# The Efficacy of a Blended Peer Mentoring Experience for Racial and Ethnic Minority Women in STEM Pilot Study: Academic, Professional, and Psychosocial Outcomes for Mentors and Mentees

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# The Efficacy of a Virtual Peer Mentoring Experience for Racial and Ethnic Minority Women in STEM: Academic, Professional, and Psychosocial Outcomes for Mentors and Mentees


## Abstract

To address the persistent underrepresentation of women and racial and ethnic minorities in STEM, the current study utilized a quasi-experimental posttest waitlist control group approach to examine the effect of a one-year virtual peer mentoring program on the academic, professional, and psychosocial outcomes of graduate mentors and undergraduate mentees enrolled in STEM degree programs at two historically black institutions. The findings demonstrated that mentors and mentees participating in the mentoring program experienced increased levels of community, STEM achievement, career self-efficacy and intent to persist in STEM degrees and careers. Mentors experienced increased interest in science, engineering, and technology, and mentees experienced increased interest in science, engineering, and mathematics. The implications of the program, especially among women and racial and ethnic minorities enrolled in historically black institutions are discussed, as well as suggestions for future study.


*Key words:* STEM, peer mentoring, women, racial and ethnic minorities, historically black institutions

## Introduction

The matriculation and persistence of women and ethnic and racial minorities in STEM degree programs and careers has been documented as a persistent problem (National Science Foundation [NSF], 2019). For example, when considering undergraduate degrees, ethnic and racial minorities were awarded only 22% of all science and engineering degrees in the United States. Although 50% of science and engineering undergraduate degrees in the United States were awarded to women in 2017, only 21.5% of women were awarded an undergraduate degree in engineering (NSF, 2019). Consequently, many efforts have been made to increase the representation and persistence of both women and ethnic and racial minorities in STEM, with mentoring being cited as one means to positively influence the academic and career success of underrepresented racial and ethnic minority women (UREMW) —"Blacks or African Americans, Hispanics or Latinos, and American Indians or Alaska Natives" (NSF, 2019, p. 2)-- in STEM (Fouad, Singh, Cappaert, Chang, & Wan, 2016; Guy & Boards, 2019; Ireland et al., 2018; Pon-Barry, Packard, & St. John, 2017).

As such, programs and books on STEM mentoring have appeared, and empirical research on innovative mentoring programs in STEM have emerged. These programs, which have been empirically investigated and validated, are primarily created for research mentoring experiences (e.g., Byars-Winston, Branchaw, Pfund, Leverett, & Newton, 2015; Pfund et al., 2013, 2014) and in a face-to-face environment (e.g., Carpi, Ronan, Falconer, & Lents, 2017; Rogers, Sorkness, Spencer, & Pfund, 2018; Whittaker & Montgomery, 2012). Most research has been focused on the academic and professional outcomes, rather than psychosocial outcomes, of mentees (Graham & McClain, 2019; Luedke, 2017; McGee, 2016; Mondisa & McComb, 2015). Research has occurred within predominately white institutions (PWIs; National Academies of Sciences, Engineering, and Medicine [NASEM], 2019; Graham & McClain, 2019), which is significant in that the type of higher education institution students attend can influence their opportunities and experiences to develop knowledge, skills, and self-efficacy (Laursen, Hunter, Seymour, Thiry, & Melton, 2010). Thus, there is a gap in the literature about how virtual and peer mentoring relationships external to STEM research labs, especially outside of predominately white institutions (PWIs), affect both professional and psychosocial outcomes for both mentors and mentees. Therefore, this pilot study examines how participation in a year-long virtual mentoring experience influences sense of belonging in STEM, STEM self-efficacy, STEM career interest, and persistence of UREMW undergraduate student mentees and graduate student mentors. To guide this study, we draw from educational and social science theoretical frameworks and use a quantitative approach to investigate the effectiveness of a virtual peer mentoring relationship.

For the purpose of this study, we define peer mentoring as a "professional, working alliance" in which peers, one more skilled or experienced than the other, "work together over time to support the personal and professional [and academic] growth, development, and success of the relational partner through the provision of career, [academic], and psychosocial support" (NASEM, 2019, p. 37). The more experienced peers—in this study, graduate students--are referred to as the mentors. The less experienced peers—in this study, undergraduate students--are referred to as the mentees. We also focus on peer mentoring collective groups (i.e., one mentor and three mentees; NASEM, 2019), and mentoring relationships that are virtual. Drawing from the distance education literature, virtual mentoring can be defined as mentoring in which all or most of the experience takes place utilizing online technology, and virtual mentoring can be categorized as exclusively at a distance and with some, but not all, at a distance (Allen & Seaman, 2017). For this study, virtual mentoring is inclusive of a blended approach to mentoring that consisted of meetings that took place both in person on campus and at other local venues (e.g., coffee shops) as well as online via virtual communication mediums (e.g., video conferencing, chat).

## Theoretical Framework

Tinto's (1975, 1987, 1993) Institutional Departure Model coupled with Bandura's (2006) concept of self-efficacy (SE) and Lent, Brown, and Hackett's (1994) Social Cognitive Career Theory (SCCT) guided this investigation into the influence of a virtual peer mentoring experience on academic, professional, and psychosocial outcomes for mentors and mentees. Tinto's (1975, 1987, 1993) Institutional Departure Model was chosen to illuminate the role mentoring experiences can play in integration or feelings of community, ultimately leading to persistence. Bandura (2006) and Lent et al. (1994) further explain how self-efficacy and confidence in one's ability to successfully perform and be successful, mediated by personal (e.g., race, ethnicity, gender) and environmental factors, influence one's academic and career behavior. Through his student attrition model, Tinto (1975, 1987, 1993) purported that students enter college with personal attributes (e.g., culture, gender, race), family backgrounds (e.g., education levels of parents, socioeconomic status), and prior experiences (e.g., academic, emotional, social). It is these characteristics that can directly and indirectly influence a student's ability to integrate (e.g., academically, socially) into their institution and develop a sense of community and belonging within their program of study (Tinto, 1993). Further, ability to integrate and the development of sense of community influence an individual's goal commitment, defined as the degree to which one will persist in order to meet goals (Tinto, 1988). Figure 1 demonstrates the  relationships and contributions of Tinto's (1975, 1987, 1993,  2017)

Institutional Departure Model, Bandura's (2006) concept of self-efficacy, and Lent et al. 's (1994) Social Cognitive Theory to UREMW persistence in STEM disciplines.

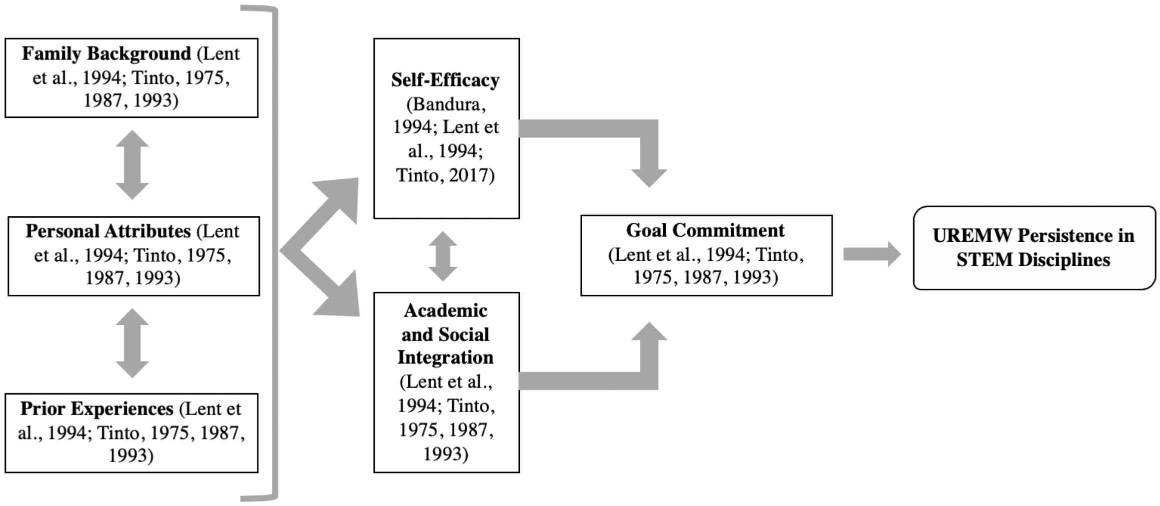


*Figure 1.* Relationships and contributions of theoretical frameworks (Bandura, 2006; Lent et al., 1994; Tinto, 1975, 1987, 1993, 2017) to UREMW persistence in STEM Disciplines.

**Sense of Belonging and Community**

Researchers have emphasized the importance of sense of belonging and community to UREMW in STEM programs, and Tinto equates integration with sense of belonging (Wolf-Wendel, Ward, & Kinzie, 2009). Sense of belonging is especially important for the persistence of UREMW in STEM disciplines (Brainard & Carlin, 2013; Good, Rattan, & Dweck, 2012; Pon-Barry et al., 2017). Students who become integrated into their institution's academic and social systems, and ultimately, into an established STEM community within their program, are more likely to persist to attain a degree in a STEM field. For instance, Espinosa (2011) conducted a study on STEM persistence among minority women and found that those who attended a college with a thriving STEM community persisted in their fields. In contrast, minority women in STEM programs without an active STEM community transferred to non-STEM majors due to a lack of a sense of belonging and mentorship (Ong, Smith, & Ko, 2018; Rainey, Dancy, Mickelson, Stearns, & Moller, 2018). Mentoring experiences have been shown to positively impact UREMW students with their integration by assisting them in developing their sense of belonging and strengthening their self-efficacy to persist in STEM programs (Carlone & Johnson, 2007; Espinosa, 2011; Estrada, Hernandez, & Schultz, 2018; Johnson, 2012; Thoman, Arizaga, Smith,, Story, & Soncuya 2014). Sense of belonging is associated with self-efficacy with numerous studies indicating that sense of belonging can influence self-efficacy (Walton & Cohen, 2007; Walton et al., 2012), especially among women in STEM (Tellhed et al., 2017). Tinto (2017) posited that self-efficacy interacts with sense of belonging to impact student motivation to persist in their degree program. He contended that self-efficacy is the "foundation upon which persistence is built" (Tinto, 2017, p. 257).

**Self-Efficacy**

Self-efficacy has been widely used by researchers to understand and support participation in STEM fields (Falk, Rottinghaus, Casanova, Borgen, & Betz 2017) and is defined as one's belief in one's own capabilities to accomplish a task (Bandura, 1977). Students who exhibit higher levels of self-efficacy are more likely to persist and experience success in STEM (Anagnos & Lyman-Holt, 2015; Fouad et al., 2016). Self-efficacy is also central to STEM career interest and development. SCCT (Lent et al., 1994) has been used to understand the influence self-efficacy, outcome expectations, and personal goals have on UREMW in STEM fields. In SCCT, an individual's self-efficacy is a powerful indicator of career goals and achievement. Research has shown that UREMW tend to exhibit lower levels of self-efficacy in STEM than their male counterparts (Hill, Corbett, & St Rose, 2010; Ireland et al., 2018; Johnson, 2012; MacPhee, Farro, & Canetto, 2013). Hence, interventions aimed at strengthening their self-efficacy are essential.

Bandura (1977, 2006) presented four intersecting malleable sources that influence the self-efficacy levels of individuals: performance accomplishment, vicarious experience, social persuasion, and physiological response. Operationalized within the current study, performance accomplishment is associated with a woman's experience as she completes a given task. Vicarious learning is associated with a woman's experience as she observes another woman successfully complete a given task. Social persuasion is associated with the encouragement or discouragement a woman may receive on her ability to succeed in STEM. Finally, physiological response is associated with a woman's response and reaction to specific situations. Incorporating these four sources into interventions has been shown to strengthen self-efficacy and persistence among UREMW in STEM programs and careers. For example, UREMW in STEM programs who engaged in mentoring experiences demonstrated higher levels of self-efficacy and persisted to complete their STEM degree (Castellanos, Gloria, Besson, & Harvey, 2016; Carlone & Johnson, 2007; Estrada et al., 2018), indicating that each of the four sources may influence self-efficacy beliefs and intent to persist. Thus, mentoring experiences can influence students' beliefs in their capabilities by incorporating opportunities that help to address sources of self-efficacy.

## Review of the Literature

Mentoring has been identified as a high impact practice to increase student interest and readiness for STEM careers and graduate degrees, especially among undergraduate students (Graham, Frederick, Byars-Winston, Hunter, & Handelsman, 2013; Junge, Quinones, Kakietek, Teodorescu, & Marsteller, 2010; Laursen et al., 2010; Pacifici & Thomson, 2011; Packard, Marciano, Payne, Bledzki, & Woodard, 2014). Researchers have established the beneficial academic and career outcomes of mentoring experiences, demonstrating that mentoring is associated with the mentees' commitment to a science career (Chemers, Zurbriggen, Syed, Goza,

& Bearman, 2011); interest in and enrollment in more science and research courses (Hunter, Laursen, & Seymour, 2007; Junge et al., 2010); matriculation of underrepresented racial and ethnic minority students into STEM graduate degree programs (Junge et al., 2010); and positive evaluations of research skills associated with science identity (Chemers et al., 2011; Thiry & Laursen, 2011). However, the majority of mentoring studies have been conducted within the research laboratory environment, have been focused on faculty-student mentoring, have examined only the experiences of mentees, or have taken place at PWIs where generalizability to more diverse populations may not be appropriate. Thus, there is a need to explore the experiences of both mentors and mentees, that examines mentoring practices that take place outside of the research context, and that consider experiences at institutions serving diverse and historically underrepresented populations (Zaniewski & Reinholz, 2016).

**Benefits of Mentoring Relationships**

Despite the existing gaps within the literature, a growing body of research surrounding mentoring is emerging. Examination of the impacts of engaging in peer mentoring experiences among undergraduate students enrolled in introductory chemistry courses, for instance, has demonstrated that students who received peer mentoring had higher on-campus retention rates than those who did not receive peer mentoring (Fehmi, Braun, & Gublo, 2017). Zaniewski & Reinholz (2016) utilized a peer mentoring model among graduate and undergraduate physical science students at a PWI with a specific focus on psychosocial support and academic support. Mentors were provided with leadership training and were required to meet face-to-face with mentees, and both were engaged in community building activities. Further, mentors and mentees were asked to report regularly on the mentoring experience. Mentors and mentees demonstrated that engaging in the mentoring relationship supported their development of science identity through social interactions and the building of trust and community as well as intent to persist in their degree programs.

**Limitations to Current Understanding of Mentoring**

However, McGee (2016) questioned if mentoring solely within the research lab is sufficient to encourage the persistence and participation of UREMW in STEM. Research on mentoring relationships may be limited in terms of the personal, social, and psychosocial support that UREMW need to pursue and persist in STEM degrees and matriculate into STEM careers. Critical for women and racial and ethnic minorities is the "psychosocial support to counter the elevated stress and discouragement and the falling confidence that some experience" (Dawson et al., 2015, p. 55). Moreover, Black women and women from other minority populations need a strong support system and community to counter the isolation that often leads to their attrition from STEM careers and degrees (Ireland et al., 2018; Mondisa, 2018; Pon-Barry et al., 2017; Rice & Alfred, 2014). Peer mentoring has, more and more, been cited as one way in which institutions can invest in environments that are collegial, supportive, and inclusive and that build community (Pon-Barry et al., 2017). Some research also supports that UREMW in science and engineering have the desire and need to discuss with their mentor issues of gender, race, and ethnicity (Byars-Winston et al., 2015), which is often ignored in research mentoring relationships where colorblind attitudes and the notion that cultural diversity is irrelevant is prominent (Prunuske, Wilson, Walls, & Clarke, 2013).

A recent study, for example, examined the predictive relationship between mentorship type (formal vs. informal), mentorship experiences, belongingness, imposter feelings, GPA, and college adjustment among Black college students at a PWI (Graham & McClain, 2019). Results demonstrated that belongingness, imposter feelings, and mentorship experiences predicted GPA and college adjustment. Increased feelings of belongingness further resulted in increased connectedness. Increased imposter feelings resulted in lower college adjustment. The authors concluded that peer mentoring serves as a buffer to negative experiences and, importantly, transcends racial and ethnic backgrounds. Peer mentoring, therefore, holds great promise for Black students, in particular (Graham & McClain, 2019). However, research is still needed to determine what effects peer mentoring might impart among UREMW at historically black colleges and universities (HBCUs), especially given that HBCUs are historically considered to be more supportive and welcoming environments for racial and ethnic minority students (Kendricks, Nedunuri, & Arment, 2013).

**Mentoring among Underrepresented Populations**

Kendricks and colleagues (2013) explored the impact of faculty mentoring of graduate students at an HBCU. The context of an HBCU was cited as being key to enhancing broader participation of racial and ethnic minority students in STEM fields. Further, HBCUs have historically supported a sense of belonging and a cultural environment conducive to both academic and personal growth. Through their work, the authors found that student mentees perceived their relationships with faculty mentors to be positive—indicating overall satisfaction with the relationships. The authors also found that mentees' academic performance was enhanced. However, the study focused on faculty-student mentoring experiences and did not examine peer mentoring experiences.

While demonstrating that a multitude of mentoring experiences are beneficial, a robust focus on women and racial and ethnic minorities is still largely missing within the research literature. This is especially important as a direct relationship exists between access to a strong mentor and women's persistence in STEM (Dawson, Bernstein, & Bekki, 2015; Preston, 2004).

However, it is well documented that a shortage of women mentors in STEM exists--often a byproduct of the underrepresentation of women in STEM fields and the various outside commitments that women hold--that may impede participation in mentoring relationships (Dawson, Bernstein, & Bekki, 2015; Stoeger, Debatin, Heilemann, & Ziegler, 2019). Peer mentoring, specifically, has been cited as beneficial to the retention and support of women in STEM degree programs (Pon-Barry et al., 2017).

Simultaneously, it is becoming more widely recognized that a move away from traditional mentoring approaches and toward more flexible (Dawson et al., 2015) and community-oriented approaches (Kobulnicky & Dale, 2016; Mondisa & McComb, 2015) may be more beneficial, especially to UREMW. Virtual is attractive as it is based on the expectation of flexibility and convenience (Bolliger & Halupa, 2012). Because of the flexibility and autonomy associated with a distance approach, a student can control when and where mentoring is completed. Further, the virtual format can allow for participation across a wide geographic area and potentially yield impacts among a larger swath of the population than traditional formats.

Some work has been conducted that begins to examine the virtual format. For instance, Dawson et al. (2015) developed on online mentoring program, *Career*WISE, to support women from a psychosocial perspective. Psychosocial support has been recognized as having a moderative effect on environmental barriers. That is, when women receive adequate psychosocial support, they may perceive decreased feelings of isolation, increased feelings of belongingness, and resilience against stress-inducing factors. The program consists of online educational modules with embedded self-tests, showcases of women role models, communication modules, and interactive multimedia simulations. Female students who participated in *Career*WISE were reported to experience increased problem-solving skills, resilience, persistence, and efficacy. However, while the results of participating in the program have been positive overall, the components do not currently address the potential needs of UREMW specifically and do not address the need for social community documented throughout the literature given the fully online nature of the *Career*WISE program (see Mondisa & McComb, 2015). Thus, there still exists a need to garner a more comprehensive understanding of what types and modes of mentoring are most effective and what models appropriately support and foster mentoring relationships effective among UREMW. A blended approach that capitalizes on the flexibility of online mentoring as well as the benefits of face-to-face interactions that support a rich development of social community (i.e., access to non-verbal cues), could be impactful.

**Mentoring Relationships and Benefits for Mentor**

Importantly, while the benefits of mentoring relationships are documented for mentees, those for mentors are more scarcely documented. Limited research demonstrates that mentors can gain a sense of fulfillment, develop leadership skills, and increase their self-awareness when engaging in a mentoring relationship (Dolan & Johnson 2009; Gloria & Kurpius, 2001). It is recognized, moreover, that expecting peer mentors to holistically understand how to effectively mentor is a misguided notion (Packard, Marciano, Payne, Bledzki, & Woodard, 2014; Pon-Barry et al., 2017). That is, peer mentors require training in order to become effective mentors (Pon-Barry et al., 2017). One study implemented at an all-women's liberal arts institution involved training of peer mentors and the development of peer mentoring relationships among women enrolled in a computer science program (Pon-Barry et al., 2017). Mentors reported, from the beginning of the program to the end of the program, increased confidence and enhanced perceptions of effectiveness as mentors. Further, mentors indicated preference and appreciation for practice/mock mentoring sessions, reflective practices, discussions surrounding inclusion and cultural responsiveness, and the development of community.

While interest in and research of mentoring is becoming more prevalent, a need still exists to determine the efficacy of peer mentoring approaches, to develop systematic approaches for effective peer mentoring, and to focus simultaneously on academic, professional, and psychosocial issues. Research is needed that explores mentoring outside of the research relationship and, importantly, that supports those who continue to be underrepresented in STEM—specifically UREMW. Thus, investigation is needed that explores which types of mentoring relationships (e.g., team, dyads, near-peer) and which modes of mentoring relationships (e.g., virtual, face-to-face, formal, informal) are most effective. And, perhaps most importantly, the development and assessment of models that support equity, diversity, and inclusion (Pon-Barry et al. 2017) are needed in order to meet the persistent call for broadening participation in STEM (NSF, 2019).

## Current Study

This exploratory, quantitative pilot study examined the effect of a one-year, virtual peer mentoring program on academic, professional, and psychosocial outcomes for both mentors and mentees. The research questions that guided the study were as follows:

**RQ1:** What influence, if any, does participation in a virtual peer mentoring relationship have on mentor and mentees' sense of community in a STEM field?

**RQ2:** What influence, if any, does participation in a virtual peer mentoring relationship have on mentor and mentees' STEM self-efficacy?

**RQ3:** What influence, if any, does participation in a virtual peer mentoring relationship have on mentor and mentees' STEM career interest?

**RQ4:** What influence, if any, does participation in a virtual peer mentoring relationship have on mentor and mentees' intent to persist in a STEM degree and career?

More specifically, a quasi-experimental, posttest waitlist control group approach was used to compare the mentor and mentees' outcomes with a waitlist control group. Mentors and mentees as well as students on a waitlist for the mentoring program completed an online survey during the final two weeks of the peer mentoring program (i.e., last two weeks of Spring 2019). Their responses were compared. Although participants were not randomly assigned to conditions or orders of conditions (Cook & Campbell, 1979) to control for the selection threat to validity, care was taken to minimize this threat through the use of homogenous groups as well as matching. Without true random assignment of the participants to the treatment and control, there remains the possibility that other confounding variables existed that we were not able to control and could have influenced the difference in outcomes between the two groups.

## Methodology

### Participants

Participants were graduate (*N*=12) and undergraduate (*N*=42) UREMW students enrolled in STEM programs across two participating public HBCUs in the mid-Atlantic region of the US. Each HBCU had a total institution enrollment of under 5000 students during the study period. During the summer of 2018, students enrolled in all STEM programs across the two institutions were invited to participate in a virtual STEM peer mentoring program. Six graduate student mentors and 21 undergraduate mentees were selected to participate in the program during the 2018-2019 academic year and were assigned to mentoring groups. The application process required that mentors demonstrate a cumulative GPA of 3.0 or higher, that mentees demonstrate a cumulative GPA of 2.8 or higher, and that all participants identify as a woman or racial or ethnic minority, be enrolled in a graduate-level STEM degree program, and provide a letter of recommendation from a STEM faculty member upon request. A faculty panel selected these individuals based on students' ability to meet the criteria, especially GPA, as well as faculty's recommendation of the need for the programs and likelihood to do well in and complete the entire program. Students not selected to participate in the program, although eligible based on the application criteria, were added to the waitlist control group. Twenty-one undergraduate students (e.g., mentees) and six graduate students (e.g., mentors) served as the waitlist control group for this study. The participating mentors and mentees and waitlist control participants were matched by age range, race or ethnicity, and STEM degree program. The mentors were matched to the six waitlist control graduate students, and the mentees were matched to the twenty-one undergraduate students on the waitlist. The waitlist control was offered the opportunity to participate in the program the following implementation year.

All of the peer mentors and comparable participants in the waitlist control group were women who identified as racial or ethnic minorities between the ages of 22-31 and were enrolled in a STEM master's degree program. Five of the participants in each group identified their race as Black, and one in each group identified as Hispanic. Similarly, the undergraduate student mentees and comparable waitlist control group participants were women enrolled in STEM undergraduate degree programs (e.g., engineering, math, biology, pre-med) who were between the ages of 18-22. Most ($n$=17 out of 21) of the participants across both groups identified themselves as Black. However, each group had one participant who identified as Hispanic, American Indian, Pacific Islander, and Mixed, respectively.

**Procedures and Setting**

A three-phase program model was examined for the current study. For Phase I, mentors and mentees were selected for participation in the virtual peer mentoring program in Summer 2018. Upon selection, the peer mentors completed a six-week online, self-paced mentoring training program, given that the importance of training mentors to ensure a productive mentoring relationship has been well documented (Gandhi & Johnson, 2016; Pfund et al., 2014). The training provided the mentors with activities to develop skill-building as a mentor as well as content and activities to be used during the mentoring process. While the training was self-paced, the faculty coordinators provided a suggested timeline to serve as a scaffold and to ensure timely completion of the training modules. The training modules covered the following topics: 1) self-reflection on barriers and triumphs of being a woman or racial or ethnic minority in STEM; 2) models of mentorship; 3) relationship skills; 4) information-giving, facilitative, and confrontational skills; 5) goal setting and visions for persistence in a STEM career pathway; and 6) using technology to mentor (i.e., how to use Google tools) to facilitate collaboration in mentoring relationships. Approximately 10-15 hours of instruction was provided through the training modules, with an additional 3-5 hours of reflective work.

Each training module consisted of three parts: topical discussion, case study, and personal application. The topical discussion provided the content, where mentors developed the skills and knowledge needed to engage in an effective mentoring relationship. The case study provided a relevant scenario that demonstrated the content's application, thus aligning with the construct of vicarious experience while simultaneously addressing students' motivation, emotion, and volition. Finally, the personal application consisted of activities for personal reflection, aligning with the construct of mastery experience and physiological response.

In Fall 2018, after completing the six-week training, each mentor was assigned two to three undergraduate mentees by the faculty coordinators. The STEM degree programs represented across participants included biology, biomedical engineering, computer engineering, computer science, economics, mathematics, mechanical engineering, psychology, and speech-language pathology. Peer mentoring relationships in STEM can be considered more effective, at least from a mentee's perspective, when there is a gender and race match. However, other research demonstrates that positive outcomes of mentoring derive not from matching demographics, but when goals and values of the mentor and mentee match (Blake-Beard, Bayne, Crosby, & Muller, 2011; Griffith, 2010). Thus, the STEM degree area, career goals, and race or ethnicity were considered when mentees and mentors were assigned, as has been done in previous research (Zaniewski & Reinholz, 2016). It should be noted that the development, implementation, and impact of the participation in the training among mentors was analyzed and reported elsewhere (Rockinson-Szapkiw & Wendt, 2020, in press; Wendt, Rockinson-Szapkiw, & Conway, 2019) and, importantly, supported the efficacy of the mentor training.

For Phase II, during the 2018-2019 academic year, peer mentors met with individual mentees on a weekly basis. They also met at least bimonthly with their mentees for group mentoring. Meetings took place both in person as well as online via video conferencing and chat. Mentors and mentees reported meeting at convenient places on campus and local coffee shops. They also reported frequently chatting on the phone and via text between meetings. Mentors were required to meet with mentees at minimum four times per month, with at least two meetings occurring face-to-face. Mentors and mentees were given the flexibility to meet in ways that were conducive to their individual schedules and aligned best with their needs and goals. Thus, all mentoring groups met at least twice monthly face-to-face in addition to at least twice monthly through an online platform. Faculty coordinators were available to assist with the coordination of schedules and various other questions as needed. Given that women often experience enhanced outside pressures (e.g., family responsibilities), the flexibility of Phase II was viewed as a necessary component to ensure access to the mentoring experience for both mentors and mentees.

During the first peer mentoring meeting, mentors guided their mentees through a goal-setting activity, helping mentees develop personal, professional, and academic goals. Using the materials provided by the mentor training, the mentors also helped their mentees develop individual development plans. These plans guided the content and activities during the individual and group meetings. Mentors reported completing a number of the activities provided in the mentor training, while also developing discussion points and activities on their own to effectively cater to each of their mentee's unique needs. After each meeting, mentors completed meeting notes and submitted them to the faculty coordinators.

Further, four times, twice at each participating HBCU, all the mentors and mentees gathered for a luncheon, where a STEM professional was invited to speak and interact with all the mentors and mentees. This component further supported vicarious experience, social persuasion, and physiological response. Data on the effectiveness of the luncheon events were collected via survey at the end of each luncheon and are reported elsewhere (Rockinson-Szapkiw, Wendt, & Sharpe, 2020; Sharpe, Rockinson-Szapkiw, & Wendt, 2020). It should also be noted that the meeting notes submitted by mentors were analyzed and reported elsewhere (Rockinson-Szapkiw et al., 2020; Sharpe et al., 2020). However, analysis of the mentor notes confirms that participation in the program followed the intended program design.

## Instrumentation

Three instruments and a series of persistence questions were used to assess self-efficacy, sense of community, career interest, and persistence.

**Self-Efficacy**. A researcher-developed scale was used to assess the mentor's STEM self-efficacy. Bandura's (2006) guidelines for constructing self-efficacy scales were followed in the development of the 54-item scale aimed at measuring mentor's STEM self-efficacy in achievement, career, and career and mentorship; however only the achievement and career subscales were used for this study. The literature on STEM self-efficacy guided the development of each question. The decision to develop an instrument was based on the lack of validated instruments available to measure self-efficacy specific to STEM in which the researchers were interested. Respondents were asked to rate their level of confidence from 0 to 10 (0 = "Cannot do"; 5= "Moderately certain I can do, 10= "Highly certain I can do") on statements such as "Persistently work toward my STEM degree even when I get frustrated," and "Have the knowledge to be successful in a STEM job." They were also asked to rate their level of agreement from 0 to 10 (0 = "Strongly disagree", 5 = "Moderately agree", 10 = "Strongly agree") to a series of affective focused statements such as "Feel excited about getting a STEM job." Higher scores on the overall scale and subscales reflected higher self-efficacy. Face and content validity of the instrument was established by the expert review of two doctoral-degree holding STEM faculty published in the area of self-efficacy. Cronbach's alpha coefficients for the three STEM self-efficacy subscales ranged from .91-.96.

**Community**. The modified Classroom Community Scale (Rovai, 2002) was used to assess the construct of sense of community in STEM.  Participants used a 5-point Likert-type scale (0 to 4) to rate their sense of community on 20 items that were modified to focus on STEM community rather than classroom community. Statements included, "I feel that students in STEM care about each other," and "I feel connected to others in my chosen STEM field." The higher the score, the stronger the sense of community felt by the participant. The scale has acceptable construct and content validity as evidenced by results of a factor analysis, and acceptable reliability with a Cronbach's alpha coefficient of .93 and the split-half coefficient of .91 (Rovai, 2002). The Cronbach's alpha coefficient of the Classroom Community Scale for the present study is .95.

**Career Interest**. The survey also consisted of the STEM Career Interest Survey (STEM-CIS; Kier, Blanchard, Osborne, & Albert, 2014), which was used to measure interest in STEM classes and careers. The STEM-CIS is a 44-item survey that uses a 5-point Likert scale and contained items such as, "I intend to enter a career that uses science" and "I am interested in careers that use science." Higher scores on the overall scale and subscales reflect more interest. Confirmatory factor analysis provided support that the STEM-CIS is a valid instrument for use with middle school age students and older, with four discipline-specific subscales: science, technology, engineering, and mathematics. Cronbach's alpha coefficient for each subscale and the composite scale was above a .70, indicating good reliability (Kier et al., 2014). Cronbach's alpha for the subscales of the STEM Career Interest Survey for this study ranged from .85-.92.

**Persistence.** Two questions also assessed mentors' and mentees' intent to persist in STEM degrees and careers, "Do you intend to complete your STEM degree?" and "Do you plan to pursue a career in the area in which you are obtaining a degree?"

## Results

Descriptive statistics for the peer mentors and mentees as well as the waitlist control group data were computed (see Table 1). A series of independent samples *t*-tests were conducted to evaluate whether the program promoted self-efficacy and community, and in turn, STEM career interest among mentees. Here it is important to acknowledge how the item responses on these instruments were formulated-- Likert-type scale format (e.g., "strongly disagree", "disagree", "agree," "agree strongly"). Although it would have been preferable to analyze the data using Rasch modeling prior to conducting the parametric statistical analyses, the small sample size did not make this appropriate (Pallant &Tennant, 2007). This is a limitation of the current study. Prior to conducting each independent samples *t*-test, the assumption of normality, homogeneity of variance, and extreme outliers were examined. While there were minor violations of normality, the independent-samples *t*-test is considered robust to violations of normality and requires only approximate normal distribution of data (Warner, 2013). There were no violations in the assumptions of homogeneity of variance as evidenced by the results of Levene's test of equality of variances. The assumption of no extreme outliers was tenable. Results (see Table 1) of the analyses demonstrated that the peer mentee group compared to the waitlist control group had statistically significantly higher community and STEM achievement and career self-efficacy. With the exception of interest in a technology career, the peer mentee group compared to the waitlist control group had a significantly higher interest in science, engineering, and mathematic careers.

Additionally, chi-square tests for independence were conducted to evaluate whether the intent to persist differed between the mentees and corresponding control groups. Prior to conducting the analysis, assumption testing was completed. The assumption of minimum expected cell frequency was violated. Thus, the Fisher's exact tests were run. The results demonstrated that students participating in the virtual peer mentoring group intended to persist in their STEM degrees and a STEM career at a significantly higher proportion than the waitlist control group (see Table 1).

A series of Mann-Whitney U analyses, the non-parametric alternative to the independent samples *t*-test, was conducted to determine whether the program promoted community, self-efficacy, and STEM career interest among mentors. The non-parametric alternative was appropriate given the small sample of mentors. Prior to conducting each analysis, assumption testing was conducted and similarity between each distribution was ensured. Results (see Table 2) were similar for the peer mentors as the peer mentees, as the mentors had significantly higher community and STEM achievement and career self-efficacy compared to the mentor waitlist control group. With the exception of interest in a math career, the peer mentor group compared to the waitlist control group had a significantly higher interest in science, engineering, and technology careers. For the mentors, additional chi-square tests for independence were not conducted to evaluate whether intent to persist differed between the mentors and corresponding control groups as each cell did not have the minimum of one cell frequency. However, descriptive statistics demonstrated that student mentors participating in the virtual peer mentoring group intended to persist in their STEM degrees and a STEM career at a higher rate than students not participating in the program (see Table 2).

## Discussion

The current study begins to address the need to develop and assess peer mentoring models among institutions that primarily serve minority populations, including HBCUs (Graham & McClain, 2019), and examine practices that support UREMW in STEM. When compared to a waitlist control group, mentors and mentees, respectively, reported higher levels of community, STEM achievement, and career self-efficacy when engaging in peer mentoring. This aligns with previous research that demonstrated positive outcomes, such as increased community and self-efficacy when engaging in mentoring relationships (Dawson et al., 2015; Graham & McClain, 2019; Pon-Barry et al., 2017).

Mentees in the current study showed greater interest in science, engineering, and mathematics than the waitlist control group, and mentors showed greater interest in science, engineering, and technology than the waitlist control group. The findings of the current study support that engaging in peer mentoring enhances UREMWs' interest in STEM and, thus, can serve as a protective or mitigating barrier to challenges inherent to STEM fields, as noted within the literature (Graham & McClain, 2019). This is especially important for UREMW who often find themselves experiencing a 'double bind', defined as "the exclusion of women of color in STEM and the undermining of their career pursuits because of both racism and sexism" (Ireland et al., 2018, p. 227). Engaging in a mentoring relationship can, thus, assist in lessening the damaging effects of the often 'chilly climate' that many UREMW experience in STEM degree programs and, importantly, STEM fields (Mondisa, 2018).

In the current study, both mentees and mentors expressed increased intent to persist in their STEM degree programs and careers post-program, further supporting previous studies indicating that engaging in a mentoring relationship can increase persistence (Dawson et al., 2015). This finding is important as it indicates that engaging in a mentoring relationship may increase UREMW's persistence in STEM degree programs and, relatedly, STEM careers. As institutions seek to broaden the participation of UREMW in STEM and to retain UREMW in STEM degree programs, finding ways to increase persistence and, thus, retention, can be beneficial. The virtual peer mentoring model utilized in the current study shows promise in impacting retention.

The current study demonstrates that mentoring experiences that address the academic, professional, and psychosocial domains may assist in addressing the needs of UREMW. These findings align with previous study that emphasizes the need to consider all three domains in mentoring programs (Zaniewski & Reinholz, 2016). The current study also demonstrates that positive outcomes can be achieved through peer mentoring among both mentors and mentees. And, importantly, peer mentoring relationships can be beneficial among UREMW enrolled in STEM degree programs at HBCUs.

Despite presumed differences in student characteristics (e.g., family background, personal attributes, prior experiences), the peer mentoring experience helped the mentors and mentees develop their sense of belonging, integrate (e.g., academically, socially), and strengthen their self-efficacy. Student characteristics influence one's ability to integrate (e.g., academically, socially), develop a sense of belonging, exhibit high levels of self-efficacy, and ultimately, persist (Bandura, 1994; Lent et al., 1994; Tinto, 1975, 1987, 1993). Mentors and mentees engaged in experiences that helped them to overcome challenges associated with student characteristics. Experiences were centered on activities that promoted integration, increased self-efficacy, and fostered a sense of belonging. Sense of belonging and integration are associated with a student's commitment to academic goals and motivation to persist in a STEM program, and ultimately, in a STEM career (Lent et al., 1994; Tinto, 1993; 2017). As such, mentoring experiences that foster a sense of belonging, strengthen self-efficacy, and encourage academic and social integration can influence persistence in a STEM program and interest in STEM careers.  As Mondisa (2018) emphasizes, understanding the experiences of UREMW engaging in mentoring relationships, including those who choose to enroll in institutions that historically support the belonging, community, and persistence of racial and ethnic minority students, such as HBCUs, is important to mitigating the negative experiences that some may encounter.

**Limitations and Recommendations**

While the results of the present study are promising, given the small sample size, additional replication to ensure consistency and generalizability of results should be conducted. Further, research suggests that it may be beneficial to allow some self-selection among mentor-mentee pairings (Zaniewski & Reinholz, 2016). This may allow for stronger matching of personal traits and communication styles, which could potentially translate to enhanced mentor and mentee outcomes. Future study may also include additional HBCUs or minority-serving institutions to ensure that the results can be generalized to UREMW in other locations and contexts. It would also be beneficial to determine if similar results are obtained among UREMW at minority serving institutions (MSIs) other than HBCUs, Hispanic serving institutions (HSIs), and at PWIs. Additional outcomes could be measured as well.

While self-efficacy has been widely utilized within the research literature, it is documented that women, in particular, tend to underestimate their abilities, skills, and competencies (Beyer, 2008). And, while the Classroom Community Scale (Rovai, 2002) and STEM-CIS (Kier et al., 2014) instruments have been utilized in previous study, examination of construct validity would further enhance future study and serves as a limitation to the current study. Likewise, the use of a researcher-created self-efficacy instrument serves as a limitation to the current study. Construct validity should be further examined for the self-efficacy instrument as well.

The use of additional measures of self-efficacy may be beneficial in ensuring accuracy of UREMWs' perceptions of their own competencies. Further, qualitative analysis may enhance understanding of how and why engaging in a peer mentoring relationship yielded positive outcomes for UREMW (Mondisa & McComb, 2015). With this noted, qualitative data was gathered as part of the larger study and are shared in separate reports (Rockinson-Szapkiw et al., 2020; Sharpe et al., 2020; Rockinson-Szapkiw & Wendt, 2020). It should also be noted that causality may not be determined given the study design and the lack of a pre-test. Future study should explore various research designs, including those that utilize a pre-test and post-test.

As noted, the current study demonstrates that engaging in a virtual peer mentoring model may support UREMW in developing higher levels of community, STEM achievement, and career self-efficacy in STEM, particularly in the context of HBCUs. The structure of the peer mentoring model used in the current study is supported by previous research that suggests that mentoring programs should include accountability, monitoring of relationships to address concerns, inclusion of community, and informal, food-centric meetings (Zaniewski & Reinholz, 2016). While also considering the flexibility afforded by the blended approach (i.e., utilizing online components as well as face-to-face components), it is recommended that future iterations of the peer mentoring model continue to address academic, professional, and psychosocial components. The findings of the current study further reinforce the need to provide opportunities for social community while simultaneously supporting the academic needs of UREMW.

## Conclusion

Our study contributes to previous literature by illuminating the significant role that a virtual peer mentoring experience can play in the academic, psychosocial, and professional outcomes of UREMW mentors and mentees. This study begins to establish that the current virtual peer mentoring intervention is a theoretically- and evidence-based intervention that can effectively target salient factors associated with academic and career persistence of underrepresented populations in STEM. Moreover, this study provides evidence for a promising peer mentoring program that can be integrated into programming external to the research lab and at HBCUs.

Table 1.

*Descriptive Statistics and Analyses for the Mentees*

| Scale | Research Question | Mentees (*n* =21) | | Wait- list Control (*n* =21) | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *M* | *SD* | *M* | *SD* | *t*-value | *p*-value | Score range |
| STEM SE Achievement | 2 | 111.76 | 25.35 | 96.50 | 17.33 | 2.45 | .018* | 10-140 |
| STEM SE Career | 2 | 109.81 | 24.48 | 94.00 | 21.14 | 2.38 | .022* | 10-140 |
| Science Career Interest | 3 | 45.86 | 7.78 | 41.15 | 9.09 | 2.19 | .034* | 11-55 |
| Math Career Interest | 3 | 44.76 | 9.22 | 36.15 | 11.98 | 2.71 | .010* | 11-55 |
| Engineer Career Interest | 3 | 36.05 | 14.65 | 27.23 | 11.38 | 2.32 | .025* | 11-55 |
| Technology Career Interest | 3 | 44.95 | 10.09 | 41.08 | 12.36 | 1.16 | .253 | 11-55 |
| Community | 1 | 34.38 | 3.92 | 28.24 | 5.38 | 4.23 | >.001* | 0-40 |
| | | Yes | No | Yes | No | | *p*-value | Responses |
| Do you plan to pursue a career in the area in which you are obtaining a degree? | 4 | 20 (95.2%) | 1 (4.8%) | 16 (61.5%) | 10 (38.57%) | | .014* | Yes/No |
| Do you intend to graduate from your STEM degree program? | 4 | 20 (95.2%) | 1 (4.8%) | 19 (73.1%) | 7 (21.6%) | | .049* | Yes/No |

Note. SE = self-efficacy; * $p < .05$

Table 2.

*Descriptive Statistics and Analyses for the Mentors*

| Scale | Research Question | Mentors (*n* =6) | | Wait- list Control (*n* = 6) | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *M (Mdn)* | *SD* | *M (Mdn)* | *SD* | *U* | *p*-value | Score range |
| STEM SE Achievement | 2 | 131.00 (137.50) | 15.06 | 112.17 (110.50) | 11.86 | 31.00 | .041* | 10-140 |
| STEM SE Career | 2 | 129.00 (133.00) | 13.07 | 104.33 (102.50) | 11.89 | 33.50 | .009* | 10-140 |
| Science Career Interest | 3 | 47.83 (48.00) | 5.57 | 35.00 (36.00) | 7.69 | 33.00 | .015* | 11-55 |
| Math Career Interest | 3 | 44.00 (46.50) | 10.84 | 32.83 (33.00) | 7.49 | 28.50 | .093 | 11-55 |
| Engineer Career Interest | 3 | 36.83 (38.00) | 7.06 | 27.00 (26.00) | 6.45 | 30.50 | .025* | 11-55 |
| Technology Career Interest | 3 | 46.00 (47.50) | 5.48 | 34.67 (35.50) | 5.89 | 33.00 | .041* | 11-55 |
| Community | 1 | 36.33 (36.50) | 1.05 | 26.00 (24.50) | 2.88 | 31.00 | .037* | 0-40 |

| | | Yes | No | Yes | No | Responses |
|---|---|---|---|---|---|---|
| Do you plan to pursue a career in the area in which you are obtaining a degree? | 4 | 6 (100%) | 0 (0%) | 3 (50%) | 3 (50%) | Yes/No |
| Do you intend to graduate from your STEM degree program? | 4 | 6 (100%) | 0 (0%) | 4 (66.7%) | 2 (33.3%) | Yes/No |

Note. SE = self-efficacy; * $p < .05$

## Conflicts of Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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