Challenges in STEM PhD Programs: Biased Mentoring

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Abstract— **Work in Progress – Research Category**

The purpose of this work in progress paper is to understand the influence of mentoring on the science, technology, engineering, and math (STEM) doctoral student experience. This qualitative case study sought to better understand mentoring relationships between faculty doctoral mentors and STEM doctoral students. This research emphasizes the role of mentoring as part of an intervening strategy for doctoral retention and suggests culturally responsive mentoring as a means to improve the experiences of PhD underrepresented minority (URM) students. This study addresses a gap in the literature related to culturally responsive mentoring and the STEM disciplines.

The findings were developed from four qualitative research focus group interviews. Focus group interviews were audio recorded, transcribed, and coded by the research team. Data were analyzed using the constant comparative method, an iterative process to extrapolate key words and identify significant patterns [1]. This study uses critical inquiry as a theoretical framework. Our findings revealed that mentoring takes place within a complex environment framed by systems of inequity grounded in race and gender. Three themes were constructed from the data: mentoring as a biased environment, lack of responsiveness to student needs, and relational tensions. This paper briefly examines one theme: mentoring as a biased environment. The data highlight how biased standpoints result in a shift in the learning experience. Bias may be based on race, gender, or age, and may be implicit or explicit. Within this environment doctoral students are challenged to navigate spaces such as classrooms and laboratories that can be wrought with difficulties springing from gender and race.

This paper is relevant to mentoring and STEM as it acknowledges that mentoring is a heavily nuanced practice with important cultural implications relative to PhD STEM students and faculty.

Keywords—STEM, URM, mentoring, culturally responsive mentoring, doctoral students

I. INTRODUCTION

This paper provides a brief synthesis of associated literature related to mentoring and mentoring in the sciences. Further, it acknowledges the need for understanding the importance of mentoring that is responsive to cultural differences such as gender [2]. This paper contends that in the STEM disciplines mentoring matters for retaining students in doctoral programs. Further, the paper suggests that mentoring should be culturally responsive.

According to [3] there is a scarcity of existing literature on doctoral student mentor relationships, which makes this study particularly relevant especially for STEM disciplines where a traditional focus on interpersonal relationship building is lacking or minimal. Mentors tend to choose mentees who are similar to them culturally. This issue is even more visible for URM students in part due to the low number of URM STEM faculty. Data from the National Science Foundation [4] highlighted that scholars of color made up 20% of faculty at US degree granting institutions as compared to within STEM, where URMs were 9% of faculty [5]. For institutions to be more intentional and responsive to diversifying and retaining URMs, mentoring must have a more targeted approach and institutional support [5]. This again supports the need for our current research that addresses the gap in the literature relative to mentoring at the intersection of STEM disciplines.

II. MENTORING

A. Defining and functions

Mentoring has been without a consistent and precise definition in spite of over three decades of research [6]. In academe, mentoring is a defined process that is understood as being a role model who has knowledge and experience on specified content matter [6]. The mentor is often seen as someone who a doctoral student would "want to emulate professionally" [7] (p. 873). This suggest that there is a relational component between a mentor and a mentee in a

mentorship. Typically the process includes intentionality in identifying or selecting a mentor, an agreed amount of time devoted to mentoring, an understanding of the skills that a mentee will receive from a mentor, the resources and activities that a mentor will make available to a mentee, and how this will be incentivized [6]. Mentoring has two primary functions, career and psychosocial, which are dominant themes in the literature [8] [9]. It was Kram's seminal research on mentoring that begins to speak to the importance of building mentors' capacity, and identity development through social support and modeling in an enriching and thriving context [9].

III. ROLE OF MENTORING IN THE ACADEME

The mentoring relationship is one of the most frequently discussed aspects of the doctoral experience [10]. Mentoring in the academe represents a space where faculty should cross into greater intentionality of guidance and direction of a doctoral student. Additionally, the role of a mentor is one of support, advocacy, reciprocity, and breaking down of siloed experiences [11]. This can be especially true for PhD doctoral students of color who bare what is termed as hidden injuries [11]. The mentoring process was characterized by those authors [11] as a "highly individualized process" (p. 48). Their research demonstrated that mentoring (1) requires extra-sensitivity, (2) takes some familiarity with topics that are of interest by scholars of color, (3) includes understanding that the mentoring "assignment" is built on a relationship, (4) and assumes some responsibility for the mentored individual. These findings have saliency for cross-race mentoring. Despite mentoring being understood as a critical factor in doctoral students' experiences, faculty are frequently left without formalized training of best practices or feedback for improvement from prior students or senior colleagues[12].

Some researchers have sought to understand mentoring specifically within the sciences. Researchers [12] conducted a survey of 235 scientists across STEM fields to better understand how they view mentoring. Seventy percent of scientists reported that they "rarely" mentored poorly; although, over half, 58%, had a self-described breakdown that had impacted their own research productivity. A second key finding was that 69% had not received any formal mentorship training although they reported spending at least one hour each week on mentoring related activities. Of those that did receive training, 74% reported only receiving limited training [12]. A final finding was that most agreed that mentors needed more training and expressed a need for additional training for themselves. Other scholars found that there was variability in the PhD experiences which provided a rationale for why mentorship is pivotal to many programs within a discipline with a heterogenous population [13] and found that gender bias persists in grading, hiring, mentoring, tenure, and promotion [14].

IV. THEORETICAL FRAMEWORK

This study uses critical inquiry as a framework for grounding the student focus group interview data. The use of critical inquiry is used to question dominant narratives. This included questioning of "how our lives are mediated by systems of inequity such as classism, racism, sexism, and heterosexism" (p. 205). Scholars contend the absence of critical inquiry in terms of assumptions linked to practices stagnates "progressive social change" [15] (p. 172). In essence they question how can there ever be change within education or academia in the absence of "truth-telling" and inquiry practices that critically position the "socially and politically constructed spaces" [15] (p. 172).

V. METHODOLOGY

This work in progress paper is drawn from a larger multiple embedded case study as shown in Table 1. Case study design incorporates "integration of data and knowledge from various sources" [16] (p. 3). The case is culturally responsive mentoring in STEM doctoral programs. There are three cases (multiple) that are university institutions, one regional, one flagship, and one Historically Black College or University, that are included in the larger study. At each institution there are 4 embedded cases: Department leadership, faculty fellows, doctoral students, URM doctoral students. Data continue to be collected for this larger project. This paper focuses exclusively on data findings from one of the embedded cases within the flagship university: doctoral students. These findings therefore constitute one embedded case for which all data has been collected.

Four focus group interviews occurred during winter 2019 at a large public university located in the south eastern part of the U.S. The groups had between 5 to 8 participants, which was consistent with research design recommendations of less than twelve participants [17]. Twenty-five STEM doctoral students, 9 of whom are URMs, who had completed at least two semesters of study participated in the focus groups. Students were from fields of STEM such as chemistry, engineering, and bioinformatics. Participants were provided light refreshments and a $25.00 gift card as incentives. Interviews took on average 90 minutes to complete.

Focus group interviewing is a data collection method used to explore how people think of or consider an issue without the pressure of making conjecture or decision making [18]. The researchers can see and hear co-constructed meanings of data that are developing and evolving as participants exchange ideas [18].

TABLE I. EMBEDDED CASE STUDY DESIGN

CASE I ***Flagship Institution***	***CASE II*** ***Regional Institution***	***CASE III*** ***Historical Black College or University***
• Department Leadership • Faculty Fellows • Doctoral Students • URM Doctoral Students	• Department Leadership • Faculty Fellows • Doctoral Students • URM Doctoral Students	• Department Leadership • Graduate Program Directors • Doctoral Students • URM Doctoral Students

The focus groups were digitally recorded, transcribed using Rev.com, and analyzed using constant comparative method, which is described by [1] as an iterative process to extrapolate key words. Research team members independently

identified patterns from the keywords and continually discussed, compared, and contrasted the emergent codes.

Through multiple independent and team based coding sessions, discrepancies were resolved and consensus was achieved. Coding was maintained in a Google Excel spreadsheet. Three themes were developed: mentoring as a biased environment, irresponsive mentoring, and relational tension, though only one: mentoring as a biased environment will be described in this work in progress paper. Collectively the themes were used to understand the role of culturally responsive mentoring from the perspectives of doctoral students.

VI. FINDINGS

Mentoring as a biased environment

For this paper, we chose to focus on one of the thematic findings due to space limitations. The concept of mentoring as a biased space was structurally understood by the research team as a.) types of biases, and b.) awareness of biases. This was a bi-directional experience for mentees and mentors. This theme speaks to the climate or conditions in which PhD doctoral students perceived their programs. In this finding we highlight that the ownership of mentoring is not exclusive to the mentor, but is inclusive of the mentee. Similarly, the full onus of responsibility for guiding a mentee and the subsequent outcomes do not singularly become that of the mentor, but also belong to the mentee.

A. Types of biases

This finding attends to mentoring across domains of differences [19]. Participants perceived that mentor engagement was framed from a standpoint that was interpreted as being from a place of bias. The most salient demographics of race, age, and gender were the basis for the biases noted by doctoral students. Participants sought out mentors who were similar to them and mentors in turn seem to gravitate toward students who were more like them as well. Doctoral students were cognizant of the impact of working with faculty who were not similar to them. For example, a pattern associated with gender bias was noted. One participant commented that "the way you pick an advisor is gender biased." Similarly, "[faculty are] very aware and conscious of the differences between males and females in the field, and the challenges that a lot of women face." Within this context there begins to be an acknowledgement of a gendered selection tendency. For another participant the positive influence of a same gender mentorship was mooted by a generational difference that was evidenced in the mentor having a rationalized more staunch position, "she's [faculty advisor] older, she is definitely older…because of her age she probably was in a field where she was literally one of the only women at the time." The participant goes on to explain that the mentor "couldn't be emotional throughout her career, so she is now non-emotional and so when I'm emotional, she just ignores it."

B. Awareness of biases

The awareness of biases, the second component of the theme, appeared more dominant in student narratives. Faculty were described as either mitigating or facilitating environments that were biased. Those who mitigated it often were seen as sources of support and allies. Understanding how bias operated was a recognized strategy of support exhibited by faculty. First, is a faculty advisor who is an ally for a student,

"I had an issue last year where my advisor's other student was a terribly sexist douche. And, I told my advisor about it, I was like, "Listen he's being a piece of [expletive]. Please fix it." And he was like, "Absolutely, I hear you." And sat down with the other student and was like, "This is unacceptable behavior. Get your head out of your [expletive]. Here's some things I want you to read about gender dynamics and mathematics." Like really went up to bat for me…So, he tries to be really aware of the dynamic, but he's also an LBGTIQ ally, so he is very aware of a lot of those different power dynamics and things."

Inherent bias informs the culture within science laboratories according to some of the students. Participants were aware of how it operated but many faculty were not. For instance, a different student conveys a sense of frustration with having only a few females in the laboratory and the "blatant sexism" that seemed to be pervasive in the laboratory.

"And, if you look at [faculty member] lab, this committee member, it's all white males. They're all white males….But, any women that would be in that particular lab, I've heard it from them too, this person treats them like crap. . . I think the biggest thing is the culture of the lab itself...you tend to do better work than if you're in a lab where you're constantly having to battle some adversity in some way, shape or form. Where you're constantly maybe having to over prove yourself, and then you run yourself ragged trying to do that."

The awareness of a biased environment differs between mentors and is critical to the mentor understanding how the mentee is thusly positioned in the laboratory setting. Those two exemplars highlight the awareness and intersection of biases through the lens of gender and how they contribute to a biased environment. Overall the biased environment was understood as the level of awareness of the implicit and explicit nature of bias and how it directly and immediately impacted the lives of students. It highlighted the importance of mentors taking an individualized approach to mentoring that prior research deemed as important [11].

These obvious overtures of faculty biases were replicated and evident with some of the doctoral student participants. They were normative dialogues and are problematic for creating environments that are not as biased. One participant stated, "we're over-represented with women. I think the majority of us are women and then definite color, there was some fishiness going on where we were trying to like increase diversity and I think that's ... Not saying that these people aren't

intelligent, but it was very clear that they got into the program because they were diverse which I felt was not okay." White females, who were the majority participants within the focus groups, readily perceived the STEM doctoral environment and mentoring as being sexist but some in turn had decidedly racist ideologies that framed understanding of fellow URM students. Biased standpoints from both faculty and students seemed to go unchecked in these academic environments.

VII. CONCLUSIONS AND IMPLICATIONS

Identity issues were salient particularly relative to gender. While issues of race were discussed, it seemed that URM students in the group setting were not as forthcoming or chose self-censorship. In this study we found that participants were in an environment that were limited due to the perceptions and biases of the STEM faculty. There were instances where faculty advocated for students, but more frequently they were unable to acknowledge that something more than the 'doing of science' was occurring. Faculty seemed at a loss for how to attend to problematic gender based issues or to understand the nuanced challenges of students' lives that extended beyond a particular field assignment or experiment. In failing to attend and understand, faculty mentors created and sustained biased learning environments.

This study contributes to the body of literature in these specific ways. It offers that mentoring is not only a heavily nuanced practice, but is one that has cultural implications that may partially explain why mentees, like women and URMs, who are culturally/demographically different from their mentors, are not fully engaged or recognized for their importance by their faculty mentors. When faculty mentors model cultural irresponsiveness, students may also see it as insignificant and replicate it in their professional practice. Prior research focuses on the relationship dimension of mentorship and how it can contribute to student retention [20]. This study goes further in contextualizing mentorship experiences as being a bi-directional interplay between the mentor and the mentee that is situated within implicit and explicit biases. Through the use of focus group interview data, critical inquiry can allow for narratives to be compared and analyzed that "bring scholarship and advocacy together in order to generate ways of knowing that interrupt power imbalances" [21] (p. 208). As this work in progress continues, a critical inquiry lens will be employed to better understand the data.

A concluding recommendation is for faculty to be better trained to function in cross-cultural, cross-race, and cross-gender mentoring. That is, faculty need to be competent culturally responsive mentors. Students in this study appreciated connections with faculty where they perceived there to be some sensitivity [23]. These types of mentoring relationships remain rich spaces for grappling with complex issues such as acknowledging, exploring, and understanding how aspects of the mentee's identity are salient in both STEM academic and professional career success. Students are seeking to see best practices of those dimensions and faculty are positioned to best provide attention to these matters.

These recommendations are not without concern. Intentional cultural responsive mentoring is frequently not recognized when making tenure decisions. This type of mentoring requires institutional support in tangible ways. The benefits of culturally responsive mentoring need to be made more transparent and discernable. This study demonstrated there is still much work to be done in providing relevant training to STEM faculty relative to mentoring for a diverse student population. The study is relevant to engineering and computing education as it provides clues to what are needed elements in STEM doctoral mentor training. Creating an inclusive STEM doctoral educational environment that leads to diversification in STEM careers is contingent upon attracting and enrolling more women and URMs while retaining those that are currently enrolled by providing more positive experiences through practices such as culturally responsive mentoring.

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