

Building STEM Self-efficacy and Persistence: The Case for Online Mentor Training for Women of Color Peer Mentors at Historically Black Institutions

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Purpose

The small number of women in science, technology, engineering, and math (STEM) programs and careers is disconcerting, especially since research shows that women's intellectual ability in STEM fields is equal to that of men (Else-Quest, Hyde, & Linn, 2010; Stoeger, Duan, Schirner, Greindl, & Ziegler, 2013). Over the last ten years, research has shown that girls' confidence in their STEM abilities drops significantly during elementary school and continues to drop in college (Hill, Corbet, & Rose, 2015). This is especially true for underrepresented women of color (WOC) who see very few women like themselves persisting through STEM programs and beginning STEM careers (Olson & Riorda, 2012). In addition to significant structural barriers, Hill, Corbet, and Rose (2010) suggested that WOC lack the self-efficacy, or belief in their own abilities, to succeed in STEM. Increasing the self-efficacy of women, particularly WOC, who wish to pursue STEM careers is critical in order to narrow the gender and race gap in this field. Exploring ways that all women can both find and provide support to one another in STEM is one of many ways that progress towards equal representation in this field can be made. One source of support that could increase the self-efficacy and persistence of STEM students who are also WOC is interaction and exposure to successful WOC in STEM through mentoring.

The incorporation of online or electronic peer mentoring programs (e-mentoring) designed to provide WOC with the support and experiences they need to feel confident in their ability to succeed in STEM programs and, in-turn, a STEM career is one potential solution. E-mentoring programs are asynchronous programs in which 100% of the training and mentoring is completed online. While traditional peer mentoring in bachelors and master's programs is both common and beneficial, weekly meetings on campus and the time it takes is prohibitive for many WOC who have jobs, family commitments, and, often unique barriers that prevent regular face-to-face meetings (Tate & Lynn, 2005). E-mentoring provides an opportunity for students to receive the benefits of mentoring without ever having to meet face-to-face. In order to develop effective e-mentoring programs, the efficacy of all elements incorporated within these interventions needs to be established, including the training programs provided for mentors. This multi-site case study explored one such e-mentoring training program (offered and completed 100% online for mentors) and collected data that can inform future iterations of e-mentoring training programs focused on increasing the self-efficacy and persistence of mentors. The primary research question for the study included: How, if at all, do the experiences of WOC mentors participating in a STEM e-mentoring training program influence their beliefs, skills, and behaviors related to STEM?

Two historically black institutions and one public, predominately white institution with a large minority population, partnered to develop, implement, and evaluate the pilot of a Virtual Peer Mentoring Training Program, an online STEM peer mentorship training program for graduate student peer mentors across two historically black institutions. Each institution served as a case in this study. The aim of the program was to assist WOC student mentors in developing their STEM self-efficacy, mentorship skills, and intent to graduate from a STEM program. The overarching goal was to broaden the participation of WOC in STEM careers. The purpose of this multi-site case study was to better understand how, if at all, STEM mentors' self-efficacy and ideas regarding persistence were influenced by an e-mentoring training program as well as what mentors who participated in the six-week e-mentoring training program experienced.

Conceptual Framework

Given the aim of the program to increase self-efficacy, and ultimately persistence, Bandura's (1977) self-efficacy theory and models related to the development of the "whole student" guided the development of the online peer mentor training (Illeris, 2015; Matteson, 2014) as well as the study. Self-efficacy affects goal choices, effort, and motivation to reach a goal, and persistence toward the goal when challenges arise (Bandura, 1977). Thus, women of color with high STEM self-efficacy are more likely to perform better and persist longer in STEM degree programs and careers compared to those with low STEM self-efficacy.

The work of Bandura (2006) on self-efficacy comes out of his social learning theory (SLT), later called social cognitive theory (SCT). Self-efficacy is an individual's belief that she can accomplish a goal given her skills and the circumstances surrounding the task (Bandura, 1986). Bandura (1977, 2006) proposed that four sources either strengthen or weaken self-efficacy, including performance accomplishments, vicarious experience, social persuasion, and psychological responses. While performance accomplishment is related to the experience one has in performing a specific task, vicarious learning refers to experiences an individual has observing another doing the task. For example, when an individual, especially like one's self, observes another modeling the completion of a task successfully, her belief that she can perform the task successfully improves (Bandura, 1977). Social persuasion refers to receiving affirmation or discouragement about one's ability to succeed (Bandura, 1977). Psychological response refers to how an individual reacts or responds given a specific situation. Researchers have demonstrated that while mastery experience is most influential in boys' and men's STEM career self-efficacy, the most influential factors for girls' and women's STEM career self-efficacy are vicarious experience and social persuasion (Zeldin & Pajares, 2000). Thus, it is important to have like others to view as a model, to serve as an example of success, and to provide support and encouragement in order to develop self-efficacy of women.

Methods

As part of a larger STEM peer mentoring program funded by the National Science Foundation (Award #1717082), an online STEM peer mentorship training was developed in Spring of 2018. Six interactive, online modules were developed that provided between 10-15 hours of self-paced, formalized instruction. The modules were developed using various authoring tools (e.g., eXe, Articulate, Camtasia) and hosted via a WordPress site. Each module ended with an assignment, which required the mentor to engage in reflective journaling activity and to participate in an online discussion with other peer mentors and faculty facilitators. Assignments took approximately five hours to complete. Mentors had eight weeks to complete the training.

Overall, six mentors participated in the training and completed survey analyzed for the study. Five mentors and two faculty facilitators participated as partners in the interviews. The mentors were required to be a woman or minority in STEM, be enrolled in a STEM degree program, have a cumulative GPA of 3.0 or higher, and provide a letter of recommendation from a STEM faculty member upon request. The selected mentors were all women between the aged of 22-31. Five of the mentors identified their race as Black, and one mentor identified her race as Hispanic. Tables 1 and 2 describe the mentors' and faculty facilitators' demographics and case.

Table 1.
Mentor Demographics

Pseudonym	Location	Gender	Race/Ethnicity
Chanara	HBCU 1	F	Black/ African American
Lorraine	HBCU 1	F	Hispanic/Latino
Joel	HBCU 1	F	Black/ African American
Inana	HBCU 2	F	African American
Genecia	HBCU 2	F	African American

Table 2.
Faculty Facilitator Participant Demographics

Pseudonym	Location	Gender	Race/Ethnicity	Content Area	Level
Dr. West	HBCU 1	F	Caucasian	Science and Technology	Faculty
Dr. Kalson	HBCU 2	F	African American	Science	Faculty

Mentors completed a pre- and post-test survey as part of the training to gain insight into how mentors' self-efficacy, and persistence changed, if at all, after finishing the training. This survey data was analyzed using descriptive statistics and provided a snapshot into changes that took place during the e-mentoring training program. Following completion of the training, one-on-one interviews were conducted with mentors, and focus groups were conducted with mentors and faculty facilitators to learn more about stakeholder experiences. In addition, observation notes of the mentors' engagement in the e-mentoring training were kept throughout the training. These notes were added to a researcher journal and used to triangulate the data collected. The data collected from interviews, focus groups, and observations were analyzed according to the forms of case study analysis outlined by Stake (1994): categorical aggregations, identification of patterns, and naturalistic generalizations through two rounds of detailed coding.

Results

Results of the pre and post-test survey demonstrated that the training program promoted an increase in self-efficacy and STEM persistence. Mentors experienced the greatest percentage change in mentorship self-efficacy (6.86%) on the researcher created STEM self-efficacy instrument (see Table 3).

Table 3. *Descriptive Statistics*

Scale	Pre Training		Post Training		% of Change	Score range
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
STEM SE Achievement	111.50	15.24	112.67	15.85	1.05%	10-140
STEM SE Career	110.67	12.69	116.33	4.76	5.12%	10-140
STEM SE Mentorship	213.83	27.94	228.50	12.90	6.86%	26-260

Note. SE = self-efficacy, *N* = 6

Prior to the training only 4 mentors indicated their intent to persist in their degree and a STEM career. All six mentors indicated their degree and career persistence after the training, a 50% increase in the number of students noting their intent to persist.

How the training experience contributed to these changes was learned through analysis of the data from the interviews, focus groups, and researcher's journal. The four themes identified

provide insight into elements of the e-mentoring training that may have contributed to mentors' positive experiences and changes in self-efficacy and persistence: (1) the training's structure and content, (2) the opportunity to reflect, (3) connecting with others, and (4) empowerment and motivation. Self-efficacy theory and the literature on mentoring were helpful for exploring how the training may have led to the changes discussed by the mentors regarding specific beliefs, skills, and behaviors related to STEM.

Scholarly Significance

Research has documented that mentorship is “a reciprocal, dynamic relationship between mentor (or mentoring team) and mentee that promotes satisfaction and development of both” (McGee & Keller, 2007, p. 316), has been associated with mentee productivity (Dolan & Johnson 2009; Steiner, Curtis, & Lanphear, 2004), self-efficacy (Baier, Markman, & Pernice-Duca, 2016) and STEM degree and career persistence (Gloria, Robinson & Kurpius, 2001; Laursen, Hunter, Seymour Thiry, & Melton, 2010). Mentorship has been shown to broaden participation and promote persistence of mentees in STEM degrees and careers (Ginther et al., 2011); however, limited research demonstrates the effects of mentoring processes on mentors (Dolan & Johnson 2009; Gloria, Robinson & Kurpius, 2001) as most research has focused on mentees. Meta-analyses (e.g., Eby, Allen, Evans, Ng, & DuBois, 2008) have demonstrated that features of effective mentoring (e.g. type of contact, amount of time) and benefits of mentoring have primarily focused on fields other than STEM, with a focus primarily on Predominately White Institutions (PWI).

While the findings of this study are not generalizable, they do provide a foundation for how mentor training may support WOC STEM students who are not attending PWIs. STEM degree programs should consider the potential benefit of mentorship programs and invest in quality training experiences for mentors when offering such programs. Providing well-designed training programs for WOC STEM students can create opportunities for students to connect with one another while developing mentorship skills and, in turn, facilitate positive changes in Cohen's (2003) six behavioral dimensions of mentors, self-efficacy, and persistence. Colleges and universities must invest in building quality support systems for WOC in STEM if they wish to see more women in STEM complete their STEM degree program and maintain a STEM career (Ong et al., 2018).

A dearth of literature also exists on how to best train mentors to support effective peer mentoring relationships. Researchers have agreed that to ensure the mentoring relationship is effective, it is important that the mentor develops skills and understands the function of the mentor (Galbraith & Cohen, 1995; Gandhi & Johnson, 2016; Pfund et al., 2014). Consequently, funding agencies such as the National Institutes of Health (2011) have issued reports asserting that there is a lack of standardized training and systematic interventions and processes for mentoring relationships in STEM fields. This study provides a snapshot of how e-mentoring training programs could be one such support system by offering insight into what five women of color found to be instrumental aspects of their training. Based on the findings, e-mentoring training programs that focus on facilitating skill and self-efficacy development, as well as persistence for WOC in STEM should provide opportunities for online training that enables flexibility, modeling, reflection, and connection. This research provide evidence for an effective approach.

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References

- Baier, S. T., Markman, B. S., & Pernice-Duca, F. M. (2016). Intent to persist in college freshmen: The role of self-efficacy and mentorship. *Journal of College Student Development, 57*(5), 614-619. doi:10.1353/csd.2016.005
- Bandura, A. (1977). Self-efficacy theory: Toward a unifying theory of behavioral change. *Psychological Review, 34*(2), 191-215. Retrieved from <https://www.uky.edu/~eushe2/Bandura/Bandura1977PR.pdf>
- Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, N.J.: Prentice Hall.
- Bandura, A. (2006). *Guide for constructing self-efficacy scales*. In F. Pajares & T. Urdan (Eds.). *Self-efficacy beliefs of adolescents*, (Vol. 5., pp. 307-337). Greenwich, CT: Information Age Publishing.
- Cohen, N.H. (2003). The journey of the principles of adult mentoring inventory. *Adult Learning, 14* (1), 4-7.
- Cohen, N.H. (2008). *The Principles of Adult Mentoring Inventory Leader's Guide*. Amherst Press: Amherst, MA.
- Dolan, E., & Johnson, D. (2009). Toward a holistic view if undergraduate research experience: an exploratory study of impact on Graduate/Postdoctoral mentors. *Journal of Science Education and Technology, 18*(6), 487-500.
- Eby, L., Allen, T., Evans, Sarah, & Dubois, D. (2008). Does Mentoring Matter? A multidisciplinary meta-analysis comparing mentored and non-mentored individuals. *Journal of Vocational Behavior, 72*(2), 254-267.
- Else-Quest, N. M., Hyde, J. S., & Linn, M. C. (2010). Cross-national patterns of gender differences in mathematics: A meta-analysis. *Psychological Bulletin, 136*(1), 103–127. [http:// dx.doi.org/10.1037/a0018053](http://dx.doi.org/10.1037/a0018053)
- Feldhaus, C. & Bentrem, K. (2015). STEM mentoring and the use of the principles of Adult Mentoring Inventory. *International Journal of Mentoring and Coaching in Education, 4*(3) 213-235, doi.org/10.1108/IJMCE-11-2014-0039
- Galbraith, M. W. & Cohen, N. H. (Eds.). (1995). *Mentoring: New strategies and challenges. New directions for adult and continuing education, 66*. San Francisco: Jossey-Bass.
- Gandhi, M., & Johnson, M. (2016). Creating more effective mentors: Mentoring the mentor. *AIDS and Behavior, 20*(S2), 294-303. 10.1007/s10461-016-1364-3 Retrieved from <https://www.ncbi.nlm.nih.gov/pubmed/27039092>
- Ginther, D., Schaffer, W., Schnell, J., Masimore, B., Liu, F., & Haak, L. (2011). Race, Ethnicity, and NIH Research Awards. *American Association for the Advancement of Science, 333*(6045), 31-614.
- Gloria, M., Robinson, & Kurpius SE. (2001). Influences of self-beliefs, social support, and comfort in the university environment on the academic non-Persistence decisions of American Indian undergraduates. *American Psychological Association: Cultural Diversity & Ethic Minority Psychology, 7*(1), 88-102.
- Hand, S., Rice, L., Greenlee, E. (2017). Exploring teachers' and students' gender role bias and students' confidence in STEM fields. *Social Psychology of Education, 20*(4), 929-945.
- Hill, C., Corbett, C., & St. Rose, A. (2010). *Why so few? Women in science, technology, engineering, and mathematics*. Association for the Advancement of University Women: Washington, DC.

- Hill, C., Corbett, C., & St. Rose, A. (2015). *Solving the equation. The variables for women's success in engineering and computing*. Washington, DC: American Association of University Women. Retrieved from https://www.aauw.org/aauw_check/pdf_download/show_pdf.php?file=solving-the-equation
- Illeris, K. (2015). The development of a comprehensive and coherent theory of learning. *European Journal of Education*, 50(1), 29-40.
- Laursen, S., Hunter, Ab., Seymour, E., Thiry, H., & Metlon, G. (2010). Undergraduate Research in the Sciences: Engaging Students in Real Science.
- Matteson, Miriam L. (2014). The Whole Student: Cognition, Emotion, and Information Literacy. *College and Research Libraries* 75(6), 862-877. doi: 10.5860/crl.75.6.862 Retrieved from <http://digitalcommons.kent.edu/slispubs/61>
- Mayer, R. E. (2009). *Multimedia learning* (2nd ed.). New York: Cambridge University Press.
- McGee, R. & Keller, J.L. (2007). Identifying future scientists: Predicting persistence into research training. *Life Science Education*, 6(4), 316-331.
- National Institutes of Health. (2011). Investing in the Future: Strategic Plan for Biomedical and Behavior Research Training. *National Institute of General Medical Sciences*.
- National Science Foundation. (2015). Women, minorities, and persons with disabilities in science and engineering. Retrieved from <https://www.nsf.gov/statistics/2015/nsf15311/start.cfm>
- National Science Foundation. (2018). Women, minorities, and persons with disabilities in science and engineering. Retrieved from <https://www.nsf.gov/statistics/2017/nsf17310/>
- Olson, S., & Riordan, D. G. (2012). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics. Report to the president*. Executive Office of the President. Retrieved from <https://eric.ed.gov/?id=ED541511>
- Packard, B. W., Marciano, V. N., Payne, J. M., Bledzki, L. A., & Woodard, C. T. (2014). Negotiating peer mentoring roles in undergraduate research lab settings. *Mentoring & Tutoring: Partnership in Learning*, 22(5), 433-445.
- Pfund, C., House, S., Asquith, P., Fleming, M., & Buhr, K. (2014). Training mentors of clinical and translational research scholars: A randomized controlled trial. *Academic Medicine*, 89, 82-774.
- Stake, R.E. (1994). Case studies. In N.K. Denzin & Y.S. Lincoln (Eds.), *Handbook of qualitative research*, (pp. 236-247). Thousand Oaks, CA: Sage Publications.
- Stake, Robert E. (2006). *Multiple case study analysis*. New York, NY: Guilford.
- Steiner, J., Curtis, P., & Lanphear, B. (2004). Assessing the role of influential mentors in the research development of primary care fellows. *Journal of the Association of American Medical Colleges*, 79(9), 72-865.
- Stoeger, H., Duan, X., Schirner, S., Greindl, T., & Ziegler, A. (2013). The effectiveness of a one-year online mentoring program for girls in STEM. *Computers & Education*, 69, 408-418. doi:10.1016/j.compedu.2013.07.032
- Tate, E. D., & Linn, M. (2005). How does identity shape the experiences of women of color engineering students? *Journal of Science Education and Technology*, 14(5-6), 483-493. <https://doi.org/10.1007/s10956-005-0223-1>
- Zeldin, A. L., & Pajares, F. (2000). Against the odds: Self-efficacy beliefs of women in mathematical, scientific, and technological careers. *American Educational Research*

Journal, 37, 215–246. Retrieved from
http://www.engr.psu.edu/awe/misc/arps/arp_selfefficacy_overview_122208.pdf