minoritized students' decisions.

5. CONCLUSIONS AND FUTURE WORK

Our study explored the mentors who are influencing minoritized students enrolling in engineering doctoral programs and what roles they play in the students' experiences. Outcomes of this study highlight the role of family, informal undergraduate mentors, and peers as people who supported their decision to enroll. Our findings also detail the expectations of minoritized students for future doctoral advisors. We identified a potential mismatch between the roles they expect them to fill and the roles they will indeed fill. Future work should look into the intersectional dynamics of gender and race with mentoring roles, as prior work has shown there is interplay with the advice they receive about pursuing graduate education (Steinpreis et al., 2000) and their graduate school aspirations (Litzler and Lorah, 2018).

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