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The Need for Critical Mentoring in STEM

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This conceptual paper discusses the importance of applying critical mentoring methods in the science, technology, engineering, and mathematics (STEM) fields, particularly in encouraging the retention of underrepresented minorities (URMs) in the STEM workforce. The 'critical' part of mentoring stems from critical race theory (CRT), which focuses on having cultural competence around race, culture, and ethnicity. Critical mentoring in STEM unites CRT with mentoring practices for URM success in STEM. URMs are those who continue to be underrepresented in particular academic or career paths relative to their proportion in the U.S. population, which includes the following demographics: African Americans/Blacks, Hispanics/Latinx, and Native Americans. Only 9%, 15%, and 10% of African Americans/Blacks, Hispanics/Latinx, and Asians constituted the STEM workforce in 2021, respectively. Critical mentoring can help increase the percentage of URMs in STEM. Although there is research on the need for critical mentoring, there is a dearth of research on implementing it in STEM. Mentoring leads to positive attitudes towards the subject area that mentees are engaged in with their mentors. However, knowing how to mentor those from diverse backgrounds helps cultivate STEM professionals with different perspectives and contribute new knowledge to the field. The outcome of this paper will confront the current issues with mentoring practices for URMs and provide a strategy that supports them in their STEM career. It will discuss the application of CRT to mentorship and the value it adds to research on STEM mentoring. It will also expand on the literature on critical mentoring and input that framework in STEM.

Keywords: STEM, underrepresented minorities, critical race theory, critical mentoring

Introduction

Critical mentoring in STEM is a strategy that advocates for equitable mentoring practices to foster inclusivity when working with underrepresented minorities (URMs) in science, technology, engineering, and mathematics (STEM) (Weiston-Serdan, 2017). Encouraging URMs in STEM throughout their academics and STEM-related careers is important to counteract the low STEM occupational rates of URMs (National Academies of Sciences, Engineering, and Medicine, 2019). Critical mentoring in STEM is inspired by critical race theory (CRT) from Ladson-Billings (1998) and is used to facilitate a deeper understanding of URM mentees' experiences, providing a means for them to seek guidance and expand their opportunities in STEM. The mentoring strategy interrogates current mentoring practices in STEM, which do not consider URM STEM mentee experiences—possibly creating a sense of isolation and might discourage URMs from pursuing a career in STEM (Griffin et al., 2010).

It is important to understand the various factors that may deter URM mentees from pursuing or remaining in STEM. For example, a lack of representative STEM teachers and a lack of STEM opportunities are two types of experiences that some URM mentees could have endured that affected their willingness to remain in STEM (Neally, 2023; Stavrianeas & Stewart, 2022). To effectively increase URM STEM student retention rates, it is necessary to analyze the obstacles they encounter in the field. Furthermore, it would be beneficial to examine the current ineffective mentoring practices that do not adequately address the needs of URM STEM students to better comprehend the need for critical mentoring in STEM.

Literature Review

Underrepresented Minorities in the STEM Workforce

URMs are those racial/ethnic groups that continue to experience lower STEM occupational rates in their field than other groups (Estrada et al., 2018; National Academies of Sciences, Engineering, and Medicine, 2019). In the STEM field, URMs include African Americans/Blacks, Hispanics/Latinx, and Native Americans (American Federation of Teachers, 2010). Asian groups are excluded since they are considered a majority population in STEM, alongside their White counterparts (Aish et al., 2017; Trenshaw et al., 2019). For instance, the National Science Foundation (2024) reported that in 2021, STEM workers were disproportionately Asian and White. In contrast, Black/African American workers constituted 8 percent of STEM occupations, 3 percentage points lower than their representation in other occupations (National Science Foundation, 2024). Hispanic/Latinx STEM workers comprise only 15% of the workplace compared to 18% of all Hispanic/Latinx workers in other fields (National Science Foundation, 2024). However, there are 10% more Asians in the STEM workforce as compared to their presence in other professions (National Science Foundation, 2024). This paper will focus on African Americans/Blacks, Hispanics/Latinx, and Native Americans racial/ethnic groups, since they are underrepresented in STEM.

Lack of Representative URM STEM Teachers

The low percentage of URMs in the STEM workforce can be attributed to multiple factors, starting with the lack of racial representation among STEM teachers (Neally, 2023) and the STEM opportunities afforded to URMs in collegiate environments (Stavrianeas & Stewart, 2022). The dearth of URM representation of STEM teachers impacts URM STEM retention rates. Only about 7% of STEM elementary and primary teachers are Black, and 8% are Latinx, while over 80% of STEM teachers are White during the 2017-2018 school year throughout the nation (National Science Foundation, 2021). However, the racial composition of STEM teachers does not match the makeup of the student population where 48%, 7%, and 8% of the students were White, Black, and Latinx in 2019, respectively (Hussar et al., 2020). Black students are more likely to have negative or unwelcoming experiences in their STEM classrooms (Basile & Thomas, 2022). Their unwelcoming experiences in the classroom can deflate their motivation for pursuing STEM as a career choice (Smith-Mutegi, 2023). For example, Hanson (2009) observed that a lack of representation of Black scientists and teachers caused many Black students to experience isolation and a reduced sense of belonging in science. Increased opportunities to work with STEM teachers with a similar background to URM students can boost retention rates.

Lack of STEM Opportunities for URM Students

Other areas that exclude or dissuade URM students from maintaining their interest in STEM are the lack of opportunities to persist in collegiate environments and graduate studies (Hypolite & Rogers, 2023; Stavrianeas & Stewart, 2022). Furthermore, less attention is devoted to secondary STEM education, where there are fewer pre-college programs dedicated to engaging URMs in STEM early and often (Stavrianeas & Stewart, 2022). The Condition of STEM 2016 report showed that 49% of tested students are interested in STEM as a career choice, but only 18% of URM students who took the test met the American College Testing (ACT) STEM readiness benchmark score (American College Testing, 2016). The low percentage of URM students meeting the ACT STEM score indicates the inadequate pre-college preparation needed to prepare them for rigorous college STEM courses. The URM students who continue to pursue STEM as a career in college usually experience discrimination and implicit biases, stemming from their interactions with peers, faculty, and administrators (Lee et al., 2020; McGee, 2020). Valencia (2010) argues that deficit thinking, on the part of those who hold implicit biases towards URM students lacking academic preparation, blames and faults URM students for their insufficient preparation, instead of the minimal STEM resources at the primary and secondary schools attended by most URM students. The education system reinforces URM student inequities, contributing to the shortage of URMs in STEM.

The scarcity of URMs in STEM has called for a nationwide call for diversity and inclusion in STEM (Basile & Lopez, 2015). For instance, the President's Council of Advisors on Science and Technology (PCAST) released a report in 2010 on STEM education that called for an increase in URMs to pursue STEM careers (Basile & Lopez, 2015). A diverse STEM faculty representative of the US population can encourage the attainment and retention of URM students (McGee, 2016). Estrada et al. (2016) suggest that institutions need to focus on the barriers that need to be removed that increase URM students' interests in pursuing STEM. A recommendation to reduce the communication barrier is for faculty members to understand their URM students and encourage their creativity in the field (Estrada et al., 2016). Mentoring practices and models practiced by faculty members can help remove the communication barrier and help increase URM student retention rates in STEM.

Current STEM Mentoring Practices

Mentoring can positively influence students' career choices, but this varies with the mentor and the practices that encourage student academic and career growth (Center for Advancement of Informal Science Education, 2016; Dubois et al., 2011). URM students have difficulty finding mentors who look like themselves and share their STEM research interests (Noel et al., 2022). Negative mentoring experiences can lead to URM STEM students losing confidence in their ability to continue in the field (Griffin et al., 2010). In order to understand effective mentoring strategies for STEM URM students, it is important to study the current STEM mentoring practices and how they impact those students.

Kupersmidt et al. (2018) list effective STEM mentoring practices and programs for elementary-aged students and undergraduate students. The 3M STEP program from Minnesota's Saint Paul Public School District matches students in their junior and senior years of high school with two mentors, who work to support students' skills and navigate professional challenges in STEM (Kupersmidt et al., 2018). The program also helps students network with other professionals and introduces them to opportunities and experiences (Kupersmidt et al., 2018). Kupersmidt et al. (2018) list other STEM programs and mention that all of the programs focus on working with URM students. Nonetheless, there is no discussion on the types of mentors in the programs and how they work to create a sense of belonging and identity for the URM mentees.

There are STEM mentoring programs that promote students' sense of belonging in STEM. If students feel like they belong in STEM, they will be more motivated to pursue STEM as a career. For example, Packard (2016) discusses a STEM program addressing students' sense of belonging before attending college. The STEM scholar mentoring program creates a peer group of students with similar academic interests who empower each other in STEM through teamwork (Packard, 2016). Scholar programs are effective among low-income students, first-generation college students, and other URM students (Packard, 2016). The scholar programs are highly selective, where students are selected based on their initial motivation and commitment to science and STEM activities (Packard, 2016). However, there is little discussion on the mentors in the scholars program and how they work with URM students to maintain their interest in STEM. Moreover, a highly selective program like the scholars program is not working to increase the quantity of URM STEM students interested in STEM but is only working with those students with prior motivation and access to STEM resources.

Adding to the argument that the aforementioned mentoring programs do not address the mentors and how they practice mentoring URM students is a quantitative study by Beck et al. (2022), where they reviewed 34 STEM programs to study their mentoring models. The study found that most articles did not address the challenges and barriers of women in STEM (Beck et al., 2022). This means the mentoring programs used the same strategies for all students and did not consider women's experiences in STEM or URMs in STEM. There needs to be more research on the importance of applying theoretical frameworks, such as CRT, when working with URM STEM students.

Conceptual Framework

Critical race theory (CRT) is a legal theory, from critical legal studies (CLS), used to dismantle structures that benefit the status quo to construct an equitable society that benefits underrepresented populations (Ladson-Billings, 1998; Parker & Lynn, 2002). CLS challenged traditional policies by focusing on individuals and groups in their cultural contexts (Ladson-Billings, 1998). Crenshaw (1988) states that the CLS movement was used to decode legal doctrines to expose how the legal system legitimizes the status quo and unequal societal structures. CRT, on the other hand, focuses on the history of oppression, such as racism and sexism (Ladson-Billings, 1998). CRT is also used in education, where CRT scholars argue that inequities in education persist because racism is deeply ingrained in American culture and schools (Annamma et al., 2017). Recognizing the systemic inequalities and inequities that impact marginalized groups will help avoid reproducing an unequal education system and promote instruction and curriculum that is more inclusive (Morris & Parker, 2019).

In order to implement CRT in mentoring practices, five CRT tenets need to be recognized: (a) there is racism in human affairs (b) understanding the necessity to dissolve oppressive social systems (c) valuing and upholding social justice (d) valuing experiential knowledge, and (e) acknowledging that interdisciplinary approaches can help understand social inequities (Ladson-Billings, 1998). STEM faculty members, including White members, can study CRT to empower them to develop new research paradigms that include their URM mentees' research interests and experiences (Vargas et al., 2020). Since most STEM teachers and faculty members are either White or Asian, it is even more necessary for them to understand the importance of using CRT in mentoring. Although some well-meaning mentors may believe that they support diversity and inclusion, they may not recognize the racist social-political systems that make racism invisible to those who benefit the most from it (Vargas et al., 2020). For instance, a faculty member might avoid providing feedback to help a URM student out of fear of appearing racist (Harber et al., 2010). Another faculty member might have a deficit lens towards URM students and avoid challenging them or providing opportunities that will increase their STEM experiences (Valencia, 2010). STEM teachers and faculty members need to be knowledgeable in CRT, especially if they will mentor URM students. Critical mentoring practices use CRT tenets to create mentoring strategies that can uplift and retain URM students in STEM.

Program

Critical Mentoring Practices in STEM

Weiston-Serdan (2017) first coined the term 'critical mentoring' to acknowledge that mentoring should be informed by critical theories, such as CRT, to address the marginalization of young people. Weiston-Serdan (2017) sought the need for critical mentoring after noticing how society marginalizes youth and how traditional modes of mentoring may ignore their traumas. URM students are those youth or adults who may have experienced problems in being ignored or shunned in STEM environments. They might have mentors who discourage them from pursuing STEM as a career and hinder their opportunities for growth in the field. Critical mentoring is an approach that centers the needs of URM mentees by addressing the contextual and systemic forces that marginalize them in STEM (Weiston-Serdan, 2017). Weiston-Serdan (2017) offers examples of how mentors were taught critical mentoring strategies when working with marginalized populations (Weiston-Serdan, 2017). In one example, Weiston-

Serdan (2017) worked with mentors who have mentees who are a part of the LGBTQ (lesbian, gay, bisexual, transgender, queer) community. The critical mentoring strategy involved building a relationship with the mentees to understand how to support them best (Weiston-Serdan, 2017). Mentors can use this strategy, among others, when working with URM students in STEM.

Program Implementation

Weiston-Serdan (2017) outline ways to implement critical mentoring practices when working with youth, which can also be used when working with URM students in STEM. For instance, one of the methods is to center the youth or youths in the mentoring relationship or in the mentoring program (Weiston-Serdan, 2017). In order to create a youth-centric mentorship, the youths need to be given leadership opportunities within a program (Weiston-Serdan, 2017). This method can be applied when working with URM STEM mentees, where mentors find ways to provide leadership opportunities where the mentees can share their ideas and knowledge with their mentor and peers.

Another critical mentoring strategy that can be used with URM mentees is allowing them to establish program goals if they are part of a STEM mentoring program. This will create a sense of belonging in the program and STEM, as well as a less hierarchical mentoring system. Traditional mentoring structures use a hierarchical relationship between a more senior individual passing their professional knowledge to guide the development and growth of the mentee into their future career path (National Academies of Sciences et al., 2019). The traditional mentoring model, however, assumes that the mentor is all-knowing and does not seek to form a relationship with the mentee to learn about their unique knowledge and experiences. Providing URM mentees the opportunity to hold positions where they can share their knowledge will allow the mentors to learn more about them.

A third critical mentoring strategy is for mentors to find ways to include URM mentees in STEM activities. This can be an event where URM mentees can network and meet other STEM professionals interested in working with the mentees. This can also provide writing opportunities where mentees can work on publishing papers with their mentors. Including URM mentees in STEM activities can help establish their STEM identity in the field, where mentees are given opportunities to learn more about their field of study. This would be another way for mentors to spend more time with their mentees and build relationships.

Lastly, mentors must challenge their implicit biases when working with URM mentees. Mentors need to understand that our society is diverse and that URM mentees have certain identities that society perceives. STEM mentoring programs need to develop ways to allow mentors to continually reflect on the nuanced understanding of identities, which will require professional training on identifying biases and challenging them through reflection and dialogue. There is also a wealth of information available from local or national organizations and at college campuses that can help mentors find proper training and resources to help them serve URM mentees.

Conclusion

Although critical mentoring can offer an alternative mentoring strategy to confront low URM retention rates in STEM, it should be noted that mentors need to do intensive work on themselves before working with those with different experiences and backgrounds. This includes reading peer-reviewed research articles on URM STEM student experiences, learning about CRT, and joining group discussions on learning more about how to serve them better. Mentors must also get comfortable confronting their biases and prejudices towards URMs and learn to work through those through reading and communication. Critical mentoring strategies offer a way for mentors to navigate working with URM STEM mentees, but it is not the only way when trying to increase motivation in STEM. Critical mentoring provides a blueprint for mentors, but it will be up to them to dig deeper and change for their URM STEM mentees.

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