Mentoring Underrepresented Students in STEMM: A Survey and Discussion

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Executive Summary

This article outlines the best mentoring practices for underrepresented and marginalized students in the STEMM disciplines—science, technology, engineering, mathematics, and medicine—according to the literature reviewed and synthesized here. STEMM fields have never been more popular majors at U.S. colleges and universities. However, White and Asian men dominate these fields, while the participation of underrepresented minoritized (URM) people (e.g., Black, Latinx, and Native American) is far lower than their representation in the U.S. population. Despite widespread recognition that the lack of racial and gender diversity among STEMM practitioners hurts these fields, various factors keep undergraduate URM students from choosing these disciplines and remaining in them. At the graduate level, underrepresentation is even worse.

The literature on URM STEMM doctoral students and mentoring suggests that mentors and mentees who have similar key identities (i.e., race, gender) has many benefits, especially in providing psychosocial support to students who are underrepresented and marginalized. Having a mentor with a shared identity who has been through similar experiences is beneficial to students

in terms of identification, developing interpersonal comfort, and role-modeling. A mentor who shares a mentee's social identity is more able to engage the student holistically. Moreover, psychosocial support appears to strengthen a student's science identity because seeing oneself in and receiving support and guidance from a similar other who is a successful STEMM professional can help the student feel recognized when they might otherwise feel ignored.

It also appears that having shared interests, values, and goals is important for successful mentoring relationships. Because some research shows that protégés receive instrumental (professional development or career-related) support from White male mentors, it may be necessary for minoritized STEMM doctoral students to seek different types of mentoring from different types of mentors. For students who struggle to find a faculty member of their race or gender—let alone one who shares similar interests and values—peer mentoring, especially step-ahead mentoring, may be an important alternative or additional option for minoritized students.

Possible Explanation for Exclusionary Practices in STEMM Fields

In STEMM (science, technology, engineering, mathematics, and medicine) educational environments, students frequently work in groups. When people categorize themselves and others based on social group boundaries (e.g., the STEMM classroom), especially when the integrity of a social identity is threatened (e.g., one's group is becoming more diverse, with more permeable boundaries), people want to maintain their group's distinction from other groups. When group boundaries are distinguished, and social groups are rank-ordered and assigned differential value, bias and discrimination can result.

Social identities, which show who does and does not belong in a given group, are defined by a common set of norms, attitudes, traits, and stereotypes, which together form a prototype, or the most normative representation of a group member. In STEMM, those who are not White, not

male, not heterosexual, not able-bodied, or not historically represented as scientists are prevented from benefiting fully from the opportunities afforded more prototypical group members.

What's Good for Mentees May Not Be Good for Mentors of Color

Effective role-modeling requires the mentee to identify with their mentor, thus it is helpful for the two to share an identity. However, faculty of color pay a high price for being mentors, as helping URM students navigate the academic culture, deal with personal or family problems, or find resources to keep them in college takes an emotional toll. Research shows that universities often do not value faculty of color's mentoring efforts and that it sometimes hurts their careers by taking time away from teaching and publishing.

White faculty members, however, can step into the breach. Those who mentor URM graduate students should acknowledge that academia is rife with unequal power relationships, discrimination, stereotyping, and oppression. White faculty who value the scholarship on a mentee's history and culture (e.g., history of the Black civil rights movement, research on race and racism in the United States) can engender supportive cross-race advising. Holistic mentoring, in which the relationship extends beyond academics, may be easier in same-race mentoring relationships, but research has shown that White mentors who engaged in successful cross-racial mentoring relationships with Black students had a heightened awareness of the unique challenges those students face, gained a holistic understanding of the student, and engaged in reciprocal relationship-building. Thus, diversified mentoring relationships (i.e., mentors of a different race or gender) can succeed when a mentor engages with the students' personal history and goals as well as their professional goals.

Students with Disabilities and LGBTQ+ Students

Students with disabilities experience a lack of support and accommodation in college settings and inadequate preparation in earlier special education programs. Solutions may include peer tutoring, lab communities, improved recruitment strategies, self-advocacy programs, professional development, mentoring programs, and e-mentoring.

LGBTQ+ faculty and students may not disclose their orientation, which can result in feelings of invisibility, isolation, and rejection. Moreover, hiding one's identity can contribute to stress, negative mental health outcomes, and lower productivity, even for a student or faculty member who does not face active discrimination**.**

What Makes a Successful STEMM Mentoring Program?

Essential components of a mentoring program for URM college students in STEMM should include:

- A meaningful, positive relationship with a mentor who supports and challenges the student
- Developing and reinforcing a scientific identity
- Institutional support, such as financial aid, recruitment strategies
- Engaging in research
- Peer and faculty support
- Minoritized or female role models
- Relationships with other minoritized staff
- Advice from advanced students of the same ethnic group

Next Steps to Improve Mentoring for Underrepresented Students in STEMM

To combat uniformity within STEMM departments, institutions should address engrained racialized and other types of bias that have contributed to the ineffective mentoring of URM and

marginalized students, which has kept them from fully thriving in the field. Cultural change is needed, which means that institutional leaders must acknowledge and dismantle the structures that perpetuate cultural bias toward URM students' academic ability.

Institutional leaders must make it a priority to

- value faculty engagement in mentorship and build capacity in this area;
- make mentorship a critical component of graduate education;
- cultivate faculty members' cultural competence in order meet the needs of URM students;
- recruit STEMM faculty and graduate students from racially minoritized backgrounds and develop holistic mentoring skills among all faculty;
- recognize the time-intensive nature of mentoring and compensate for it; and
- establish STEMM mentoring programs specifically for URM graduate-level students.

Meanwhile, researchers can further investigate how the mentoring of URM, and marginalized graduate students relates to intersectionality (i.e., being doubly marginalized by several aspects of identity), the effects of racism on students, the effects of mentoring on faculty and students' careers, and the role of networking support.

Introduction--Mentoring Underrepresented Students in STEMM

This article synthesizes the literature on the role social identity plays in STEMM mentoring programs and practices at the undergraduate and graduate levels. It also addresses practices that bridge demographic differences, outlines the scholarship on understudied groups, and summarizes the impact mentorship has on underrepresented students in postsecondary STEMM education settings.

The article has five parts. Part I details the role of social identity in STEMM mentoring programs and focuses on the relationship between same-race mentors and mentees. Part II defines the types and functions of mentoring offered in postsecondary environments and addresses the benefits and costs. Part III describes some of the special challenges of mentoring URM students at the graduate level. Part IV discusses two groups of students who are underrepresented in STEMM due to other social identities—students with disabilities and those who identify as LGBTQ+—and thus do not receive the same attention in the STEMM research community as URM and women students. In Part V, we outline some next steps institutions and organizations that care about mentoring underrepresented STEMM students can take in current and future programming. We draw largely from undergraduate research, and from some emerging research on graduate-level mentoring programs and studies on underrepresented students in doctoral programs in general, with a specific focus on the racially underrepresented in STEMM.

Much of the programming dedicated to the advancement of URM students includes mentoring as one of multiple efforts to increase student development and retention. Other components, such as stipends, research/internship opportunities, and opportunities to attend conferences and present research, are often touted as crucial for student development and retention because they increase students' self-efficacy in their academic domain. However, simply feeling that one is capable of performing science may be insufficient. While self-efficacy is necessary, what is even more critical in terms of predicting underrepresented students' long-term commitment to and persistence in the STEMM fields is actually feeling like and holding the same attitudes and values as a scientist—that is, having a strong science identity. Mentoring can serve a function similar to these capacity-building activities in that mentors are expected to

provide professional development. However, our review of extant research suggests that receiving psychosocial or emotional support is particularly critical for underrepresented students because it can strengthen their science identities. While same-race and same-gender mentors are theoretically best suited to provide underrepresented students with psychosocial support, these pairings are frequently not possible due to the even greater underrepresentation of faculty with similar social identities.

It is difficult to define which programming components qualify as mentoring and which further complicate the investigation of multilayered graduate programming. Research that determines if mentoring programs have led to change at the departmental or institutional level is scant. Moreover, mentoring is often a single component of a multifaceted program, thus any reported outcomes that do not disaggregate the program components cannot be attributed solely to mentoring. To our knowledge, the research and academic communities do not systematically evaluate the impact mentoring programs have on the culture of departments and institutions, perhaps because it is difficult to operationalize and measure cultural change and to control for other factors that have an impact on institutional change. To help guide this discussion, we offer some definitions that frame and name our population of study.

To signify the racial marginalization and subordination within U.S. institutions, including colleges and universities, we use the term “underrepresented racially minoritized” to refer to students who are underrepresented in terms of race, which acknowledges a system of policies and practices that racializes people of color. The passive term “minority” implies an inherent (and normalized) state of affairs and obscures the fact that individuals are rendered a minority or are minoritized through White supremacy, which has created a society that normalizes a hegemonic worldview, to the detriment of non-White people. To define who qualifies as a URM

student, we borrow from the National Science Foundation National Science Foundation (2017, p. 2), which defines underrepresented minority as a category that "comprises three racial/ethnic minority groups (Blacks, Hispanics, and American Indians or Alaska Natives) whose representation in science and engineering is smaller than their representation in the U.S. population." The National Science Foundation acknowledges that people have certain advantages or disadvantages in the labor market based on social structural factors, including race and gender (National Science Foundation, 2017).

A large focus of STEMM mentoring research is on URM and women undergraduate and graduate students, although other groups are underrepresented and marginalized based on social identities that do not fit the prototypical STEM identity (not to mention the intersection of these identities). Disability, for example, is a social identity that shapes a person's life, as students with disabilities identify with others who have impairments, experience oppression, and wish to challenge notions of normalcy. We also argue that, although people who share an identity with others who are disabled do not perceive their difference as a deficit (similar to people of color), those in our society who have a disability often are marginalized or treated as insignificant. Like people of color who have a highly salient and affirming racial identity, a disability identity refers to having a positive sense of self and feelings of connection to, or solidarity with, the disability community (Gregg et al., 2016). Gender identity can correspond with or differ from one's assigned sex at birth, and individuals with nonnormative gender identities experience marginalization and discrimination. Moreover, policies, practices, and behaviors have been enacted that limit their ability to express their gender identity, which has implications for their academic and STEMM experiences.

PART I: Exploring the Role of Social Identity in STEMM Graduate Mentoring Programs

Although STEMM departments in higher education have been characterized as objective, meritocratic, and color- and gender-blind (Baber, 2015), their legacy of exclusionary practices still shapes educational experiences and creates particular challenges for students who have been historically underrepresented in these intellectual spaces (Camacho & Lord, 2011; Solórzano, Ceja, & Yosso, 2001). In terms of race, Black, Latinx, and Native American/indigenous students are especially underrepresented in STEMM doctoral programs (National Science Foundation, 2018), meaning that their representation in STEMM fields is significantly less than their representation in the U.S. population. In 2014, 3.5% of doctoral awardees in science and engineering were Black (1,375), 4.4% were Latino (1,620), and less than 1% were indigenous peoples (33; National Science Foundation, 2017) In this paper, we argue that mentoring relationships have great potential to lessen these social disparities in various ways and to affirm underrepresented students' identities as scientists, especially when mentoring is framed as a set of interactions affected by the social identities of the mentor and the student/mentee/protégé.

STEMM Social Identity

Student experiences in STEMM contexts are highly contingent upon their social identities, or the categories that derive from social groups that students identify with and are affiliated with (Kim, Sinatra, & Seyranian, 2018; Tajfel, 2010; Tajfel & Turner, 1986). Whether social identities are based on assigned characteristics (e.g., race, ethnicity, gender) or self-determined characteristics (e.g., scientist, student), they are shaped within a social context (Barker, 2012, 2016; Eggerling-Boeck, 2002). According to social identity theory, in intergroup contexts in which individuals categorize themselves and others based on social group boundaries (e.g., the STEMM classroom), especially when the integrity of a social identity is threatened (e.g., one's group is becoming more diverse, with more permeable boundaries), individuals are

motivated to maintain or increase how positive and distinct their group is relative to other groups (Tajfel & Turner, 1986). This can result in bias and discrimination, in which group boundaries are more clearly delineated and social groups are rank-ordered and assigned differential value (Brewer, 1979; Chen & Li, 2009). This might explain some exclusionary practices in STEMM fields, as STEMM environments often implement learning strategies such as group work and collaborations that require students to work alongside their peers (Prince, 2004). In these learning contexts, group boundaries are drawn and reinforced through mechanisms such as subtle discriminatory behaviors (Ridgeway, Brockman, Naphan-Kingery, & McGee, 2018).

Individuals develop social identities to fill psychological needs, such as increasing self-esteem (Reid & Hogg, 2005) and reducing self-uncertainty (Hogg & Mullin, 1999), because these identities essentially delineate who belongs in a group and who does not. Accordingly, social identities are defined by a common set of norms, attitudes, traits, and stereotypes, which together form a prototype, or the most normative representation of a group member (Hogg, Terry, & White, 1995). Individuals who deviate from this prototype are marginalized within the social group and not extended full membership. In STEMM fields, those who are not White, not male, not heterosexual, not able-bodied, not middle class or higher, or historically not represented as scientists are barred from enjoying the full benefits of opportunities afforded to members of more highly regarded and prototypical groups.

This type of marginalization and ostracization can challenge the process through which emerging scientists who may not look the part develop their identity as a scientist. This is because developing a social identity requires both a sense of belonging to a particular group and being accepted as a member of that group by its existing members (i.e., recognition from one's scientific community; Kim et al., 2018). Carlone and Johnson’s (2007) science identity model

offers one way of understanding how individuals develop an identity as a scientist, which has two necessary but insufficient requirements for developing that identity: (1) being competent in science, and (2) being able to demonstrate that competence. Research has shown that exposure to research experiences that increase students' self-efficacy and help them feel competent to perform their role as a scientist is one way to increase individuals' science identities (Kendricks, Nedunuri, & Arment, 2013). However, Carlone and Johnson (2007) argue that *recognition from others as a scientist* is a critical component of developing a science identity. More broadly, URM students' awareness that society and schools position them as underachieving influences how they construct their academic identities (McClain, 2014). Although many of their participants could competently perform scientific research, Malone and Barabino (2009) used qualitative research with minoritized STEMM doctoral students to show that they lacked recognition from lab mates and principal investigators as legitimate and competent members of their scientific communities. Because individuals cannot construct a social identity in the absence of recognition from others, the invisibility they feel as a result can thwart the development and reinforcement of one's science identity (Malone & Barabino, 2009). As Carlone and Johnson (2007) stated, "It is much easier to get recognized as a scientist if your ways of talking, looking, acting, and interacting align with historical and prototypical notions of scientist" (p. 1207). The women in their study who had disrupted identities said their bids for recognition and thus their science identity development was unsettled by interactions with others, which were largely shaped by those individuals' perceptions of who does and does not belong in science based on race, ethnicity, and gender.

Furthermore, research shows that students underrepresented by race and/or gender were often expected to conform and assimilate into the dominant (i.e., White male) culture and

minimize their raced and gendered identities (Davidson & Foster-Johnson, 2001), which often were deemed less necessary to conducting science than their more valued science identity and thus were "extra-scientific." Although the ideal is to unify one's various identities, particularly for young adults (Erikson, 1968), this compartmentalizing of identities appears to reflect an underlying process called identity interference (Settles, 2004). This occurs when cultural meanings and stereotypes assigned to social identities cause those with multiple identities to feel that one of their identities (e.g., race, gender) interferes with the successful performance of another (e.g., STEMM). Therefore, URM students often maintain separate social and academic peer networks (Tate & Linn, 2005), minimize their raced and gendered identities, and, rather than integrate these critical identities with their science identities, they compartmentalize them (McCoy, Winkle-Wagner, & Luedke, 2015).

Resolving this interference by disidentifying, minimizing, or downplaying their devalued social identity (McGee, 2016; Roberts, Settles, & Jellison, 2008; Settles, 2004) can in turn challenge students' sense of authenticity and their sense of belonging in their discipline. Feeling they must change themselves to fit in is associated with depression, poor psychological well-being, and impaired academic performance (Roberts et al., 2008; Settles, 2004). One explanation for these poor psychological outcomes is that, when individuals deemphasize one of their social identities, like race, by subscribing to "assimilationist" and "humanist" racial ideologies that stress the similarities between Black Americans and others, they focus less on structures like racism and attribute invalidating academic experiences and outcomes to internal rather than external causes (Oyserman, Bybee, & Terry, 2006; Oyserman, Elmore, & Smith, 2012). In her overview of racial and ethnic identity development, Byars-Winston (2010) suggested that therapists can help minoritized students to better understand, identify, and deal with racism by

helping them depersonalize invalidating experiences while simultaneously reinforcing their self-efficacy in their field. This could extend to STEMM faculty who mentor minoritized students or are themselves minoritized.

Besides harming a student's well-being, feeling that their ascribed identity (e.g., race, gender) and achieved identity (science identity) are in conflict can adversely affect their academic or professional performance. Darling and colleagues' (2008) model of identity integration and professional achievement posits that those who feel a professional identity is incompatible with their race, class, or gender achieve less professionally than those who see these identities as compatible (Darling, Molina, Sanders, Lee, & Zhao, 2008b). This is because they often exert greater cognitive energy to monitor social cues, so they know when to actively suppress their devalued identity, which results in greater stress and distracts them from their work (Benet-Martínez, Leu, Lee, & Morris, 2002). The effects of deemphasizing a devalued identity in terms of psychological and academic outcomes are worse for students whose racial identity is central to their sense of self (Oyserman et al., 2012; Settles, 2004).

This paper focuses on the potential for student-mentor relationships to ameliorate these socially caused, identity-related challenges for STEMM students in higher education. As discussed later, mentors serve three critical functions: recognizing students' abilities, validating the simultaneous existence of their multiple identities (Davidson & Foster-Johnson, 2001; Gazley et al., 2014; Malone & Barabino, 2009), and role-modeling, which can increase students' self-efficacy. Minoritized STEMM students often do not look, act, and interact in ways that conform to hegemonic representations of scientists (Hall & Burns, 2009). Having a mentor can greatly increase these students' likelihood of thriving in STEMM environments (Thomas, Willis, & Davis, 2007), which can validate their various identities.

In response to the stagnating diversification of STEMM, a number of formal programs have been designed and implemented to recruit and retain URM students in STEMM. They often include a mentoring component (Girves, Zepeda, & Gwathemy, 2005), which has been critical in these students' retention and persistence. Because the relationships of faculty involved in mentoring programs are especially critical in predicting the retention of URM STEMM doctoral students (Gloria & Robinson Kurpius, 2001), we pose the following questions: How does having a mentor with similar social identities (e.g., race and gender) affect the outcomes of the mentoring relationship for URM doctoral STEMM students? Are the effects of receiving different types of support (e.g., instrumental and psychosocial) from a same-race or same-gender mentor more positive for URM STEMM doctoral students? Can "diversified" mentoring relationships (Ragins & McFarlin, 1990) yield similar results?

Race- and Gender-Matched STEMM Doctoral-Level Mentoring

The literature on race- and gender-matched mentoring in undergraduate STEMM education and in some workplace settings supports the idea that URM students in STEMM benefit from having mentors of the same race and/or gender, especially in terms of emotional/psychosocial support (Blake-Beard, Bayne, Crosby, & Muller, 2011; Patton & Bondi, 2015). URM STEMM students must navigate everyday and systemic forms of racism (Barker, 2016; McGee, 2015, 2016; McGee & Martin, 2011), and faculty mentors can help them reframe these negative racialized and marginalizing messages (Felder & Barker, 2013; O'Meara, Knudsen, & Jones, 2013).

The opportunity to provide same-race mentoring is challenged by the scarcity of URM faculty in STEMM. In 2015, of the 248,500 science and engineering faculty in the United States, 8,600 were Black (3.5% of the total), 11,850 were Hispanic (5%), and 500 were Native

American (< 0.33%; National Science Foundation, 2017). Based on the literature presented here on race- and gender-matched mentoring in undergraduate and graduate STEMM education and work settings, we contend that graduate students of color in STEMM fields are likely to benefit from having a mentor of the same race and/or gender. As Barker (2011) explained, same-race connections allow Black doctoral students to experience meaningful validation, affirmation, and success, which are crucial to completing the doctoral program. These connections also serve as a visual representation that confirms students' participation in STEMM programs. In addition, same-race and same-gender pairings provide students with mentors who understand the shared experience of being underrepresented in STEMM spaces (Felder & Barker, 2013). Studies also found that mentors who are culturally competent and understand power dynamics and oppression are also highly successful in fulfilling the needs of URM students (Felder & Barker, 2013; O'Meara et al., 2013). Another strong indicator of STEMM success for URM students is the mentor-mentee "fit" (i.e., the area the mentee needed support in was an area in which the mentor could provide support; Baker & Griffin, 2010; Blake-Beard et al., 2011). However, studies also agree that supporting URM students poses additional challenges that a mentor must be aware of to help URM students successfully navigate the academic environment; this includes providing specific institutional knowledge, advocating on their behalf, and being culturally competent (Baker & Griffin, 2010; Blake-Beard et al., 2011; Felder & Barker, 2013; Gasman, Hirschfeld, & Vultaggio, 2008).

In same-race and same-gender mentoring relationships, protégés witness and experience what their mentor does, thereby gaining a sense of self-efficacy and the confidence that they too will succeed (Williams, Thakore, & McGee, 2016). Early research on mentoring showed that female protégés with male mentors had difficulty seeing their mentors as suitable role models

(Kram, 1985), while women in same-gender mentoring relationships reported significantly greater role-modeling from their mentors (Ragins & McFarlin, 1990). However, later research has shown that both male and female students perceive female mentors as offering more psychosocial support, including role-modeling, and male mentors as offering more instrumental support, which is consistent with normative gender roles (Sosik & Godshalk, 2000). Woolnough and Fielden (2014) similarly found that female protégés see male mentors as focused primarily on academic or career goals and female mentors as focused primarily on psychosocial support. Thus, a female protégé's goals will guide her perspective on how suitable a male or female mentor will be for her academic and career goals. Male mentors have been found beneficial for women in the workplace, in that these women typically earn more promotions and higher pay.

Availability and Access Issues with Same-Race Mentors

Research has shown that workers of color in organizations most often have difficulty gaining access to same-race mentors, due to the low number of mentors at higher organizational levels and because they often are positioned on the periphery of workplace social networks (Blake-Beard, Murrell, & Thomas, 2006; Thomas, 1990). This causes Black workers and other workers of color to seek mentoring relationships outside their organization, to form cross-race and other more diverse types of mentoring relationships, including peer mentoring and "skip-level relationships" (i.e., with peers who are a level ahead of them in their workplace hierarchy; also called "step-ahead mentoring"; Thomas, 1990). Researchers (e.g., Mainiero, 1994) have found that people from underrepresented groups across social contexts (e.g., workplace, graduate school) generally tend to have to seek "a diverse constellation of mentors who vary in organizational affiliation, status, and personal characteristics" (Ensher, Thomas, & Murphy, 2001, p. 420). URM doctoral students seem to feel somewhat conflicted about seeking

mentorship from faculty of color. Lacey, a Black doctoral student in biomedical engineering, explained: “I would say it probably is helpful to get someone—especially if they are guiding you along the career journey—that [has] gone through your experiences . . . But the minority faculty always has so many other things and pressures already going on” (Williams, Thakore, & McGee, 2016, p. 10).

STEMM Doctoral Mentoring and Psychosocial Support

In their study of minoritized graduate STEM students, Chemers, Zurbriggen, Syed, Goza, and Bearman (2011) found that instrumental mentoring increased students’ self-efficacy in science, while socioemotional/psychosocial mentoring reinforced their identity as scientists, both of which increased students’ commitment to a science career (see Table 1). However, the relationship between one’s science identity and commitment to their field was found to be much stronger than that between self-efficacy and commitment (Chemers et al., 2011). Thus, increased self-efficacy, which maps onto an individual’s sense that they are competent to perform their role as a scientist, is less important than science identity in predicting long-term persistence in STEMM. Research supports the idea that developing a science identity and adopting the values of one’s scientific community are much stronger predictors of long-term integration into the science community than domain-specific self-efficacy (Estrada, Woodcock, Hernandez, & Schultz, 2011). Therefore, we might expect that mentoring relationships focused on psychosocial support rather than instrumental support would help URM and other underrepresented students persist in STEMM, in that they support the development and reinforcement of their social identities as scientists. Because of the demonstrated relationship between psychosocial support and science identity (Chemers et al., 2011), it is particularly important to understand how same-race and same-gender mentoring relationships positively affect psychosocial support—and to

understand what happens when this is not the case.

In one of the few studies focused on mentoring outcomes in STEMM across various race groups, Blake-Beard and colleagues (2011) found that an overwhelming majority of racially diverse undergraduate and graduate STEMM students (N > 1,000) felt it is important to have a mentor of the same race and gender. The participants (especially students of color and women) felt it was important that a mentor understand how a student's backgrounds could affect their professional career. Respondents in same-race and same-gender mentoring relationships also were likely to report they had received high levels of instrumental and psychosocial support, although this greater amount of mentoring had no apparent effect on the outcomes measured: increased GPA, self-efficacy, or confidence about their fit in the science profession. As described in further detail below, the research generally shows that having a mentor with similar key identities (e.g., race and gender) seems particularly important to their ability to provide psychosocial support (Blake-Beard et al., 2011; Thomas, 1990).

Greater trust and interpersonal comfort. Research shows that same-race and same-gender mentoring relationships provide better psychosocial support because having a common social identity (e.g., race, gender) creates a greater sense of trust and comfort between protégés and mentors. For example, Thomas (1990) found that protégés in same-race mentoring relationships received greater psychosocial support than those in cross-race mentoring relationships. People often identify more readily with those who share salient identity group characteristics (Tajfel, 1974), owing to similar experiences and shared understandings based on those identities. Thus, a mentor with different social identities from their protégé, such as race and gender (a diversified mentoring relationship), could restrict their ability to identify and empathize (Ragins & McFarlin, 1990). Additionally, it was found that doctoral students did not

feel they could enact their full range of social identities in a professional environment defined though Eurocentric middle-class standards that permeated their interactions with their faculty advisors (Barker, 2016).

Robnett, Nelson, Zurbriggen, Crosby, and Chemers (2018) found that mentors they interviewed found holistic mentoring—that is, the relationship with their protégé extends beyond academics—to be effective. They theorized that holistic mentoring may be easier in same-race mentoring relationships and called for future research in this area. Reddick and Pritchett (2015) found that White mentors who successfully engaged in cross-racial mentoring relationships with Black students at a predominantly White institution (PWI) reported (1) having a heightened awareness of the unique challenges facing Black students, (2) gaining a holistic understanding of these students, and (3) engaging in reciprocal relationship-building. Therefore, engaging in holistic mentoring, wherein mentors show curiosity and concern for students' cultural backgrounds and their non-STEMM social identities, may be one-way mentors, especially those in cross-racial relationships, can validate their students' multiple identities (Syed, Azmitia, & Cooper, 2011). This is because discussing or asking about students' various non-STEMM identities could signal the mentor's recognition and acceptance of their various identities.

For example, in his study of cross-racial mentor-protégé relationships in a nonacademic work organization, Thomas (1993) found that some Black protégés had highly salient racial identities and wanted to integrate their racial and professional identities, and to discuss race openly with their mentors. When they were paired with a White mentor with a colorblind perspective who preferred to suppress discussions of race and diversity (due to power dynamics, the mentor dictated this aspect of their relationship), the protégés described receiving instrumental support but not psychosocial support. They felt uncomfortable, which they said was

a barrier to forming a closer relationship, and they did not trust their mentor to make decisions based on race in a racially diverse workplace (Thomas, 1993). Research by Blake-Beard and colleagues (2011) confirmed Thomas's findings about the White mentor–Black mentee dyad. When the mentor and mentee agree on the significance or insignificance of race in the relationship and workplace, they can develop trust. Ultimately, effective mentoring is based on the ability to trust, share strengths, and to identify with and authentically engage with one another (Blake-Beard et al., 2011). Some researchers refer to this ability to speak freely and express opinions without repercussions as interpersonal comfort (Brunsma, Embrick, & Shin, 2017; Ortiz-Walters & Gilson, 2005).

Research by Ortiz-Walters and Gilson (2005) showed that pairing protégés and mentors who had deep similarities (in interests and values) predicted interpersonal comfort, which in turn predicted psychosocial, instrumental, and networking support Notably, although interpersonal comfort partially mediated the relationship between perceived deep similarities and psychosocial and instrumental support, it fully mediated the relationship between having similar values and receiving networking support. The authors explained that, unlike psychosocial and instrumental support, networking can create risks for the mentor outside the relationship because it entails introducing the protégé to colleagues and vouching for them, and thus requires a certain level of trust and comfort between them.

Underrepresented STEMM doctoral students' desire for same-race mentors. Williams, Thakore, and McGee (2016) found that a majority of their participants who were underrepresented in their fields (e.g., 54% of biomedical doctoral students of color) "felt that it was important to have mentors with life experiences similar to their own, including experiences pertaining to race and ethnicity" (p. 13). Blake-Beard et al. (2011) found that, compared to White

students, Asian students and URM students in STEMM (including Black, Native American, Hispanic, Hawaiian or other Pacific Islander, and bi- or multiracial participants) were significantly more likely to state that it is important to have a same-race mentor and to have a mentor who understands their background. They also found that the majority of women they interviewed wanted a same-gender mentor and felt it was important to have a mentor who understands their background.

Most recent research has found that minoritized doctoral students want mentors of the same race. Only one study, by Lee (1999), found that Black undergraduate students at a PWI that put special emphasis on STEMM degrees felt it was more important to have a mentor in their field than to have a Black faculty mentor. However, after further probing, Lee found that this was most likely because of the paucity of Black faculty in these students' disciplines. Students' mentoring experiences with faculty of the same race outside their field were ineffective because the mentor seemed impatient and lacked interest in the student. Lee reasoned that this was perhaps because of their different fields, and perhaps because many Black mentors were junior faculty (given the overrepresentation of Black faculty in junior faculty positions) whose attention was not attuned to mentoring but to earning tenure and promotions. Although this study is nearly 20 years old, the proportion of Black faculty in academia and in certain STEMM fields (e.g., engineering) has changed little. Moreover, although this study involved undergraduate students, doctoral students are also likely to need mentors in their field. Thus, these findings may apply to minoritized STEMM doctoral students who struggle to find a same-race mentor.

Diversified Mentoring for URM Students

Statistically speaking, mentors in STEMM fields are most typically White and secondly Asian and are more likely than mentors of color who are underrepresented to hold colorblind

views of their students and to dismiss the idea that important social identities such as race and gender shape their students' academic experiences (Brunsma et al., 2017; McCoy et al., 2015). To ignore race, gender, and other important social identities is to deny the formative effect they have on students' experiences, in both their programs and their later careers.

Although race, gender, and ethnicity can play significant roles in the mentoring process, researchers have found that the mentor's commitment to the mentee's academic success is the most beneficial component (Blake-Beard et al., 2011; Felder & Barker, 2013). White faculty who value the scholarship of Black history and culture engender supportive cross-race advising, whereas institutions that fail to have faculty with whom URM students can discuss such interests create a strenuous and challenging experience for the students (Felder & Barker, 2013, p. 8). Gasman et al. (2004) demonstrated that crossing racial boundaries requires advisors to "move out of familiar and prescribed spaces in order to forge new relationships built on honesty, equity, reciprocity, respect, and integrity" (p. 708). Similarly, in their study of cross-racial mentoring experiences between White faculty mentors and Black college students, Reddick and Pritchett (2015) found that White faculty perceived mentoring as a purposeful and iterative process of developing relationships with students. They also found that White mentors at a PWI who engaged in successful cross-racial mentoring relationships with Black students reported having a heightened awareness of the unique challenges these students faced and gaining a holistic understanding of them. Thus, it may be that diversified mentoring relationships can succeed when the mentor engages with more than the mentee's professional goals.

Research by Allen, Day, and Lentz (2005) on women in cross-gender and same-gender workplace mentoring relationships also suggests that certain factors may be more important than gender similarity in predicting mentoring outcomes. These researchers found that interpersonal

comfort fully mediated the relationship between gender similarity in mentoring relationships and the instrumental and psychosocial mentoring the protégés reported receiving. Although gender similarity predicted positive mentoring outcomes, when interpersonal comfort was added to the equation, the relationship between gender similarity and outcomes became insignificant. In other words, the discomfort associated with interacting with a male mentor is what predicted worse mentoring outcomes, not the mentor's gender per se (Allen et al., 2005). This suggests that increasing interpersonal comfort across diversified mentoring relationships is critical.

Furthermore, some research suggests that URM protégés may be more likely to receive better instrumental support—and thus better tangible outcomes—from White males. In their study of a multiracial sample of MBA graduates, Dreher and Cox (1996) found that protégés who had had White male mentors (regardless of their own race) earned significantly more annually (an average difference of $16,840) than those who had had a mentor with a different demographic profile. Theoretically, these differences in compensation result from differences in formal institutional power, and from informal power through their mentors' central positions in relevant networks (Dreher & Cox, 1996). More recently, Ortiz-Walters and Gilson (2005) found that MBA students of color reported receiving more instrumental support from White mentors than from mentors of color, although this difference was not statistically significant.

Peer Mentoring

In the absence of suitable mentors, URM STEMM doctoral students mentor each other throughout the PhD process (peer mentoring) or are mentored by a peer who is slightly more advanced ("step-ahead mentoring"; Ensher et al., 2001). In their comparative study of traditional, peer, and step-ahead mentoring relationships, Ensher et al. (2001) found that employees in traditional mentoring relationships had the highest job satisfaction. They theorize that this is

because, compared to peers and step-ahead colleagues, traditional mentors have greater access to power and influence, which translates into better career outcomes. Nonetheless, peer and step-ahead mentors can be an important solution to the problem of a lack of STEMM faculty of color. Wendt et al. (2018) found that e-mentoring modules that train graduate students for peer or near-peer mentoring improve self-efficacy for women in STEMM, facilitate student success in STEMM programs and the workplace, and increase persistence and graduation rates through college STEMM programs.

Using a case study design in her dissertation research, Brown (2016) found that, for 10 racially minoritized graduate students in STEMM, peer mentoring was equally important or more important than faculty mentoring. Reasons for this included closer proximity to peers and the less hierarchical, more reciprocal nature of their relationships. The participants in Brown's (2016) study found that peer (step-ahead) mentors from older cohorts in their department, with whom they formed relationships through their research labs, helped them reach required milestones, passed along useful information, and helped them prepare for exams and presentations. Mentees felt that their step-ahead peers had "insider knowledge" about the department culture and that they could ask them anything without fear of judgement, as they could not do with a faculty mentor (Brown, 2016). As Allen, Day, and Lentz (2005) pointed out, because peer mentors share an important identity (namely, STEMM doctoral student), they are likely to have greater interpersonal comfort. The Fisk-Vanderbilt Master's-to-PhD Bridge Program has found that a "tiered, peer mentoring approach" (similar to step-ahead mentors) in which senior Bridge students are connected to first-year Bridge students helps the newer students feel emotionally supported (Stassun, Burger, & Lange, 2010). Furthermore, whenever a mentor is in a more advanced position than the protégé, as in a traditional mentoring or step-ahead

relationship, the mentee can learn vicariously from the mentor (Williams et al., 2016).

Summary of the Role of Identity in URM STEMM Mentoring Relationships

In sum, the literature on URM STEMM doctoral students and mentoring, while not conclusive, suggests that having mentors who are similar to them on key identities (i.e., race, gender) has many benefits for protégés—especially in receiving psychosocial support and for students who are underrepresented and marginalized. Having a mentor with a shared identity who has been through similar experiences is beneficial in terms of racial and gender identification, developing interpersonal comfort, and role-modeling. A mentor who shares a mentee's social identity is more likely than others to be able to engage the student holistically. Receiving psychosocial support also appears to strengthen a mentee's science identity because seeing oneself in and receiving support and guidance from a similar other who has successfully performed their role as a scientist can help a student feel recognized, whereas they otherwise might feel unrecognized. It also appears that, in addition to sharing race and gender or other social identities, having shared interests, values, and goals is important for having successful mentoring relationships. Additionally, because some research shows that protégés receive the most instrumental support from White male mentors, it may be necessary for minoritized STEMM doctoral students to seek different types of mentoring from different types of mentors. For minoritized students who may struggle to find a faculty member of their race or gender—let alone one who shares similar interests and values—peer mentoring, especially step-ahead mentoring, may be an important alternative or additional option.

PART II: Higher Education Mentoring for Underrepresented Students

Definition of and Traditional Forms of Mentoring

Research on mentoring began in the 1980s with Kram (1983; 1985), who delineated its two main functions: (a) instrumental (career) support, which includes sponsorship, protection, increasing the protégé's exposure and visibility, and providing access to challenging assignments; and (b) psychosocial (emotional) support, which includes role-modeling, acceptance, affirmation, counseling, and friendship (Blake-Beard et al., 2011). Mentorship requires making a long-term emotional commitment to the mentee's professional and personal development. It helps students develop their networks, confidence, teaching, and long-term career aspirations (Brunsma et al., 2017). Mentors can be faculty members, as well as staff members, postdoctoral fellows, graduate students, and peers.

The literature lacks a comprehensive theory that fully defines mentoring. However, Nora and Crisp (2007), Gershenfeld (2014), and Crisp and Cruz (2009) have identified four mentoring domains: (1) psychological and emotional support, (2) support in setting goals and choosing a career path, (3) academic subject-knowledge support aimed at advancing a student's knowledge and skills related to their chosen field, and (4) role-modeling.

Table 1. Mentoring Domains

Psychosocial Mentoring	
Psychological and emotional support	Mentor encourages mentee, helps with problem-solving, uses active-listening techniques[1]
Role-modeling	Mentor guides mentee's behavior, values, attitudes
	Most effective for mentees who share an identity with mentor[7]
	Allows mentees to see themselves as future academics[8]
Instrumental Mentoring	

Support for setting goals and choosing a career path	Mentor assesses academic and career goals by evaluating mentee's strengths, weaknesses, and abilities, especially * helping mentee reflect and think critically about goals;[2] * facilitating reflection on[3] and exploration of mentee's interests, abilities, beliefs, and ideas; * reviewing mentees' progress toward goals; * challenging mentee's decisions or avoidance of decisions;[4] and * helping mentee to realize their dreams.[5]
Academic subject-knowledge support	Mentor educates, evaluates, and challenges mentee academically; tutors; and focuses on subject learning[6]

Sources: Crisp & Cruz (2009); Nora & Crisp (2007); Gershenfeld (2014).
Key: [1]Brunsma et al. (2017)Cohen (1995), Kram (1988), Levinson et al. (1978), Miller (2002), Roberts (2000), Schockett & Haring-Hidore (1985) [2]Cohen (1995); [3]Roberts (2010); [4]Cohen (1995); [5]Levinson et al. (1978); [6]Kram (1988), Schockett & Haring-Hidore (1985); [7]Davidson & Foster-Johnson (2001), Syed et al. (2011); [8]Syed et al. (2011).

Mentoring Studies in Higher Education

Literature reviews have identified both qualitative and quantitative studies of mentoring that used diverse research designs and data collection techniques. The qualitative studies often used case study methods and interviews to explore the benefits of mentoring, including the recommended characteristics and how students and mentors experience the process (Baker & Griffin, 2010; Bell & Treleaven, 2011; Griffin, 2013). Qualitative methods were used to explore students' and mentors' expectations and perceptions of the mentoring relationship, including its functions and roles. The quantitative research usually addressed helping students adjust to

college (Apprey, Preston-Grimes, Bassett, Lewis, & Rideau, 2014), career and personal development (Haddock et al., 2013; Kinkel, 2011; Sams et al., 2015), and measures of academic progress and success (Fox, Stevenson, Connelly, Duff, & Dunlop, 2010; Hu & Ma, 2010; Zell, 2011).

The majority of studies did not distinguish between mentoring and other types of supportive relationships, including those with advisors, institutional agents, and coaches (Baker & Griffin, 2010; Bettinger & Baker, 2011; Museus & Neville, 2012; Tovar, 2015). Research suggests that relationships formed naturally are more likely to be successful and to result in superior outcomes than relationships formed by assigning students to mentors (Davidson & Foster-Johnson, 2001; Gándara, 1999). Some intervention programs attempt to foster informal mentoring relationships through cohort- or community-building among peers and program staff.

In her literature review, Jacobi (1991) explored the importance of pairing students with mentors of the same gender or ethnicity. Jacobi noted the need for mentoring studies that focus on women and traditionally underserved groups. Crisp and Cruz (2009) explored the literature on mentoring in higher education and found a growing trend of programs that focus on specific populations, including online students, nursing students, and athletes. Mentoring of other groups also came under study, such as Black students (e.g., Griffin, 2013), Latinx students (e.g., Tovar, 2015; Zell, 2011), American Indian/Alaskan Native students (e.g., Guillory, 2009), and first-generation college students (Owens, Lacey, Rawls, & Holbert-Quince, 2010).

Benefits of Mentoring in Higher Education

Research has generally shown that instrumental and psychosocial forms of mentoring result in different outcomes for protégés. Instrumental support often results in better career outcomes, such as promotions (Scandura, 1992), and greater productivity for graduate students,

including publication output (Haeger & Fresquez, 2016; Tenenbaum, Crosby, & Gliner, 2001). In contrast, psychosocial support results in outcomes that are necessary for promotion and productivity, including student well-being, satisfaction with the mentoring relationship, and commitment to the academic program (Phinney, Torres Campos, Padilla Kallemeyn, & Kim, 2011).

Other positive mentorship programs outcomes include students' stronger academic performance and increased involvement in programs and with the college/university more generally (Brittian, Sy, & Stokes, 2009; Dahlvig, 2010), easier adjustment to the college environment (Smojver Ažić & Antulić, 2013), improved personal and career development (Kinkel, 2011), greater persistence in degree programs and more degrees earned (Gross, Iverson, Willett, & Manduca, 2015), and civic outcomes such as social responsibility and socially responsive leadership (Haddock et al., 2013).

Mentoring relationships can be characterized by their purpose, intensity, and duration. Successful mentoring relationships result from the mentor's intentional and purposeful commitment to helping their mentee succeed. This is typically a long-term commitment (Baker & Griffin, 2010). Mentoring programs also help students develop time-management skills, study skills, communication skills, and to adjust to college. Engaging and guiding students in research, helping them develop their career goals, and creating a sense of belonging in the college department are strategies that have proved successful in mentorship programs (Crisp, Baker, Griffin, Lunsford, & Pifer, 2017).

Meaningful mentoring relationships also foster students' growth through networking, asking questions, and exploring research opportunities. Scholars have found that mentoring at the undergraduate level is a pivotal factor in URM students deciding to enter graduate programs,

although there are many variables to consider, such as institutional selectivity and faculty encouragement (DeAngelo, 2016). DeAngelo (2016) described the STEMM environments as ideal for developing mentor-mentee relationships because they often include work in laboratories, which puts the faculty member and student in a one-on-one situation conducive to informal mentoring. However, students and faculty often have to initiate this type of pairing on their own. DeAngelo (2016) found that positive mentor-mentee relationships are particularly important in determining whether URM students pursue graduate degrees, and Felder (2010) found that faculty-student relationships increase the likelihood that URM students will engage in research.

Limitations of Higher Education Mentoring Efforts

Research supports that undergraduate research mentoring is beneficial for students (see Seymour, Hunter, Laursen, & DeAntoni, 2004), and positive effects of engaging in undergraduate research for faculty mentors are that it informs their teaching keeps them enthusiastic about their work (Dolan & Johnson, 2010). However, it does not appear to be equally beneficial for faculty members of color who serve as mentors, as engaging in undergraduate research requires additional time, effort, and funding, can cause increased tension between mentee and mentor, poses challenges in gauging students' research ability, and results in little recognition or reward for their efforts (Dolan & Johnson, 2010). The negative effects are worse when faculty work in an institutional culture that does not value undergraduate research or which is under-resourced (Schwartz, 2012). For example, Schwartz's (2012) qualitative research found that faculty of color paid a high emotional, professional, and even financial cost that outweighed any altruistic satisfaction they gained from it. The faculty mentors in this study said that helping students of color navigate their new academic culture, supporting them through

personal or family problems, and finding resources that enable them to stay in college took a toll on them emotionally. They experienced professional costs from spending 10-16 hours per week or more mentoring undergraduate researchers (Schwartz, 2012), which restricted their teaching and scholarship—activities that are more valued in the tenure and promotion process by institutions (Shavers, Butler, & Moore, 2014). The particular institution Schwartz studied was in an urban setting, offered two and four-year STEM degrees, and 85% of the student body were students of color, leaving a funding vacuum that mentors of color filled for their students, not unlike financial costs primary school teachers in the U.S. incur for buying school supplies for their students (Spiegelman, 2018).

Another study found that mentoring took a toll on Black faculty members' personal and family lives because it took them more time to complete research that they could have completed faster without the help of their student mentees (Hunter, Laursen, & Seymour, 2007). Crowe (2006) discussed the personal and professional costs to the mentor of funding undergraduate research and the need to develop institutional mechanisms to help with these costs. Faculty members see covering these costs themselves as potentially harmful to their academic and professional advancement; faculty of color who mentor students of color may incur even higher costs because they have additional barriers to overcome.

The culture of a department or institution coupled with the culture of a particular academic discipline can create formidable barriers to mentoring students of color (DeAngelo, 2016). For example, what an institution expects of faculty in terms of teaching and advising can prevent them from developing mentoring relationships and from guiding students toward graduate study. On the other hand, an institution can promote mentoring by creating settings in which faculty members commit to both mentoring and promoting graduate study. DeAngelo

(2016) concluded that faculty members who want to engage in mentoring but lack a supportive institutional culture often must work against the existing culture.

PART III: Mentoring for Underrepresented Students in STEMM

Certain criteria have been found useful in mentoring URM students, many of whom have not had access to the same resources and mentoring or networking groups as their majority counterparts (Palmer & Gasman, 2008). First, the mentoring program must be culturally appropriate and provide diverse instructors. However, having a role model from a similar cultural background and academic program is beneficial but not essential to students, whereas institutional forms of support such as financial assistance and an infrastructure that supports students' lifestyles and goals are vital. Finally, the institution must have a consistent process and instructional norms for the selection and retention of Black students (Kendricks et al., 2013).

It is unwise to assume that structures that benefit the general student body are what works best for URM students. Being mentored is vitally important to URM students' ability to graduate. When students of color are mentored by faculty in their discipline, the role-modeling can increase the students' cultural and social capital (Whittaker & Montgomery, 2014); however, they are less likely than White students to receive mentoring (Felder, 2010; Johnson, 2015). While the diversification of STEMM programs has improved, many scholars still point to the effects of race and racism they experience in STEMM, including feeling alienated, having to work twice as hard to receive recognition, and working under constant scrutiny (McGee, 2016; McGee, Griffith, & Houston, 2019) that can impede URM students' access to mentorship.

Graduate Mentoring Programs for URM Students across Disciplines

Doctoral students rely on their advisors to provide both academic socialization and professional mentorship, which influence their graduate school experience and their postdoctoral

career choices. This relationship is most effective when the transfer of knowledge of norms and behaviors enables doctoral STEMM students to accumulate the social and institutional capital that allows them to successfully navigate the academy and specific institutional structures (Zambrana et al., 2015). However, URM STEMM doctoral students' social identities, their mostly non-URM STEMM faculty, and the broader departmental culture can complicate the mentoring relationship.

To provide further background on this, we consider the literature on the advising of Black graduate students in various academic disciplines. The literature identifies three critical areas that affect the experiences and outcomes of URM graduate school students: navigating a mostly Eurocentric curriculum in a climate that is not inclusive of faculty and graduate students of color; how race and racism manifest in graduate school; and academic advising of doctoral students of color?].

Navigating a Eurocentric curriculum. A collaborative research project carried out by Gasman et al. (2004) revealed that unspoken assumptions about race and status often created a turbulent climate for the participating Black doctoral students and White faculty members who shared values of inclusivity (Gasman et al., 2004, p. 689). The authors concluded that faculty who work alongside URM graduate students should acknowledge that the academy is rife with unequal power relationships and cultural forms of discrimination and oppression (Gasman et al., 2004, p. 712).

Race and racism in the graduate school climate. Felder and Barker (2013) conducted semi-structured interviews with recent URM doctoral graduates, who revealed that their mentors and advisors had added to their daily load of slight verbal and behavioral indignities, better known as microaggressions. They concluded that "these perceptions of behavior characterize an

encoded system of behavior that underscores a historical legacy of exclusion that affects the development of positive student-faculty relationships and serves to continually marginalize Black students and other students of color" (Felder & Barker, 2013, p. 470). They found it essential to recognize that marginalization may be heightened when academic fields are designed in a hegemonic Eurocentric fashion.

Having a positive relationship with an advisor throughout graduate school has been found to be integral to student success in a program (Gasman et al., 2008). It also has been shown that a successful mentoring relationship is even more important for URM students, who must balance academics with continual marginalization (Felder, 2010). The literature on graduate students of color reveals that the hegemonic and Eurocentric design of graduate schools puts URM students at a disadvantage (Gasman et al., 2008). The design, creation, and maintenance of higher education has traditionally been Eurocentric, meaning that it derives from a White, male, able-bodied, heterosexual, Christian, middle-class value system (Patton & Bondi, 2015). Hegemony is an important component of Eurocentrism, as it normalizes the dominance of one group over another and often supports them by transforming norms and ideas into official policies and legislation. Thus, inherently unfair policies become commonsensical and intuitive, thereby inhibiting the dissemination or even the articulation of alternative ideas and leaving racism intact in our Eurocentric society (Nelson, 2016).

The Uniqueness of STEMM Mentoring for the Marginalized

Research on URM STEMM students has shown that mentoring programs have been instrumental in increasing their retention and persistence in the STEMM fields (Bean & Eaton, 2001; Cambridge-Williams, Winsler, Kitsantas, & Bernard, 2013; Crisp et al., 2017). Other essential components of a STEMM mentoring program for URM students include the

development of a scientific identity, institutional support (e.g., financial aid and recruitment strategies), engagement in research, peer and faculty support, interest in STEMM, co-curricular involvement, minority or female role models, relationships with other minority staff, personal motivation, support from family members, and advice from advanced students of the same ethnic group. For URM students in higher education settings, ideal mentoring relationships include valuing ideas, intellect, and a commitment to uplift both students and their communities from systematic oppression (Estrada et al., 2017; McGee & Bentley, 2017; Zambrana et al., 2015).

STEMM diversity programs are typically created to broaden the participation of underrepresented populations (Aspray, 2016; Wheeless, Blaser, & Litzler, 2007). Although STEMM diversity programs might vary in focus and implementation, they share the goal of broadening participation in STEMM by supporting students (Aspray, 2016). Recruiting and retaining URM students, particularly undergraduate students in the STEMM disciplines, has gained national attention in the past few decades. DeAngelo (2016) focused on the unique support needed for Black, Latinx, and Native American graduate students in STEMM. Research suggests that one reason students of color are especially challenged at institutions with high research activity is not the widely cited academic mismatch theory but a lack of encouragement and engagement with students of color (DeAngelo, 2016). The challenges URM STEMM doctoral students face includes confronting racial discrimination, stereotyping, and hostile environments (Clancy, Lee, Rodgers, & Richey, 2017; McGee & Stovall, 2015; Robinson, McGee, Bentley, Houston, & Botchway, 2016). To add to their stress, they are often a numerical minority and as such experience racial isolation (McGee et al., 2016).

Most college programming has focused on interventions at various levels and with various populations (Chubin, May, & Babco, 2005), including incoming freshmen (e.g.,

Meyerhoff Scholars Program), undergraduates (e.g., Louis Stokes Alliances for Minority Participation, Summer Research Opportunity Program), and master's students en route to a PhD (Fisk-Vanderbilt Master's to PhD Bridge Program; Clewell et al., 2005; Girves et al., 2005; Stassun et al., 2010). By instituting programs like creating new chapters of the National Society of Black Engineers (NSBE), institutions acknowledge the need to support URM students in STEMM (Aspray, 2016; Wheeless et al., 2007). Many STEMM diversity programs are funded externally by the National Science Foundation, national professional organizations (e.g., NSBE), and alliances (e.g., Southern Regional Education Board), or internally by the institution (Aspray, 2016). All these programs acknowledge the need to actively mentor and engage students at various points in their educational trajectory. For example, some programs (e.g., Next Prof) help doctoral students consider and prepare for faculty positions. These programs cater to the unique social and technical needs of URM students (Aspray, 2016; Wheeless et al., 2007). Many programs have chosen mentoring as a means to address students' racial and ethnic identities as well as their STEMM academic and career development (Aspray, 2016; DeAngelo, Mason, & Winters, 2016). However, the majority of these programs are geared to undergraduate students, which often leaves graduate STEMM students with limited mentorship options. Although each of these programs focuses on a slightly different population and has different intended outcomes and measures of success, formative and summative evaluations showed that they met program objectives.

PART IV: Vulnerable yet Neglected Populations in STEMM

We have focused thus far on URM students in STEMM, who include Black, Latinx, Native American, and women students. Two more understudied groups in STEMM are LGBTQ+ students and students with disabilities. Data on the number of people with disabilities

enrolling in undergraduate and graduate STEMM programs is limited. For example, in the National Science Foundation Report titled “Women, Minorities, and Persons with Disabilities in Science and Engineering,” there are sections dedicated to "women,” “minorities,” and “women, men, and racial ethnic groups,” but no section on individuals with disabilities (NSF, 2017). In 2018 the NSF only began to discuss the inclusion of questions on sexual orientation and gender identity on the Survey of Doctoral Recipients and the National Survey of College Graduates (Langin, 2018).

Underrepresented Students with Disabilities in STEMM

The American Disabilities Association defines disability as a physical or mental impairment that substantially limits one or more major life activities. For legal purposes, this also includes those who have a documented impairment (Francis, 2018). For some individuals, their disability plays a large part in shaping their sense of self; however, most individuals with disabilities do not want the disability to define or limit them. In 2014, roughly 6% of all science and engineering doctoral recipients reported a disability, but this does not indicate a lack of interest in STEMM; people with disabilities pursue STEMM degrees at the same rate as those without, as 6% of those 18-34 years of age in the civilian U.S. population had a disability that same year (National Science Foundation, 2017; Thurston, Shuman, Middendorf, & Johnson, 2017). Nonetheless, dropout rates increase with the transition from high school to college, and again from undergraduate to graduate school (Booksh & Madsen, 2018). Many students with disabilities struggle with the transition from a structured high school and family setting to a university setting with more freedom and less structure. Students with disabilities also usually have an Individualized Education Program (IEP) or 504 plan during their K-12 schooling that includes a support team of teachers, parents, and educational support staff, but in college they are

left largely on their own to obtain accommodations for campus and classroom support (Kurth & Mellard, 2006). Many colleges offer disability services but not with the same level of integration and monitoring as K-12 schools. Only about 24% of students who had a 504/IEP plan register with college disability services and only 60% of those receive accommodations (Cawthon, & Cole, 2010). Students with disabilities also report a lack of support from the academic community, which creates a feeling of not belonging in a group and brings shame associated with the disability (Booksh & Madsen, 2018).

Challenges Unique to Students with Disabilities

Faculty members, administrators, and university staff often show a lack of cooperation and understanding of the needs of students with disabilities. In the STEMM fields especially, there are not enough adaptive aids, accessible spaces, and accommodations to meet their needs (Moon, Todd, Morton, & Ivey, 2012). Furthermore, research has shown that students with disabilities are not usually recruited by colleges and no methods to accurately measure the effectiveness of programming at schools that do recruit students with disabilities (Thurston et al., 2017).

One group of people with disabilities who pursue STEMM majors at a higher rate than their non-STEM counterparts is those diagnosed with autism spectrum disorder (ASD). Among students with disabilities who enter college, those with ASD have the third-lowest rate of actually attending college, but a higher percentage of those who do select STEMM majors (White, Ollendick, & Bray, 2011). It is theorized that students with autism are above average in terms of creating systems, analyzing, and understanding rule-based systems that help them excel academically in certain STEMM majors (Austin & Peña, 2017).

Despite their academic strengths, ASD students score below average on emotional and social thinking, which becomes a barrier to their success in college (White et al., 2011). Students with ASD often have the academic skills and strengths to succeed in college but they also have limited interests, difficulty communicating, problems understanding others' behaviors, sensory and executive functioning challenges, and social skill deficits that create unique challenges (Boutot & Myles, 2011). A critical component of postsecondary education is navigating the classroom environment and interactions with faculty and staff (Austin & Peña, 2017), and Harris and colleagues (2011) found that students who interact more with faculty are more satisfied with their education, get better grades, and are more likely to graduate. In other words, a faculty member's interaction with a student with ASD can play an important role in their success, and the perceived attitude toward providing accommodations for the student is a big factor. Faculty members are legally required to provide "reasonable accommodations," but students with ASD often do not follow through with registering at the university's disability services or notifying faculty members of their needs (Austin & Peña, 2017). Faculty members are often aware of the needs of individuals who are blind or deaf, but more training is needed to make faculty members aware of the needs of people with ASD (Taylor, 2005). Very few articles have addressed strategies for faculty to work with students with ASD. Shmulsky and Gobbo (2013) outline three strategies that were found effective: minimizing classroom anxiety, improving executive functioning, and supporting critical thinking instruction. A later article by Gobbo and Shmulsky (2014) found that providing structure and giving attention to the classroom's emotional climate were effective support strategies.

Thurston and colleagues (2017) discussed some ways to overcome the additional challenges facing college students with disabilities. Using disability services and existing

resources allows faculty to focus on STEMM content, peer tutoring, lab communities, improved recruitment strategies, self-advocacy programs for students, professional development, and mentoring programs for STEMM students with disabilities. Gregg et al. (2016) found that e-mentoring is an effective way to reach students with disabilities and improve their persistence through self-advocacy and self-determination.

Underrepresented LGBTQ+ Faculty and Students in STEMM

Unlike race and gender, sexual orientation and transgender identity are social identities that are more concealable, and this has contributed to the lack of attention paid to individuals with these identities. These identities significantly shape the experiences and outcomes of students and faculty in STEMM fields—fields which are largely heteronormative and cis-normative (Trenshaw, Hetrick, Oswald, Vostral, & Loui, 2013) and in which ascribed personal identities are considered inconsequential to the performance of science, and scientific identity. While more research has explored LGBTQ+ students and faculty across academic disciplines (LaSala, Jenkins, Wheeler, & Fredriksen-Goldsen, 2008; McNaron, 1997; Noack, 2004; Renn, 2010), less research has explored the experiences of STEMM LGBTQ+ students (Cech & Waidzunas, 2011; Hughes, 2017; Trenshaw et al., 2013) and faculty (Bilimoria & Stewart, 2009; Patridge, Barthelemy, & Rankin, 2014), and most are qualitative, given the lack of comprehensive government funded research on this population (Langin, 2018). This extant work has provided important insights on LGBTQ+ student and faculty experiences of microaggressions, harassment, intimidation, fear, exclusion, discriminatory practices in hiring, tenure, and promotion, and exclusion from networking and scholarly collaborations (Bilimoria & Stewart, 2009).

Similar to individuals with cognitive disabilities which may be difficult to detect, LGBTQ+ faculty and students with non-normative sexual orientations and gender identities that are not readily visible may have the option to conceal their LGBTQ+ identity. Research has shown that individuals who choose to "out" a concealable identity are more able to access different forms of social support than those who do, which can impact health outcomes (Weisz, Quinn, & Williams, 2016), however this is moderated by the social context. For example, Patridge et al. (2014) found that LGBTQ+ faculty in STEM who were "out" experienced significantly more interpersonal discomfort in their departments than those who were not, and that these faculty were more likely to consider leaving their department. On the other hand, Yoder and Mattheis (2016) found that LGBTQ+ employees working for employers who supported LGBTQ+ workers, and employees in fields with greater gender parity reported a higher degree of openness about their concealable identity (Yoder & Mattheis, 2016). Thus, STEMM climates are consequential in influencing whether or not individuals can be open about who they are, or if they must conceal their identities, resulting in feelings of invisibility, isolation, and rejection. Similar to the ways in which racially minoritized individuals and women, whose stigmatized identities are more apparent, LGBTQ+ students and faculty individuals experience stress and negative mental health outcomes when they compartmentalize their professional and personal identities (Meyer, 1995; Pachankis, 2007), strained social relationships (Yoder & Mattheis, 2016), and reduced workplace productivity even in the absence of active discrimination (Clair, Beatty, & MacLean, 2005; Darling, Molina, Sanders, Lee, & Zhao, 2008a; Patridge et al., 2014). A more inclusive work environment that provides support and benefits specific to LGBTQ+ needs would be ideal (Bilimoria & Stewart, 2009), but first,

more research is necessary to better understand the experiences of LGBTQ+ individuals and their needs.

While many departments are aware of LGBTQ+ rights, most do not understand the efforts needed to address the issues adequately. As shown by Yoder and Mattheis (2016), individuals employed in academia were more likely than those outside of academia to not know what support their employers provided to LGBTQ+ employees (42% of academic versus 29% of nonacademic). Graduate students, who were overrepresented in this study, may be even less aware of and have less access to same-sex partner benefits or trans-specific health insurance coverage than faculty (Yoder & Mattheis, 2016). To improve the climate, the LGBTQ+ physicists advocacy group created a *Best Practices Guide* that suggests using gender- inclusive language, inviting LGBTQ+ speakers to campus, and joining ally groups (LGBT+ Physicists, 2013). Moreover, broad institutional support is needed to help create a supportive environment in which faculty and students feel comfortable being "out" about their sexual orientation (Ackerman et al., 2018). As STEMM works to diversify its faculty and students, it is crucial to create an environment in which faculty and students can be out and to make this awareness part of the mentoring process for students in an environment that may be discriminatory toward the LGBTQ+ community. Further research is needed on the role of "out" mentors and how they can help students who have self-selected out of the STEMM fields because of discomfort caused by intolerance (Yoder & Mattheis, 2016).

PART V: Next Steps and Recommendations

The next steps and recommendations offered here incorporate some of the findings of our comprehensive literature review on the role of identity in the STEMM fields. However, we would be remiss if this section did not also include recommendations from what we have learned

from our research. Research on diversity, inclusion, and social identities in STEMM, frequently but must not neglect how race and gender, and other identities intersect within the complex structural dynamics of STEMM higher education.

The Explorations in Diversifying Engineering Faculty Initiative (EDEFI; pronounced "edify") was formed in part as a response to this omission. I (Ebony McGee) cofounded EDEFI (with Dr. William Robinson, professor of electrical engineering) because my fellow researchers and I see the problem of recruiting and retaining Black engineering faculty (and Black STEMM faculty in general) as a multifaceted challenge that must counter the inertia of the status quo. The mission of EDEFI is to investigate the institutional, technical, social, and cultural factors that affect decision-making, career choices, and career satisfaction for engineering and computing doctoral students, postdoctoral researchers, and faculty who have been marginalized by race and/or gender. EDEFI also looks at how those factors contribute to the current underrepresentation of these marginalized groups in engineering and computing faculty positions, paying particular attention to how Black people are marginalized in these contexts. Our research has identified the barriers of race, ethnicity, gender, social class, sexual orientation, culture, and language, which riddle the educational system and deprive some students and faculty of their rightful full participation in STEMM (McGee, 2016; McGee, & Bentley, 2017; McGee, Griffith, Houston, 2019; McGee, Naphan-Kingery, Mustafaa, Houston, Botchway, & Lynch; McGee & Robinson, in-press; McGee, White, Jenkins, Bentley, Houston, Smith, Robinson, & Botchway, 2016). We created several categories of recommendations that may help different stakeholders focus their attention on specific ways to hone their expertise: diversify institutional and STEMM departmental cultures; implement identity-conscious STEMM mentoring programs; conduct further research on graduate-level mentoring for URM STEMM

students; and conduct further research on graduate-level mentoring for STEMM students and faculty with disabilities and LGBTQ+ identities.

Diversify Institutional and STEMM Departmental Cultures

Before mentoring efforts for URM and other underrepresented and marginalized students can be successful, institutional and STEMM departmental cultures must not only increase demographic diversity by recruiting diverse students and faculty. They must implement sustainable actions that create equitable and inclusive contexts in which students feel welcome and can be open about who they are and see themselves as thrive and succeed in their discipline. Institutional diversity efforts often claim to work for and achieve equity and inclusion, but often, practices and policies are masked in colorblindness and blindness to other social identities, reinforcing marginalization.

Institutions and departments should promote cultural change that requires institutional leaders to acknowledge and dismantle the oppressive structures that perpetuate cultural bias toward URM students' academic ability, e.g., create spaces where non-URM students are working to create an inclusive culture that accepts members of diverse social groups. To do so, administrators and university leaders should:

- Conceptualize what we mean by "diversity," and acknowledge that, although diversity has become almost mandatory, it varies widely in definition and action, resulting in generic and unsophisticated conceptualizations of diversity without actually diversifying the racial landscape (e.g., "diversity" only means more White women).
- Address the bias, racialized and otherwise, engrained in institutional cultures that has resulted in a lack of effective mentoring for URM and other marginalized students.

- Assess the climate for URM and other marginalized students in STEMM departments by participating in or conducting climate surveys, collecting demographic information, and carrying out classroom climate assessments. Respond by establishing a departmental climate committee and/or liaison and creating explicitly supportive policies for URM and other marginalized students.
- Assess the conditions of STEMM academic spaces that can reproduce bias and stereotypes outside the university (e.g., national and international conferences, fellowship meetings, summer internships at STEMM companies).
- Highlight the scientific contributions of URM and other marginalized STEMM members at all levels. STEMM departmental policies should include using welcoming language and adhering to non-discrimination policies in syllabi and on department websites and inviting URM and other marginalized people to speak on campus.
- Understand and account for institutions/departments that house STEMM faculty, university administration, trustees, and donors who have colorblind views and ideologies, and who might not see the need for racial diversity or see their institutions as already inclusive for all.
- Base recruitment on the standard that diversity is an asset and admit more racially minoritized STEMM graduate students. Offer them more fellowships, as sustained financial assistance remains a persistent barrier to their retention and persistence.

Implementing Identity-Conscious STEMM Mentoring Programs

Because effective mentoring is an important element in retaining and improving the experiences of URM and underrepresented STEMM students, it is an important way to diversify

STEMM students. Although the literature, theories, and research on mentoring relationships has grown, it continues to lag behind program development, implementation, and evaluation of mentoring at the local, state, and national levels. Academics characterize this area of research as underdeveloped. STEMM mentoring programs need better guidelines to consider the dynamic intersections of students' social identities and STEMM identities, and discourage colorblind approaches to supporting URM student retention. To build effective faculty mentors, institutions and departments can:

- Make mentorship a critical component of graduate education by providing training and professional development to faculty members, especially those who lack adequate mentoring experience, skills, and/or credentials. Training and coaching on mentoring will help improve both formal and informal mentoring relationships.
- Recognize the time-intensive nature of mentoring and the workload associated with it. To validate faculty's mentoring behavior, institutional leaders should reward it through compensation, tenure, and promotion; this could shift the institutional culture toward working for greater diversity.
- Hire (or train) counseling staff who can competently address the psychological stress of underrepresented and marginalized STEMM graduate students to supplement mentoring efforts.
- Cultivate more culturally responsive faculty who can meet the needs of URM students; all students would ultimately benefit.
- Recruit STEMM faculty from racially minoritized backgrounds.

- Advance more racially minoritized faculty and staff through tenure and promotion, and put them in senior-level roles, including administration.
- Provide professional development and mentoring support for all faculty, as it is critical to enabling them to engage in holistic mentoring practices with URM STEMM graduate students, and for the ultimate benefit of all students.

Conduct Further Research on Graduate-Level Mentoring for URM STEMM Students

STEMM mentoring programs focused on URM students should be guided by critical theories that challenge deficit-based perceptions mentors may have of their protégés and questions and counters the minoritization of people of color and their forced adaptation to dominant ideology. For example, we point to *Black Neoliberal Resilience,* which exposes how racial empowerment/uplift/resilience mentoring initiatives are contrived and oversimplified representations of the Black experience and a way of masking structural racism and hegemony (Clay, 2018).

Research on the best practices for URM students in mentor-mentee relationships is inconclusive; thus, research that distinguishes the most beneficial components of academic support, social support, career advice, and role-modeling will help pinpoint which student-faculty interactions will results in outcomes of academic achievement, retention, and earning a graduate degree.

- Explore the importance of the intersection of the STEMM academic identity and racial identity for URM graduate students in developing meaningful and sustainable connections in and engagement with their disciplinary contexts. (*Sample research question:* Does a strong sense of racial group connectedness impede or support the development of a robust STEMM identity? More generally,

what is the relationship between racial identity and STEMM identity development for the underrepresented and marginalized?)

- Gain a better understanding of how students' racial and cultural identities enable them to be resilient in the face of stigmatizing experiences, which is not so resilient that it hampers students' wellbeing and academic success.
- Explore the causes and consequences of the stigmatizing experiences URM students are likely to encounter, such as racial discrimination, treatment based on stereotypes, or a negative racial climate. (*Sample research question:* How do racialized experiences undermine or promote URM students' academic identity and their subsequent adjustment to and participation in STEMM?)
- Assess current mentoring practices for URM STEMM graduate students and the impact they have on material gains post-PhD (e.g., higher salary, and ideal job, coveted postdoctoral opportunities).
- Investigate the role of racial- and gender-majority STEMM mentors and the impact they have on their URM graduate STEMM mentees. (*Sample research question:* What role do White and Asian male STEMM faculty play in mentoring URM graduate STEMM students and what impact do they have on their mentees?)
- Investigate further the impact STEMM culture and institutional practices and policies have on the climate and experiences of URM graduate students (and faculty). (*Sample research question:* How does the reality of the STEMM environment differ from how institutional commitments and inconsistencies are

portrayed (e.g., interactions and structures that maintain racism, often masked in terminology such as an unwelcoming environment)?)

- Unpack the role of STEMM faculty, who will identify and train the next generation of STEMM innovators. (*Sample research question:* What exclusionary practices do STEMM faculty institute that create scientific norms and biases in STEMM that faculty to equate difference with deficiency?
- Capitalize on the notion that minoritized students may be particularly invested in doing work that addresses persistent social problems or serves their communities, or that helps to diversify higher education and problematize traditional conceptualizations of academic STEMM "pure" research and laboratory work. We call this an equity ethic (for more information, see McGee & Bentley, 2017).
- Examine the networking as a function of mentoring, which introduce STEMM protégés to influential others and colleagues from other institutions (Tenenbaum et al., 2001). Such networking will allow the scientific community to recognize the protégés and their scholarly contributions.
- Explore how the status of mentors affects the mentee-mentor relationship; for example, how the tenure process impacts the STEMM mentor-mentee relationship and support. (*Sample question*: Do the benefits of mentoring vary according to the mentor's institution and position (e.g., whether the mentor is an assistant, associate, or full professor, and the type of institution)?
- Conduct a more robust exploration of the mental and physical health of URM students in order to create interventions that will promote the "soft skills" related

to motivation, integrity, and interpersonal interaction, all factors that affect STEMM students' graduate experiences and degree completion.

Conduct Further Research on Graduate-Level Mentoring for STEMM Students and Faculty with Disabilities and LGBTQ+ Identities

Research on STEMM students with disabilities and LGBTQ+ is lacking, which means that administrators and university leaders lack knowledge that would guide actionable policies around inclusiveness of these groups. To succeed in both undergraduate and graduate education, STEMM students with disabilities may require special accommodations. Because a disabling event or illness can occur throughout one's life, having a better understanding of the disability diagnosis and its influence on STEMM enrollment and degree persistence would enable university disability services to provide the appropriate supports for students, including those with a recent disability diagnosis.

The National Science Foundation (2017) states that about one in nine scientists and engineers age 75 and under has a disability. A targeted study on these STEMM professionals with disabilities, particularly their reflections on their persistence through the STEMM degree program, could help STEMM researchers and universities create targeted recruitment and retention programs for this vulnerable population.

LGBTQ+ faculty and students in the STEMM fields often encounter a disregard for their gender and sexual identity and face many discriminatory practices and policies in this climate, which is not conducive to productivity, largely due to the high value placed on the scientist identity. This reflects a lack of understanding and of efforts to create sustainable and equitable changes that will allow LGBTQ+ faculty and students to be open about their sexual orientation and gender identity. In order to diversify the STEMM disciplines and improve best practices and

mentoring, more research needs to address the LGBTQ+ population, particularly research addressing the climate conditions that allow for openness. Research should address the role of LCBTQ+ faculty, who can mentor students with similar identities but who may consider leaving the STEMM fields due to negative experiences.

Concluding Remarks

Current literature on broadening participation through mentoring in STEMM fields supports recommendations for institutional policies and practices and mentoring programming that encourage students to integrate rather than compartmentalize their social and STEMM identities, and create community spaces that affirm students' identities and minimize hostility from those who do not see diversity as an asset. Ultimately, validation of students' multiple, intersecting identities, cultures and perspectives, endows students with the power to be successful in the academy and beyond (Weiston-Serdan, 2017).

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