THE UNIVERSITY OF NEW MEXICO

THE CHRONICLE of MENTORING & COACHING

# Doctoral Mentoring Relationships in STEM Programs: Faculty Perspectives

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## Abstract

*Mentorship has been established in the literature as being salient to degree completion for doctoral students. Mentoring primarily focuses on the extended academic development of a less experienced student by a more experienced faculty scholar. Federal governance policies have enabled greater participation in STEM by underrepresented populations, and as a result, enrollments in doctoral STEM programs by groups underrepresented in STEM have increased, but their success frequently hinges on support resources such as quality mentorship (Millett & Nettles, 2006). A substantial commitment to high-quality mentoring is needed to best prepare doctoral students for high skilled careers requiring innovation. This paper explores the perceptions of STEM doctoral faculty from three institutions in the southeastern part of the United States to understand their knowledge of STEM doctoral mentoring. This work seeks to improve STEM doctoral education by focusing on the mentorship relationship, an experience that is vital to matriculation, degree completion, and career planning Millett & Nettles, 2006). Using a qualitative multiple embedded case study design, the researchers interviewed and surveyed STEM doctoral faculty about their perceptions of STEM doctoral mentoring. This article focuses on five key findings from the qualitative interviews. STEM doctoral faculty: (a) have difficulty differentiating mentoring responsibilities from and in addition to advising; (b) have limited mentoring training opportunities; (c) see mentoring more exclusively as the development of scientific knowledge; (d) lack meaningful understanding of the role of culture in mentoring; and (e) lack deep understanding of the importance of relational connections with mentees.*

## Introduction

The term STEM refers to education and learning in the fields of science, technology, engineering, and mathematics (Granovskiy, 2018). STEM education has been linked in the United States to advances and competitiveness in the military and healthcare, has contributed to social and economic growth, and represents “critical human capital competencies for the 21st century” that include communication, innovation, and critical thinking (Granovskiy, 2018, p. 1). These benefits, specific to STEM education, are not enjoyed across all population groups due to the lack of equitable racial representation in STEM fields. For example, African Americans are 12% of the United States population but only account for eight percent of general engineering majors, seven percent of mathematics majors, and only five percent of computer engineering majors (Carnevale et al., 2016). Diversity in the United States STEM workforce contributes to knowledge and innovations produced through STEM professions that contribute to local communities and the nation (Okahana et al., 2016).

Disparities in participation in U.S. STEM education by traditionally underrepresented groups is a concern because of two systemic factors. First, large sectors of the populations are excluded from consideration due to under preparation. Second, lack of participation often results from a lack of opportunity to develop the skills and knowledge necessary to be included in the STEM talent pool, which, in turn, limits their economic competitiveness (Granovskiy, 2018). To gain access to STEM careers, students who are underrepresented must first gain access to the educational opportunities needed for recognition in the talent pool and then complete their degrees. For those who are in STEM doctoral programs, mentoring is noted as being salient to degree matriculation and in career development (Dawson et al., 2015). The lack of access to mentoring may function as a barrier to degree completion for doctoral students. In the STEM disciplines, a mentor can help students develop the critical research skills necessary through collaborative and directive experiences that address degree completion requirements and the necessary career development skills such as scholarly productivity. Degree completion and career development are separate constructs that must be attended to differently by faculty to meet STEM doctoral student’s needs.

## Literature Review

Mentorship, denoted as one of the most important resources in doctoral programs, has been linked to an increased likelihood of completing a degree in STEM (Dawson et al., 2015). Mentoring contributes to an important part of the academic growth of doctoral students and may be an essential element to their matriculation (Lyons et al., 2006). The aim of graduate-level mentoring has been two-fold, with an emphasis on enriching and developing academic research skills and a focus on career and personal development (Lunsford et al., 2017). This aligns with the earlier work of Millett and Nettles (2006), who reported that the key dimensions of the doctoral mentorship experience include not only having a mentor but also being a research assistant, publishing an article, and completing the degree. Mentoring is part of a larger system that involves multiple relationships and is often shaped by the cultural norms and beliefs associated with mentoring. That is, mentoring does not occur in a vacuous space (Merriweather et al., 2019; Yip & Kram, 2017). Mentoring is an academic community of practice that represents a system where doctoral programs can provide opportunities for engagement and learning relative to the institutional norms and mores, which equips the student with a sense of agency and competency (Thein & Beach, 2010).

STEM mentors understand the importance of grooming their mentees to become scientists. As such, mentoring is an intentional part of programs that is foundational to STEM doctoral student development and development of a science identity through scholarly experiences and interactions with faculty. Emphasis on science identity often occurs at the expense of the students' other identities. Doctoral students establish and maintain varying identities simultaneously with being students and emergent scholars (Foot et al., 2014). STEM faculty doctoral mentorship success requires sensitivity to other identities: individual; cultural; racial; and ethnic (Wright-Harp & Cole, 2008), especially when one realizes academic disciplines tend to reflect more of an "androcentric perspective" that may limit their vision of mentoring (Bernstein et al., 2010, p. 45). Cultural, gendered, or racialized experiences are commonplace in STEM education and can undermine a students' academic or career trajectory. Bailyn (2010) contended that "…the academy is anchored in assumptions about competence and success that have led to practices and norms constructed around the life experiences of men…as the normal, universal requirement of university life" (p. 143). Faculty mentors should hold larger, more inclusive visions of the STEM field.

Mentoring in doctoral education is not equal, and the experiences of students vary, but for many students who are historically underrepresented, the mentoring relationship is important to moving through the complex academic bureaucracy toward degree completion and navigating a career path (Douglas et al., 2020; Williams-Nickelson, 2009). This suggests that a certain level of cultural competence is needed to ensure a quality learning experience for Black, Indigenous, People of Color (BIPOC) students. Doctoral STEM faculty who appreciate the role of cultural responsiveness in mentoring practices have the potential for long-term engrained effects on the discipline. Cultural responsiveness is necessary to engage with diverse STEM doctoral students who are forming their professional identities. STEM faculty mentors who are less culturally competent and who have less experience working with BIPOC students may be stifled by expectations and beliefs associated with "preserving the traditional academic canon" that "exclude[s] diverse perspectives through narrowing epistemological approaches versus challenging or extending the canon through innovative knowledge production with our mentees" (Figueroa & Rodriguez, 2015, p. 28). This results in faculty members with less experience with culturally responsive practices diminishing or, both, devaluing diversity out of the belief that academic rigor means preserving the traditional academic canon, rather than recognizing potential limitations of the canons for integrating diverse worldviews.

With so much hinging on the mentoring experience, it concerns that most faculty lack training or preparation to be mentors, but rather employ strategies, good or bad, that they encountered as doctoral students (Wright-Harp & Cole, 2008). Mentoring requires institutional and faculty commitment. There are limited studies about the practice of STEM doctoral mentoring in terms of how faculty perceive their role, particularly in mentorships with cultural "others." This paper explores the ways that faculty, the linchpins to academic success, perceive doctoral mentoring.

## Methodology

A qualitative multiple embedded case study was conducted. The study aimed to understand the role of mentoring in STEM doctoral education. The primary research question was: what are the perceptions of STEM doctoral faculty mentors? This article highlights findings from one set of embedded cases within a larger multiple embedded case study. According to Yin (2018) case study is an "empirical method that investigates a contemporary phenomenon (the "case") in depth and within its real-world context, especially when the boundaries between phenomenon and context are not clearly evident" (p. 15). There are several types of case study according to Yin (2018) – exploratory, descriptive, and explanatory – and within each, the case study design structure may vary, single versus multiple or holistic versus embedded. A multiple embedded case study design was selected in which each case contained embedded subcases. "Embedded case studies involve more than one unit…of analysis" and focus "on different salient aspects of the case" (Scholz & Tletje, 2002, pp. 9-10).

The cases for this study included three different types of institutions within the same state: Predominately White Institution Regional (PWI-Regional), Predominately White Institution Flagship (PWI-Flagship), and Historically Black College or University (HBCU). Those cases contained embedded cases: faculty fellows; departmental leadership; doctoral STEM students of any race; and BIPOC doctoral STEM students, each of whom participated in an interview; and a survey. Additionally, STEM faculty who were not faculty fellows participated in the survey. That is, each embedded case represents a separate unit of analysis within the larger case (institution). Findings from the cross-case analysis of the faculty fellows and faculty are presented in this article.

## Participants

Participants from STEM departments across three institutions who were serving as faculty fellows in a National Science Foundation (NSF) sponsored project focusing on institutional change were recruited to participate, as well as STEM faculty from those departments. Data were collected during Fall 2018 from PWI-Flagship (five faculty fellows), Fall 2019 from PWI-Regional (six faculty fellows), HBCU (six faculty fellows), and surveys were distributed from Fall 2018 through Fall 2020 based on when departments began participating. Participants taught in the physical, biological, computer, and mathematical sciences. Demographically, the ages of faculty participating in the survey ranged within between: 25–45 (n=64), 46–65 (n=74), and 66+ (n=5). Race, gender, academic rank, and institution type were collected. The majority of participants were Caucasian, male, and from PWI-Flagship. Participants were given the option to not report any demographic data.

## Data Collection and Analysis

Eighteen faculty fellows participated in one semi-structured interview, averaging 60 minutes. The interviews were digitally recorded and transcribed using Rev.com. Interviews were analyzed using a constant comparative method (Glaser, 1965) as a coding process resulting in the identification of findings. The coding process was a well-defined inductive process of data analysis that includes open, axial, and selective coding (Strauss & Corbin, 1990).

This study also included a quantitative analysis of survey data administered to faculty in STEM departments across the three cases. The survey included adapted versions of The Mentoring Competency Assessment (MCA) (Fleming et al., 2013) and the Cross-Cultural Counseling Inventory-Revised (CCCI-R) (LaFramboise et al., 1991) that were self-reported faculty perceptions of their overall mentoring competencies, as well as faculty perceptions of their cross-cultural mentoring abilities. The adapted version of the MCA includes a 44-item skill inventory that contributes to six constructs of mentoring competency: maintaining effective communication; aligning expectations; assessing understanding; addressing diversity; fostering independence; and promoting professional development (Fleming et al., 2013). The adapted CCCI-R inventory includes 19 items that assess three constructs of cross-cultural mentoring skills: cross-cultural counseling skill, socio-political awareness, and cultural sensitivity. Descriptive and comparative analysis of survey data was conducted, examining differences across the three cases. The final survey sample included 150 cases, with most cases deriving from the PWI-Flagship university (n=103). Survey analysis was conducted in SPSS using non-parametric procedures, which included the Wilcoxon-signed rank test and the Kruskal-Wallis H test to determine if there are statistically significant differences between groups across various constructs.

## Findings

The following are the identified and described key study findings.

### *[1] Difficult Time Conceptualizing Mentoring Responsibilities as Different and in Addition to Advising*

Consistently across all three cases, faculty failed to distinguish meaningfully between the terms mentoring and advising. Most felt the terms referenced the same thing and highlighted skills that are often associated with advising, such as helping students develop their academic programs when describing mentoring. For example, a faculty in the computing department at PWI-Regional discussed how in their department that "a research advisor [was] more synonymous with their mentor. That is the person that [students] are actually working on research with…[and] that's the one-on-one scientific development relationship." The faculty member went on to deduce, "the research advisor is the mentor, but we all do mentoring." While this is, in fact, an important component, it falls short of attending to mentees in a more holistic manner.

### *[2] Limited Mentoring Training Opportunities*

Faculty remarked that they had to think about seeking out opportunities for training because they "don't even think about mentorship as something that you can be trained in." This perception was notably different than those from faculty fellows at the HBCU institution. A male engineering faculty commented that in mentoring two African American students, he "didn't use any special skills or special mentoring plan." The faculty member reflected on prior preparation in his doctoral program that may have contributed to his mentoring abilities with underrepresented students. Similarly, other faculty fellows attributed their competency or mentoring preparation to prior doctoral experience. While some faculty had learning experiences with mentoring from previous settings, few mentioned receiving formal training. Only 27% of participants indicated they had received training as a faculty mentor for doctoral students. Despite the absence of formal training, STEM faculty, on average, perceived the overall quality of their doctoral mentoring as slightly above average (M = 5.46, SD = 0.98), and generally, they perceived that they were meeting their mentees' expectations (M = 5.39, SD = 0.95).

### *[3] Seeing Mentoring More Exclusively as the Development of Science Knowledge*

As a whole, faculty spoke confidently of their ability to effectively mentor doctoral students. So much, so that data from the survey found that participants highly rated their mentoring ability in spite of being unable to name key aspects associated with mentoring during the interviews. Many linked mentoring skills with the transmission of knowledge related to science as opposed to better understanding students' needs beyond academics, which reflects a holistic approach more associated with mentoring. A chemistry participant at PWI-Flagship explained that you are "guiding [students] down a scientific path [and] you don't necessarily have to explore other things in their life that can be more challenging." This was echoed by HBCU faculty in biology, who explained that much of the effectiveness connected with mentoring related to the "philosophy of knowledge and standards of science in terms of study designs." The faculty made a link between their intentional mentoring engagement and the sciences in terms of academic and career trajectory but never extended beyond that.

### *[4] Lacking Meaningful Understanding of the Role of Culture in Mentoring*

Based on the survey data, faculty indicated the greatest confidence in the area of cross-cultural mentoring (M = 4.98, SD = .561). Indicators that scored highest within this construct included an awareness of their professional and ethical responsibilities as a mentor, with slightly lower confidence in socio-political awareness (M = 4.78, SD = 0.66). Composite scores in cultural sensitivity were the lowest of the three constructs (M= 4.49, SD = 0.75). The lowest indicator in this construct was demonstrating an understanding of the URM mentee's culture (M = 4.31, SD = 0.09). This contrasts with the Wilcoxon-signed rank test that was conducted to determine if differences exist between paired items within the six constructs from the Mentoring Competency Assessment. Most notable in the data was the lack of variability in how faculty fellows viewed their mentoring skills with all students compared to their thinking on mentoring Black, Indigenous, and People of Color (BIPOC) students specifically. Those means were only slightly less in reference to mentoring racialized students who were underrepresented in STEM. The absence of significantly different findings suggests that faculty believe they engage with all their students similarly. For example, a colleague at the HBCU institution in the chemistry department commented that he learned to be "more sensitive" but knew how to "[extract] the best out of people" because with people, "there's more similarities than differences" and he tries to be an "influence to whoever's in [his] vicinity or environment." Culture was not a chief consideration in mentorships, especially when the culture was of domestic BIPOC students.

Interestingly, lack of confidence was conveyed by doctoral mentors in meeting the needs of racialized underrepresented students in STEM. A male engineering faculty fellow at PWI-Regional suggested that the inability to meet the needs of underrepresented students in part lies in the fact that they are underrepresented at the graduate level: "we have an undergraduate body that is fairly diverse, but with graduate students, we really don't have a lot of underrepresented minorities…I can't say if I'm prepared or not because I have no idea what kind of challenges I could run into." A chemistry faculty member at PWI-Flagship explained, "I don't know that I ever treated anyone differently based on a real or perceived cultural difference." Furthermore, faculty failed to recognize that domestic BIPOC students might have unique needs based on their culture and backgrounds while readily accepting the fact that international students may have unique needs based on their backgrounds and culture. A biological science participant at the PWI-Flagship thoughtfully explained, "I have this great student who's a first-generation college student, underrepresented minority. Do I really understand where he comes from? I don't think so…I'm not sure that I actually truly understand…what unique circumstances he brings to the table." It was during the interview that this faculty began to give the culture of the student serious consideration. While many considerations may account for this diminished recognition of culture, it is likely that, in part, STEM faculty mentors' lack of focus on culture was due to a hypersensitivity toward the culture of science. There was a greater emphasis on developing scientists instead of developing people who would become scientists. These examples underscore the missed opportunities of understanding the intricacies of mentoring and culture that may make a difference for BIPOC doctoral students in STEM.

*[5] Lacking Deep Understanding of the Importance of Relational Connections with Mentees*

Collectively, the experiences of mentors painted a picture of how the faculty relationally connected with their mentees. While many factors may be at play, two relational factors that stood out were trust and communication. These factors appeared to vary depending on who the mentor was mentoring. In the survey, one item that demonstrated a statistically significant median increase on the Wilcoxon-signed rank test in response was establishing a relationship based on trust compared to establishing a relationship based on trust with your URM doctoral students, $z = 3.584$, $p < .0005$. Additionally, of the 111 participants who responded to the item employing strategies to improve communication with mentees, 18 of the faculty fellows felt more confident about employing strategies when thinking of all their mentees versus their URM mentees specifically, $z = 3.273$, $p = .001$. An engineering faculty fellow at PWI-Regional explained how “misalignment” could occur when you “don’t provide a lot of detailed guidance” to prepare students for projects and “30 minutes, 45 minutes, it’s really not enough to really get involved” in their work. Similarly, a biology faculty fellow at HBCU stated that “If you can give a mentee feedback within 20 words or less, that’s better than bantering about for two hours.” Both examples highlight the need for more defined academic support by faculty.

## Discussion

STEM doctoral education is important because it not only contributes to our pool of talented scientists but it also produces our pool of talented scholars who teach in higher education. If this pool continues to be shallow in terms of representation from BIPOC individuals, STEM fields will continue to suffer from issues of inclusivity. Understanding more about faculty doctoral mentors is key to better prepare such mentors to better mentor BIPOC students. Such considerations are understudied. What we learned from this study was that STEM doctoral mentoring challenges exist across various institution types. The findings suggest that holistic mentoring that includes cultural concerns in STEM is not commonplace. Across the institutions, the most consistent concerns were related to science research and bringing in funded students. There were also questions about the need to provide more intentional support for URM students. The lack of holistic mentoring concerns when juxtaposed along multiple institutional hierarchies that are frequently culturally different for doctoral students to navigate. Faculty and leadership must recognize that the absence of culturally responsive practices in mentoring may impede the success of URM students.

## Conclusion

Effective preparation for STEM faculty to work in mentor relationships with doctoral students requires a focus on diversity and inclusivity that is intentional to the recruited diverse student population. Changes in the STEM workforce, particularly the professoriate, require successful integration of doctoral students from diverse racial and ethnic backgrounds during their training as doctoral students. A component of that strategy should include culturally responsive mentoring from faculty who are purposeful in developing a more inclusive science identity for the STEM disciplines.

The importance of this study points to the criticality of mentoring training for STEM doctoral faculty with an emphasis on culturally responsive training that allows for a lens on the unique needs of URM students. Changes in institutional policy and practice should be considered to elevate the role of mentoring and to make faculty accountable for the use of culturally responsive mentoring practices. Such policy supports the idea that there needs to be continued training on what it means to be a faculty mentor, specifically to URM students. The training also can address the gap in skills for those faculty who report no formalized training. These findings how to ask faculty to consider the following: 1) how is their advising different from mentoring; 2) what specifically are their mentoring practices; 3) how are their mentoring practices specific to URM students; and even more so, ask 4) if they are dampening down diverse student populations recruited by expecting them to assimilate. Finally, are they allowing for the unique contributions BIPOC students manifest into the program? The survey results suggest that while faculty believe they are “good” at mentoring, there lacks a metric for understanding what “good” mentoring implies. Overall, we believe there are good intentions toward mentoring, but there remains much work to be done to make STEM mentoring more effective for STEM URM doctoral students.

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**Acknowledgment**

*This study is part of an ongoing research project and is based upon work supported by the National Science Foundation under Grant Nos. 1820536 182058 and 1820582. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.*