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Supporting Historically Underrepresented Groups in STEM Higher Education: The Promise of Structured Mentoring Networks

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Although institutions of higher education have placed a large emphasis on increasing the number of underrepresented minority (URM) students matriculating in higher education, the disparities in STEM retention and graduation rates between URM and non-URM students emphasize the dire need for increased support to help URM students navigate challenges including stereotype threat, impostor phenomenon, and lack of social connectedness that disproportionately affect URM students in majority-dominated fields. Prior research has demonstrated that structured mentoring has the potential to generate substantial improvements in academic, social, and career outcomes for URM STEM students. In particular, network-based mentoring approaches that allow for students to receive both professional and peer mentoring, as well as the opportunity to mentor other students, have demonstrated success in this realm. In this article, we discuss how the current state of academia often fails URM STEM students and faculty, review literature regarding the ways in which structured mentoring approaches can alleviate barriers to success among URM groups in STEM fields, and offer recommendations regarding how academic institutions can successfully implement holistic student and faculty mentoring programs.

Keywords: mentoring, diversity and inclusion, STEM—science technology engineering mathematics, minority, broadening participation, higher education, networks

THE IMPORTANCE OF ACCESS TO MENTORS AND ROLE MODELS

Given the large-scale challenges currently facing our society, it is undeniable that STEM education is imperative for solving problems such as sustainable energy, national security, and effective prevention and response to widespread disease, such as the current coronavirus pandemic. Yet, it is also indisputable that there is a glaring chasm within the U.S. STEM workforce. Although individuals who identify as African-American/Black, American Indian or Alaska Native, or Hispanic/Latino make up 33.2% of the U.S. population (U.S. Census Bureau, 2019), only 22% of STEM undergraduate degrees and 9% of doctoral U.S. STEM degrees in 2016 were awarded to

students identifying with one or more of these groups (NSF NCSES, 2019). Further, the current 6-year graduation rate for underrepresented minority[1] (URM) STEM majors is 33.8% as compared to 53.1% for White STEM majors (Whalen and Castleberry, 2019). Although predominantly White institutions (PWIs) have placed a large emphasis on increasing the number of URM students matriculating in higher education (Reardon et al., 2018), these institutions generally have not placed a comparable emphasis on providing support to URM STEM students to help them navigate the added challenges they face as URM students in majority-dominated fields (Hurtado et al., 2015; Sowell et al., 2015). As a result, a large body of evidence indicates that URM individuals in STEM fields report feeling invisible, isolated, and undervalued, not only as students but throughout their entire careers[2] (Walton and Cohen, 2007; Malone and Barabino, 2009; Schwarz and Hill, 2010).

Even more concerning is the underrepresentation of minority groups in STEM academic professions, as only 8.9% of STEM academic faculty are members of URM groups (NSF NCSES, 2019). Further, URM individuals make up only 3.9% of biology and chemistry faculty at the top 40 universities in the United States (Li and Koedel, 2017). This underrepresentation in academia often means that compared with White peers, URM STEM students and faculty do not have comparable access to similar-background role models, mentors, and informal networks that are critical to academic success and career advancement (Smith et al., 2000; Chen and Li, 2009; Byars-Winston and Dahlberg, 2019; Harris and Lee, 2019). Specifically, lack of access to role models can result in reduced satisfaction, self-efficacy, engagement, and achievement (Thomas, 2001; Schulze, 2010). In one study of career trajectories of minority and white professionals, Thomas (1990, 2001) concluded that minorities who advanced furthest in their careers all shared one common characteristic: A strong network of mentors who nurtured their professional development. Regarding STEM professions, this disparity in available mentors can influence URM students and faculty to leave STEM fields, resulting in a missed opportunity for highly talented individuals to contribute to the STEM workforce. In fact, URM chemistry students studying in departments that include at least one underrepresented faculty member are more likely to aspire to faculty positions in research-intensive institutions than those in departments without any URM faculty members (Stockard et al., 2021). Although one could make the case that mentors can be and have been effective even with mentees whose racial backgrounds differs from their own, the amount of time, effort, dedication, knowledge, and skill it takes to be effective mentors with mentees who are already isolated in a predominantly white institution is quite high (Thomas, 1993). Thus, many mentors may not have the requisite training to provide URM mentees with the kind of mentorship needed to navigate racial barriers and thrive in an isolating academic environment (Stanley and Lincoln, 2005). In fact, a study of 603 STEM doctoral programs across the United States found that only 36% offer targeted mentoring or peer mentoring for URM doctoral students and only 26% offer mentor training for faculty (Sowell et al., 2015), indicating that the current state of support for URM STEM doctoral students is sorely lacking in most academic institutions.

We postulate that the lack of diversity and representation within academic STEM departments creates a perpetuating cycle wherein the dearth of URM STEM faculty leads to fewer URM STEM graduates, resulting in fewer URM individuals entering faculty positions. However, even among URM students who do graduate with a STEM degree, a considerably smaller percentage go on to obtain academic faculty positions compared with their White peers (NSF NCSES, 2019). Therefore, in addition to increasing representation of URM students in STEM, we argue that STEM academic departments must undertake greater efforts to encourage URM students to explore academic careers. Furthermore, STEM colleges and departments must not only *hire* URM faculty but *invest* in these faculty by cultivating an environment of inclusion that fosters a sense of belonging among minority faculty. As Manuel and Karloff (2020) note, instead of asking whether a faculty *candidate* has what it takes to succeed, academic institutions should ask whether the *institutional environment* has what it takes to support a candidate's success.

In this vein, many of the mentoring tenets for students can also be applied to cross-race mentoring of faculty members. One way that academic departments can create this kind of inclusive environment is to organize faculty mentoring programs that allow established faculty members to provide listening, support, and guidance to newer faculty members, especially URM faculty who may feel unsupported, misunderstood, or unable to connect with others in the department (Stanley and Lincoln, 2005). However, mentoring faculty members requires training in how to establish a trusting, supportive relationship, and an understanding of how systemic inequality in the academic environment creates barriers for URM groups, making it critical for departments to arrange for faculty mentors to receive this kind of professional learning prior to working with their faculty mentees.

As outlined in this manuscript, structured mentoring programs for URM STEM students and faculty provide a promising approach to addressing race barriers because they can provide appropriate training prior to establishing the mentor–mentee relationship, thus benefitting mentees both within and outside of the program. In the following sections, we explore literature documenting major barriers to retention and graduation of URM STEM students, provide evidence for the benefits of structured mentoring programs, and describe a model for implementing successful mentoring programs using an inter-institutional approach.

[1] We use the term "underrepresented minority" (URM) to refer to individuals who identify with one or more groups whose representation in STEM education and employment is smaller than their representation in the U.S. population. These groups include: Blacks or African Americans, Hispanics or Latinos, and American Indians or Alaska Natives (NSF INCLUDES Alliance, 2020).

[2] Although we acknowledge that there are other groups including women and first-generation students that face systemic barriers in STEM fields and strongly support efforts to increase equity for these groups, our work and expertise is primarily focused on URM groups, and this article is directed toward increasing success for these individuals.

MENTORING FOR REDUCING RETENTION AND GRADUATION BARRIERS AMONG UNDERREPRESENTED MINORITY STEM SCHOLARS

Although there are numerous factors that influence URM student retention, graduation, and career choices, we focus on four of the most challenging barriers faced by URM groups in higher education: stereotype threat, microaggressions, impostor phenomenon, and lack of social connectedness. In this section, we highlight how these issues may prevent both URM students and faculty from reaching their full potential and describe evidence regarding the potential for mentoring to prevent or reduce the negative impacts of these barriers.

Stereotype Threat

A well-established phenomenon, stereotype threat refers to the negative effects of identity stereotypes on the performance of members of groups when engaged in activities related to those stereotypes (Steele and Aronson, 1995). Stereotype threat has been shown to negatively impact the performance and retention of URM groups (Walton and Cohen, 2003; Spencer et al., 2016; Thomas and Erdei, 2018), especially in STEM fields (Beasley and Fischer, 2012; Woodcock et al., 2012, 2016). In a longitudinal study using a large, nationally representative sample of undergraduate minority science students, Woodcock et al. (2012) found that stereotype threat was associated with scientific disidentification, predicting a decline in students' persistence toward STEM careers. Stereotype threat is not only prevalent in URM STEM students, however, but also among URM STEM faculty. Studies indicate that the effects of stereotype threat for marginalized groups at the faculty level are much like those effects noted at the student level and include reduced openness to feedback, reduced domain identification, reduced engagement, and career aspirations (Casad and Bryant, 2016). These effects, if not addressed, can lead to faculty reluctance in pursuing leadership roles that make them accessible to students that need support and advocacy.

Several studies have attempted to reduce stereotype threat by conducting values affirmation exercises, but have produced mixed results, with several findings failing to be replicated in the same setting (Kost-Smith et al., 2012; Harackiewicz et al., 2014, 2016; Borman et al., 2016; Hanselman et al., 2017). A potential reason for lack of consistent findings of these studies is that engaging URM groups in periodic values exercises merely treats "symptoms" of a larger systemic issue rather than making long-term transformations in academic and social systems that contribute to this issue. Culturally responsive mentoring programs represent a promising approach for combating the effects of stereotype threat, as they offer a consistent and institutionalized method for ensuring that URM students and faculty receive value and identity affirmation (Mondisa and McComb, 2015; San Miguel and Kim, 2015; Byars-Winston and Dahlberg, 2019). Indeed, recent work suggests that a major factor responsible for preventing and reducing the effects of stereotype threat is interactions that URM groups have with "like me" faculty and mentors (Thomas and Erdei, 2018). Further, a study of undergraduate URM STEM students revealed that those who had received culturally responsive mentoring reported feeling greater confidence as researchers and became more committed to pursuing graduate degrees (Haeger and Fresquez, 2016). Additional support for the importance of role models comes from Meador (2018), who used a qualitative case study approach to examine factors that influenced recruitment and retention among undergraduate minority STEM majors. Students frequently cited role models, including teachers and family members, as the primary inspiration for their choice to pursue a STEM degree and a major reason for choosing to remain in their major even when it became challenging. These studies suggest that culturally responsive mentoring can provide protective effects against the negative impacts of stereotype threat. Although research investigating methods for combating stereotype threat for URM STEM faculty in particular is scarce, studies suggest that having a network of like-minded peers, mentors, and advocates in work settings is an effective strategy that can mitigate stereotype threat (Block et al., 2011).

Microaggressions

A related barrier for URM groups in STEM fields is the occurrence of microaggressions, which refer to "subtle insults (verbal, non-verbal, and/or visual) directed toward people of color, often automatically or unconsciously" (Solorzano et al., 2000) and can trigger experiences of stereotype threat (Bair and Steele, 2010; Harrison and Tanner, 2018). Microaggressions are commonly experienced by URM groups in many social settings (Sue et al., 2007), and there is a wealth of literature focusing on microaggressions in higher education environments (Young et al., 2015; Harris et al., 2019; Lee and Hopson, 2019; Ogunyemi et al., 2020). Examples of microaggressions include playing down the importance of certain individuals' viewpoints or racial identities, expressing an assumption that insinuates a stereotype, asserting that others "shouldn't be so sensitive," or pathologizing cultural differences, including communication styles (Sue et al., 2007; Sue, 2010). Evidence indicates that microaggressions can have negative psychological effects that detract from wellbeing, and interfere with learning, engagement, and social connectedness in academic settings (Torres et al., 2010; Wang et al., 2011). Recipients of microaggressions may face difficulties interpreting whether their assumptions about the intent of such acts are valid, and whether it's worth the effort to say something or let it go. Such dilemmas may be especially challenging if the act is committed by an authority figure within the academic environment (e.g., professor/advisor for students or chair/dean for faculty members) (Harris and Lee, 2019).

At the faculty level, URM groups report experiencing microaggressions in much the same way as URM students. It is not uncommon for URM faculty to encounter colleagues who assume they are incapable of successfully navigating the rigors of academic positions, and begin to sow seeds of doubt in their counterparts (Solorzano, 1998; Sue et al., 2007; O'Meara et al., 2019). The subtle forms of discrimination that shape

professional interactions among URM faculty and colleagues can have serious consequences, as studies demonstrate that small forms of discrimination over time can result in severe problems for faculty including health problems, dissatisfaction, and departure from their position (Griffin et al., 2011; Thomas et al., 2014).

Although persistent microaggressions can leave URM students and faculty feeling as though they don't have what it takes to succeed in Alexander and Hermann (2016), mentoring that explicitly addresses these issues has the potential to combat their negative impacts (Harris and Lee, 2019). As noted by Harris and Lee (2019), mentoring can help mitigate the effects of microaggressions if (1) mentors and mentees have open dialogue and acknowledge that the mentee experiences racial barriers, (2) the pair discuss the mentee's needs related to race-based challenges, and (3) mentors share their plans and progress regarding their efforts to address social injustices currently affecting the mentee. Such communication places both mentor and mentee on the same page and allows them to better understand the goals of the mentee. In addition, mentors can utilize positive micromessaging to affirm their mentees' competence and foster a growth mindset (Lee, 2018; Kyte et al., 2020). Given the necessity of effective communication in mentoring relationships, it is critical for mentors to receive proper training in fostering open dialogue, especially concerning issues of race and racial justice.

Impostor Phenomenon

Another barrier commonly experienced by URM students and faculty in academic settings, impostor phenomenon refers to a feeling that one is not truly as capable or intelligent as others perceive them to be, which results in the self-perception that one is a fraud (Clance and Imes, 1978). Along with this feeling of fraudulence, individuals experiencing impostor syndrome often have a pervasive fear of being found out or exposed by others, making it difficult for them to be confident that their successes are due to their ability, hard work, and intelligence (Harvey and Katz, 1985; Chakraverty, 2019; Feenstra et al., 2020). URM students who enter into STEM programs may experience impostor phenomenon, which can lead to mental health concerns such as depression (McGregor et al., 2008), anxiety (Thompson et al., 1998, 2000; Fraenza, 2016), lowered self-esteem (Sonnak and Towell, 2001), low self-efficacy (Blondeau and Awad, 2018), procrastination, perfectionism, self-doubt (Fraenza, 2016), and self-handicapping (Ferrari and Thompson, 2006). Similarly, URM academics who experience imposter phenomenon describe this encounter as persistent thoughts of intellectual deception (Hutchins and Rainbolt, 2017). Results of this prolonged experience causes severe psychological stress that results in faculty from URM groups questioning their acceptability and aptitude in academic environments (Hall and Burns, 2009; Dancy and Jean-Marie, 2014).

Despite much of the research on impostor phenomenon focusing on the personal characteristics of the individuals who develop it, studies indicate that relationships with others in the academic environment also play a significant role in determining the prevalence of this phenomenon (Barnes and Austin, 2009; Baker et al., 2014; Feenstra et al., 2020). Thus, to reduce impostor phenomenon, mentoring programs must focus not only on the characteristics of individuals or the environment in isolation in isolation but also on the fit between mentors and mentees. Indeed, there is evidence suggesting that proper mentor–mentee fit can reduce impostor phenomenon (Sanford et al., 2015; Cohen and McConnell, 2019; Barr-Walker et al., 2020; Chakraverty, 2020). Specifically, Baker et al. (2014) stress the importance of basing mentor–mentee fit on three aspects of identity: (1) professional identity (perceptions of self-related to the major tasks and roles of the academic career); (2) relational identity (self-concept as it relates to family roles and responsibilities and interpersonal relationships outside of the professional context); and (3) personal identity (general sense of self, including the perceived salience of personal characteristics within specific contexts). Thus, to reduce impostor phenomenon, STEM academic departments should consider administering surveys to students and faculty and utilizing the results to match mentors with mentees according to these three types of identity.

Sense of Belonging and Social Connection

A fourth major barrier that can reduce URM students' interest in STEM and lead to dropout is low levels of social connectedness and what researchers have called "belongingness": the perception of acceptance, connection, and social support one receives as well as feelings of mattering and being valued and respected by the community (Baumeister and Leary, 1995; Stachl and Baranger, 2020). A strong connection to one's environment, via positive and frequent interactions with diverse peers, is associated with greater persistence and academic achievement (Walton and Cohen, 2007; Zaniewski and Reinholz, 2016; Ito and McPherson, 2018) and having a sense of belonging is a known indicator for STEM retention (Kim and Sinatra, 2018; Robnett et al., 2018). Research indicates that URM students, particularly at PWIs, experience challenges connecting socially and culturally with the overall campus community, and report greater feelings of isolation than White students (Strayhorn, 2009). URM students describe several factors responsible for feelings of isolation and social separation including a negative campus climate, racist and/or sexist interactions with White peers and faculty members, and having a strong racial identity that is marginalized at their institution (Brown, 1990; Locks et al., 2008; Thelamour et al., 2019). For URM faculty, isolation is often both institutional (i.e., feeling that they lack knowledge about and access to sources of power, prestige, support, and information that is important for career success and social (feeling excluded from supportive networks and limited to superficial friendships because others are unable to relate) (Smith, 1998; Smith and Markham, 1998; Smith and Calasanti, 2005). Given that feelings of isolation are a central factor impeding both URM student and faculty success in STEM (Fisher et al., 2019), institutions of higher education and individual STEM colleges, schools, and departments must work to foster a culturally inclusive environment that promotes a sense of belonging so as to increase STEM retention and success (Johnson and Elliott, 2020).

Several studies have demonstrated positive impacts of mentoring relationships on mentees' sense of belonging (Chan, 2008; Stolle-McAllister et al., 2011; Apriceno et al., 2020). Apriceno et al. (2020) found that both URM and non-URM STEM students who reported having an engaged mentor early during their first year of college reported significantly greater academic self-efficacy and sense of belonging than those without mentors. With regard to specific populations, research suggests that greater levels of support from mentors is associated with a stronger sense of belonging among Black (Maton et al., 2000), Hispanic (Holloway-Friesen, 2019), and international students (Curtin et al., 2013). The impact of mentoring on students' sense of belonging also applies to mentoring received from peers (Maton et al., 2000; Inzlicht et al., 2006) as connecting with similar-age students who have similar backgrounds and interests can normalize struggles and bolster students' positive science identities (Zaniewski and Reinholz, 2016). This finding suggests that peer mentoring may be a powerful addition to faculty mentoring in alleviating barriers and supporting the success of URM students (Craig, 2019). Although research regarding the role of mentoring in increasing faculty members' sense of belonging is scarce, Wright-Mair (2020) indicates that mentoring relationships, including holistic and critically conscious mentoring by colleagues, supportive peer mentoring, mentoring students, and community-based mentoring relationships have the potential to enhance feelings of social connection for URM faculty at PWIs. Taken together, the extant literature strongly points to the role that supportive mentoring relationships play in facilitating career success for URM groups.

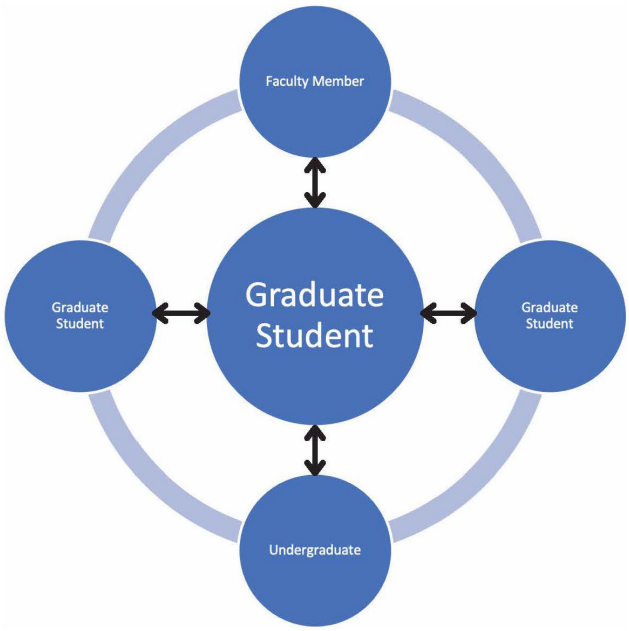

FIGURE 1 | Depiction of non-dyadic, holistic mentoring relationships utilizing an example of a graduate student who receives mentorship from a faculty member while providing mentoring to undergraduates and peer mentoring to fellow graduate students.

MENTORING UNDERREPRESENTED MINORITY STUDENTS IN HIGHER EDUCATION: A ROADMAP FOR DIVERSIFYING THE STEM WORKFORCE

Thus far, we have discussed the potential for mentoring to mitigate challenges faced by URM groups in academia. However, mentoring that effectively maximizes academic and career success among URM STEM students requires innovative structures, a comprehensive implementation plan, buy-in and commitment from both administrators and faculty, and coordination among key stakeholders within and outside the academic environment. In this section, we offer recommendations that institutions of higher education can take to implement a system of mentoring that meets the needs of URM groups.

Recommendation 1: Create Opportunities for Non-dyadic Mentoring

The prevailing model utilized in academic environments involves dyadic mentoring, in which one mentee works with one mentor to acquire knowledge and skills in a specific research area. Some mentors may also provide personal and career advice, but this is typically not required and is left up to the mentor to decide if they want to offer this type of guidance. While URM students and faculty can certainly benefit from structured dyadic mentorships, these relationships are often limited because a single mentor may not have the capacity, breadth of knowledge, or expertise to adequately address all of a single mentee's needs (Yun et al., 2016). In terms of social capital, there are many beneficial networks that are not being leveraged in the traditional dyadic model. As the National Academies of Sciences, Engineering, and Medicine (2019) suggest, there are often more effective approaches for mentoring than a singular relationship between one mentee and one mentor, especially in contexts with relatively few available mentors or in which mentees have varied needs. Therefore, dyadic relationships are important, yet insufficient for optimizing career trajectories among URM groups.

As a supplement to traditional, dyadic mentoring, academic institutions must create opportunities for network-based "holistic" mentoring, in which mentees at multiple levels of education also serve as mentors to other scholars who are at the same level of education or below while receiving mentorship from mentors who possess a greater level of expertise (e.g., a graduate student mentors undergraduate students while also receiving mentorship from a faculty member; **Figure 1**). In a national study of undergraduate researchers, students who described having significant mentoring relationships with faculty, graduate students, and postdocs in their laboratory, as opposed to only graduate students and postdocs, reported greater scholarly productivity, scientific identity, and likelihood to pursue a Ph.D., suggesting that multi-level mentoring relationships can increase students' sense of belonging and sense of connection to their institution and the larger scientific

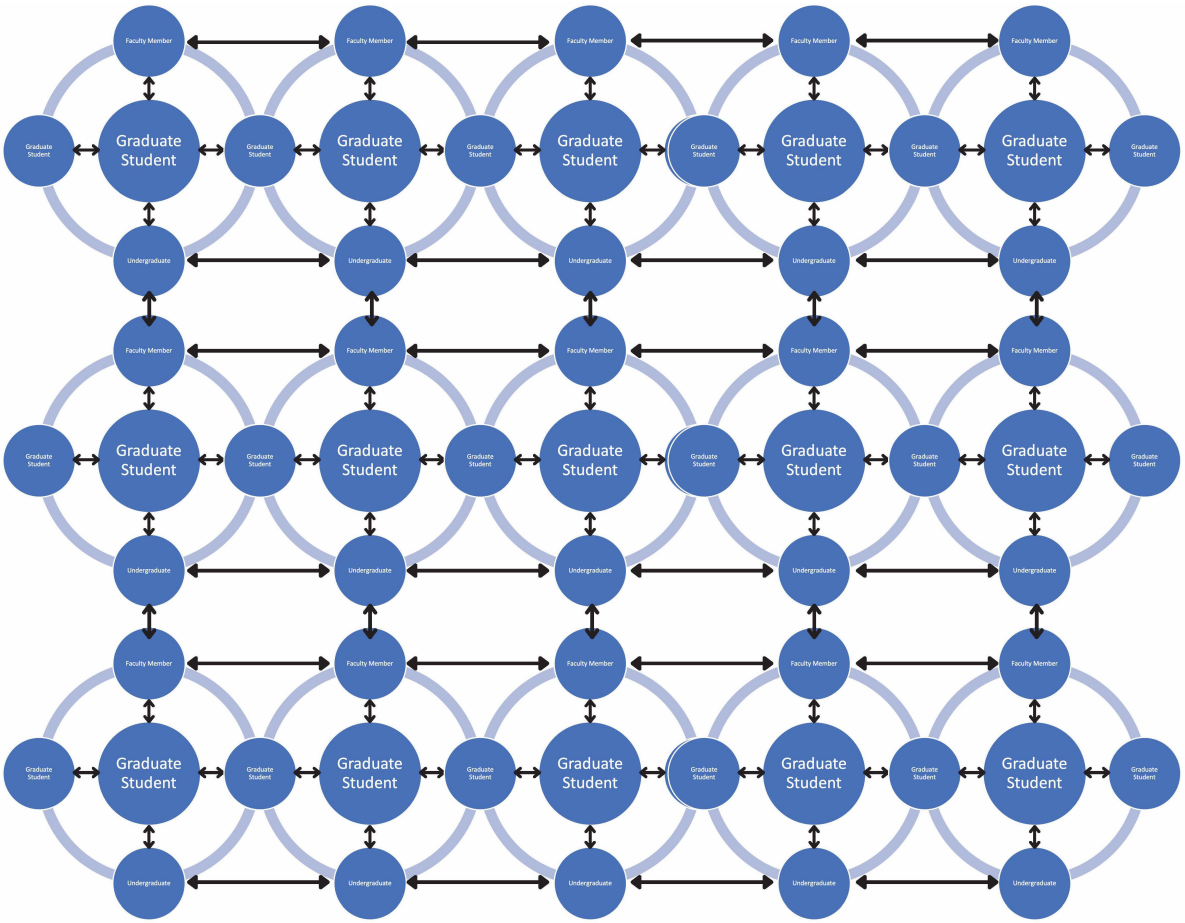

FIGURE 2 | Extended network of mentorship throughout an entire academic environment.

community (Aikens et al., 2017; Joshi et al., 2019). In another study, undergraduate students engaged in a peer mentoring network were less likely to consider leaving their university than a comparison group (Collings et al., 2014). In addition, a study of graduate students, postdoctoral fellows, and junior faculty found that scholars who participated in peer mentoring groups in addition to traditional mentoring rated time spent with their mentors as more valuable than those who did not (Lewis et al., 2017). Furthermore, research indicates that positive impacts of mentorship extend beyond the immediate relationship between a single mentor and mentee. For instance, the engagement of postdoctoral fellows in laboratory meetings was found to positively influence graduate student skill development independently of the graduate students' relationships with their PIs, suggesting a "cascading" effect of mentorship (Feldon et al., 2019). These findings emphasize the importance of expanding the way that academic institutions conceptualize mentoring to include more complex structures and relationships than dyads and considering how these relationships exist within and affect extended networks. We envision this extended network of mentoring relationships as a "net" that connects all stakeholders within a given environment (**Figure 2**).

Although holistic mentoring networks hold a large degree of potential, academic institutions must develop an effective strategic plan that will allow such a system to thrive within each of its individual academic departments/colleges/schools. Given our experience implementing mentoring systems for URM groups within STEM higher education, we believe the best approach is for the institution's central governing body to provide a broad set of requirements that each academic department or college (collectively referred to hereafter as "academic units") must follow, leaving it up to the individual academic units to determine how they will implement each of the requirement. At the same time, the central governing body should require each unit to document their efforts and utilize data collection/analysis to evaluate progress. In addition to these requirements, the central governing body should also disseminate suggestions and guidelines based on mentoring literature that are not necessarily required but can help academic units plan and implement mentoring initiatives. Below, we outline several additional recommendations that can guide academic units toward the successful implementation of holistic mentoring systems.

Recommendation 2: Establish a Committee or Implementation Team for Overseeing Mentoring Within the Academic Unit

The overarching goal of a mentoring implementation team is to help inform, prepare, and support mentors and mentees in developing effective and meaningful mentoring relationships. Implementation teams should consist of a team leader who is familiar with mentoring systems (see section on training below), as well as a diverse array of representatives from varying research areas within the academic unit, racial and ethnic backgrounds, and any other characteristics deemed important by the unit. Team members should understand the contextual influences in the setting and may also be well acquainted with members of the setting (Meyers et al., 2012). Implementation teams must also seek regular and consistent feedback from stakeholders within the academic unit including students, faculty, and staff to inform the decisions made with respect to the mentoring system. Implementations teams can also help reduce negative effects of power differences (see recommendation 5).

Recommendation 3: Align Mentoring Networks With Existing Formal Advisors/Research Mentors

Academic units will need to determine how to structure their mentoring networks so that they complement the already established dyadic relationships between mentors and mentees and that mentors' advice and guidance for a given mentee do not conflict with another. One approach to addressing this issue is to designate one mentor as a student's primary research mentor (for graduate students, this relationship is typically already in place when they are admitted into a graduate program). Students can then be matched with non-primary mentors either by allowing the student to choose who they work with (from a group of available mentors) or by implementing a matching process based on career and research interest surveys as well as personality inventories. This process allows for matching based on professional, relational, and personal identities, which can increase mentorship quality and reduce impostor phenomenon (Baker et al., 2014; Cohen and McConnell, 2019; Barr-Walker et al., 2020; Chakraverty, 2020). As part of this arrangement, students should understand that they have an obligation to complete work for their primary research mentor before any other mentors. Therefore, non-primary mentoring relationships should not be as task-intensive but rather should focus on providing support, guidance, and connections for mentees.

Recommendation 4: Implement Practices to Reduce Overcommitment and Minimize Emotional Labor Burden

Overcommitment is rampant in academia given the multi-faceted nature of academic work which includes teaching, writing, conducting research, serving on committees, and of course, mentoring. Lack of healthy balance between work and personal life is consistently cited by academics as a major stressor and has been demonstrated to negatively affect mental health, especially among women, and faculty with children (Solomon, 2011; Bell et al., 2012; Cannizzo and Osbaldiston, 2016). However, faculty of color face additional "cultural tax" burdens when they are asked to take on extra responsibilities to address issues of diversity and inclusion such as serving on DEI committees, educating others about diversity, participating in community service, and mentoring students and colleagues from URM groups (Padilla, 1994; Dancy and Brown, 2011; Akin, 2020). If universities are to successfully implement culturally relevant mentoring without overtaxing mentors of color, both the institution's central governing body and individual academic units must convey to faculty that the responsibility of achieving diversity, equity, and inclusion goals falls on all faculty, not simply faculty who identify with marginalized groups (see section on training for mentors below). As Dancy and Brown (2011) note, the myth that students (and faculty) of color may receive mentoring only from mentors of color can prevent the formation of high-quality mentoring relationships between White mentors and mentees from URM groups. Another factor contributing to the stress of mentoring is that mentoring efforts are rarely recognized, rewarded, or considered in performance review and promotion processes (Montgomery et al., 2014). Academic institutions and individual units should take measures to assess and acknowledge mentors' accomplishments. These efforts may involve creation of both institution and department-level awards for mentoring, as well as re-examining tenure and promotion processes to place a higher degree of emphasis on mentoring outcomes.

To further reduce the burden on faculty, academic units should take stock of all faculty commitments required by the department, college, or school and determine how much each requirement contributes to institution, department, and individual goals. Academic units should consider whether some of these requirements can be reduced or eliminated entirely to allow more time for cultivating students through mentorship. In addition, the central governing body must empower academic units to discover strategies to support faculty who engage in mentorship through merit (i.e., tenure packages, awards, external nominations) and monetary (i.e., start-up packages, program support, department backing) initiatives. This type of support will ensure faculty feel that the academic units value the work they do to grow the demographic of the departments. Given the large variation in the mission, goals, and culture of academic institutions and their discipline-specific academic units, we are aware that there is no single solution that will work for all academic institutions. However, our intention in writing this paper is to encourage individuals within academia to begin having conversations about the role that mentorship plays in creating an equitable academic environment and how efforts can be taken to optimize the effectiveness of mentoring for URM groups.

Recommendation 5: Put Systems in Place to Address Power Differences

Power differences are often present in mentoring relationships given that one person is typically designated as the mentor and one person is designated as the mentee. Although peer mentoring can mitigate against the negative effects of power abuse in traditional mentoring relationships, peer mentoring is not without its own set of potential problems, including competition among peers, limited professional experiences, and fewer connections (Bussey-Jones et al., 2006). Thus, there is no practical mentoring system that is guaranteed to be free from the risk of abuses of power or from the disadvantages of inexperienced mentors. The limitations present within each system are why we advocate for a holistic mentoring approach that encompasses the benefits of both traditional, dyadic mentoring and peer mentoring approaches while mitigating against the drawbacks of each. Even with this type of system, however, implementation committees must take heed to the disadvantages of dyadic and peer approaches to design a system that minimizes potential limitations. One consideration is to assign peer mentors to one another rather than allowing mentees to choose their own peer mentors. To the extent possible, these assignments should involve the use of quantitative and qualitative data such as field of study, personality fit, potential for cooperation vs. competition, and professional accomplishments. Academic units may also consider creating peer triads or quads to increase social capital and maximize sharing of professional and personal knowledge and support. Finally, mentors (including peer mentors) must receive training that incorporates information about what constitutes an abuse of power, how to recognize and minimize the negative effects of power differences, and how to utilize one's status to help mentees accomplish their career and personal goals.

Recommendation 6: Provide Training to Mentors and Mentees

Although proper training is critical for mentoring to be carried out effectively in a holistic mentoring system, very little training is typically provided to mentors regarding data-informed best practices for effective mentoring (Pfund et al., 2006; Johnson and Gandhi, 2015). Academic institutions should keep in mind, however, that a "one-shot" training at the beginning of a semester is often insufficient for maintaining trainees' skills over time. In addition to a general orientation that provides the foundational elements of evidence-based mentoring, it is often useful to have shorter, regularly occurring sessions throughout the semester to revisit critical aspects of mentoring, introduce new ideas for mentoring practice, and allow mentors and mentees share insights and ask questions based on their experiences. If mentors' schedules allow, utilizing a curriculum such as *Entering Mentoring* (Handelsman et al., 2005) can be a beneficial way to ensure that mentors acquire skills necessary to help their mentees reach their full potential. Whatever training method is used, it should be based on mentoring literature and include instruction and discussion around key aspects of mentoring practice, such as Pfund et al. (2016) five fundamental attributes of effective mentoring. Based on theoretical models of academic persistence, these five core attributes include research, interpersonal, psychosocial/career, culturally responsive/diversity, and sponsorship. Devoting time for instruction and discussion regarding each of these areas can help mentors understand barriers for URM groups such as stereotype threat, impostor phenomenon, microaggressions, and lack of social connections and help make clear how mentors can play a significant role in reducing the impact of these barriers. Such training can help mentors understand how they themselves may have contributed to these barriers as well as how to help their mentees when they experience them.

Regarding the implementation of training initiatives, the implementation team will need to be trained in evidence-based mentoring approaches or to identify experts who can lead these trainings. One way to ensure that all mentors receive the training is to assign mentees within the program only to mentors who have completed training. Mentors who do not participate in the training can still have primary research mentees but cannot take on additional secondary mentees unless they have completed training. Some academic units may wish to break training participants into small groups that allow for more interactive training workshops, where participants can practice skills with one another. As with small groups of mentees, creating cohorts of mentors is likely to help create camaraderie, comfortability, mutual support, and motivation among mentors (O'Meara et al., 2019).

In addition to mentor training, training for mentees should not be overlooked as a means for maximizing the effectiveness of mentoring initiatives. Students not only need *access to* relationships, but also the *ability to mobilize* those relationships through communication skills, help-seeking behavior, and self-awareness. Research suggests that involving students in training that increases help-seeking and network orientation, such as the Connected Scholars curriculum (Parnes et al., 2020) can have positive impacts on both GPA and student-instructor relationships. For academic units concerned about the time and resources involved in training students, it may be helpful to integrate mentee training within existing structures, such as asking instructors to embed the learning and practice of interpersonal skills into their courses as well as taking advantage of interpersonal skills training opportunities offered by other units on campus such as career and academic success centers. In this way, mentees get the most out of their mentoring relationships while at the same time building skills that they can use throughout their career to create connections and support networks that can help them achieve their goals.

Recommendation 7: Implement Culturally Responsive Mentoring Practices

Minority students and faculty at majority institutions face challenges that affect their STEM identities. Effective mentorship for URM groups requires mentors to recognize and appreciate the lived experiences of their mentees and understand how barriers impact their participation in STEM. Culturally responsive

mentorship acknowledges differences in backgrounds and shows interest in mentees' social identities as well as their science identities (National Academies of Sciences, Engineering, and Medicine, 2019). Mondisa and McComb (2018) suggest that mentors must be aware of key areas of URM mentees' experiences including: (1) differences between their own cultures and the culture of their institution, (2) how mentors identify with their students' worldviews, and (3) racial and ethnic identities in the mentoring relationship. Consideration of mentees' lived experiences and values can help mentors provide the appropriate support for their mentees' goals. With regard to students, affirmation of STEM identities through mentorship can positively impact academic performance (Crisp and Cruz, 2009; Haeger and Fresquez, 2016). Mentors committed to wholly understanding a student or faculty member should invest the time to learning how that individual's background and experiences can influence their academic or job performance. Going beyond encouragement and taking a genuine interest in a mentee socially and emotionally as part of mentoring practice can strengthen mentees' career identities and alleviate common barriers experienced by URM groups (National Academies of Sciences, Engineering, and Medicine, 2019). Academic institutions that intend to be inclusive and promote effective mentorship should provide their faculty and peer mentors with cultural awareness resources and/or trainings to provide them with the necessary tools to support their mentees. The Culturally Aware Mentoring (CAM) training program from the Center for the Improvement of Mentored Experiences in Research (CIMER) offers cultural competency resources for faculty and administrators (Sorkness et al., 2017). Participation in this program could aid mentors with the toolkit to learn and embrace differences experienced by their mentees.

Recommendation 8: Create Connected Communities

Creating communities in which all members feel valued, respected, and safe is a core underlying component of an effective mentoring system. As Mondisa and McComb (2015) state, social community is created through "dynamic, multidirectional interactions among peers and with faculty in both formal and informal settings." Therefore, academic institutions who hope to create more equitable environments must create opportunities for formal and informal multidirectional interactions, in which participants both benefit from and contribute to their relationships with mentors and peers. Formal interactions may involve classes and regularly scheduled mentoring meetings, while informal interactions may involve recreational gatherings such as attending sporting events or impromptu conversations between peers or colleagues in the hallway. These interactions lead to the development of social support, in which community members are familiar enough with one another that they support each other not only academically, but also personally. Indeed, research demonstrates that sense of community among minority STEM scholars leads to perceived program benefits, which ultimately leads to increased science identity and research self-efficacy (Maton et al., 2016).

One way in which academic units can facilitate community is to create smaller peer groups within the larger community. Smaller peer groups who engage in informal activities together tend to form bonds that allow them to build trust among one another, and in turn, make their campus community feel smaller. Washington and Mondisa (2021) posit that building these types of social communities leads to five important outcomes: (1) connectedness, which includes strength of relationships and sense of belonging, (2) resilience, or the ability to recover from difficult challenges, (3) communities of practice, which are groups of similarly minded individuals who share experiences and social resources, (4) social capital, which refers to the tangible and intangible resources and benefits that result from having personal and professional connections, and (5) satisfaction with one's current academic and social environment. Another beneficial component of mentoring programs that helps to develop a strong sense of community is to create opportunities for alumni to remain involved in various capacities such as providing mentorship to current scholars, serving on informational panels, or attending periodic events. Washington and Mondisa (2021) demonstrated that if there is a strong connection and sense of belonging among participants in the program, alumni are more likely to want to engage with the program even after they leave. Engagement with alumni allows current participants to (1) have access to a larger pool of mentors, (2) grow into fully participating members, and (3) take advantage of the social capital that alumni have to offer as part of their networks.

Finally, providing current participants with a degree of agency in determining how the mentoring program is structured provides an increased sense of connection to the program (Matthews, 2016; Pack and Peek, 2020). Establishing mentee and mentor advisory boards can help to create buy-in for the program, and "crowd-source" solutions to challenges that arise within the program. In addition, collaborating with faculty, staff, and administrators can help build students' skills with regard to designing and planning collaborative learning experiences and can bolster confidence in their ability to positively impact the world around them. Given that mentoring systems will need to adapt and change over time based on emerging research on mentorship, changing populations of students and faculty, shifting priorities of department/institution, and cultural/societal factors, advisory boards that are comprised of people who the program serves can be a critical determinant of whether a mentoring program successfully meets the needs of its participants.

Recommendation 9: Develop Inter-Institutional Partnerships

Once a system of mentoring is in place, academic units may want to consider expanding the impact of their mentoring networks through strategic partnerships with other academic institutions. As Estrada et al. (2016) point out, there is much to be learned from programs that have demonstrated success in raising the retention and persistence of URM

groups in STEM. They suggest that strategic partnerships between programs with similar goals can "ignite institutional transformation. . .and may be the most important factor for producing systemic change" (Estrada et al., 2016). Creating collaborative communities of support that transcend individual institutions allows for an even greater expansion of mentees' social capital by allowing access to mentors with different backgrounds, skills, and connections. By partnering with successful programs, institutions can build on proven strategies and give scholars access to a network of support for academic career stages from undergraduate through junior faculty.

Given that there are multiple types of higher education institutions (research institutions, community colleges, minority-serving institutions, etc.), it is also important to ensure that structures are in place to help students overcome barriers to successful transitions between institutions. For example, students who transfer from an HBCU to a PWI may encounter a less supportive environment and experience greater levels of impostor syndrome, microaggressions, and lower sense of belonging. Thus, it is critical for institutions to consider using the ideas listed in this section with respect to creating opportunities for non-dyadic mentoring, training mentors in culturally sensitive mentorship, and creating tight-knit communities. One set of programs that provides a helpful example for academic institutions seeking to learn how to create communities and inter-institutional partnerships are the Louis Stokes Alliances for Minority Participation (LSAMP). LSAMP are a set of programs funded by the National Science Foundation with chapters at close to 200 colleges and universities throughout the U.S. LSAMP alliances are engaged in successful efforts to increase student retention, graduation, and career excellence for historically underrepresented minority students, and can serve as a great resource for creating successful mentoring programs and tight-knit communities. Given the vast reach of the LSAMP network, it is likely that most academic institutions in the U.S. have an LSAMP program or are close to an institution who does. Academic institutions should consider reaching out to the principal investigators and program managers of their institution's LSAMP programs to learn about their approaches to supporting students from URM groups and to collaborate in developing successful mentoring approaches on a larger scale, as LSAMP programs typically only have funds to serve a relatively small cohort each year.

When discussing inter-institutional collaborations of this type, it is also important to address the criticism that by allowing students to have mentors at other institutions, these extra-institutional mentors may try to "steal" students away from their current institution. We posit that this attitude represents a failure to think about what is best for students. Effective mentors who listen to their mentees' motivations and desires and understand their talent and potential should offer advice based on what will help the mentee achieve their desired career goals. If students prefer to take a path at a different institution, they should have no shame about pursuing that path. Allowing students to have this level of freedom helps to create a well-prepared workforce consisting of individuals who have been presented with several opportunities and have chosen the ones that best fit their passions and skills.

CONCLUSION

Barriers to retention, graduation, and career success among URM groups in STEM fields continue to persist despite many institutions' efforts to admit more diverse students and hire more diverse faculty, indicating that the supports needed to mitigate these barriers are still lacking. It is critical for academic institutions to act now to implement these supports, especially given the way in which the COVID-19 pandemic has eroded the traditional methods of interaction and increased the occurrence of more impersonal, virtual interactions among students, faculty, and staff. Many students who envisioned college as a social environment that could provide camaraderie, connections, and social support are deciding not to attend given that many of these experiences are diminished in a virtual environment (Ma and Pender, 2021). Experts predict that this trend will only continue even after the pandemic is over, due to increasing costs of tuition, stagnating wages, rising interest rates for student loans, and the increasing popularity of all-online institutions (Parker, 2020; Witze, 2020; Levine, 2021; Levine and Van Pelt, 2021). URM faculty also need strong, supportive connections as social capital is critical for faculty retention and career satisfaction (Bland et al., 2009; Stupnisky et al., 2015). Traditional brick-and-mortar academic institutions have the advantage of being able to provide students and faculty with meaningful interactions and strong network ties that they cannot easily receive through virtual learning. Therefore, creating a sustainable model for higher education must involve the development of strong communities and high-quality relationships that reduce barriers to URM student persistence in STEM, increase the appeal of scientific careers, and provide exceptional support and connections that lead to easily observable positive outcomes for students' careers.

We recognize that the challenges to creating a truly inclusive academic environment are numerous and that there is no single approach to addressing these challenges. In this paper, we have delineated ideas for implementing a mentoring system that incorporates many of the features demonstrated to reduce barriers to success among URM groups in STEM. We are aware that many changes will need to occur in multiple areas on a systemic level and that this process of change will be slow and gradual. However, our intention in writing this article is to convey the need for academic institutions to begin having these conversations about how to address the barriers outlined in this paper and to identify some key considerations for implementing a holistic mentoring system that has the potential to do so. We welcome further discussion on this topic from others in the field and hope to see this issue move toward the forefront of conversations about the need for equitable and inclusive education, STEM diversity, and the future of higher education.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Louisiana State University Institutional Review Board. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

RM, TMW, KG, KW, DB, and IMW wrote sections of the manuscript. RM, KG, and TMW contributed to the organization and editing of the manuscript. All authors contributed to the conception of the manuscript, read, and approved the submitted version.

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