STEM E-Mentoring and Community College Students with Disabilities

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Abstract

This article reports the findings from a qualitative study to understand the provision of electronic mentoring (e-mentoring) to support the educational persistence of students with disabilities at a two-year college in a large city in the U.S. South. Building upon a five-year project at three postsecondary institutions and three secondary school systems, this article presents the results from interviews with selected participants, which were analyzed using a qualitative case study design. Three aspects of a STEM e-mentoring program were examined: (1) the use of virtual environments and social media settings; (2) the development of e-mentoring relationships; and (3) the examination of persistence constructs. Eight participants were recruited for the study representing individuals with disabilities, non-traditional age students, and individuals from minority populations. Four critical findings were observed: (1) virtual environments and social media tool usage varied depending on context, accessibility, and practical considerations; (2) STEM learning and emotional supports were enhanced when embedded in the practice of e-mentoring; and (3) five persistence constructs (intention to persist, self-determination, self-advocacy, science affect, and math affect) informed STEM outcomes for community college students with disabilities.

Keywords: disability, virtual mentoring, persistence

The science, technology, engineering, and mathematics (STEM) professions are not limited to bench scientists and engineers with bachelor's and graduate degrees. A more inclusive, holistic definition of STEM includes engineering technicians, systems administrators, computer specialists, and others whose skills may be obtained at the sub-baccalaureate level (Rothwell, 2013). The need to prepare students for entry into this expansive STEM workforce cannot be underestimated, as the number of STEM jobs is projected to grow by 17 percent between 2008-2018, compared to just 10 percent for non-STEM occupations (Carnevale, Smith, & Mellon, 2011). Thirty-five (35) percent of all STEM jobs will be held by people with less than a bachelor's degree by 2018, and wages paid to these individuals will exceed their non-STEM peers (Carnevale, Smith, & Mellon, 2011).

Students with disabilities historically have been excluded from postsecondary STEM education, as these students face significant barriers to access and inclusion in such programs. Although these individuals may not represent the traditional profile of STEM professionals, they may possess interest and ability in STEM and should be strongly encouraged to persist into STEM careers. Unfortunately, the outcomes data on the participation and persistence of underrepresented community college students with disabilities in STEM programs is dismal, especially when the definition of "underrepresented" is extended to include students from minority racial and ethnic groups and women (NSF, 2011). For the purposes of the research presented in this study, we define "underrepresented" as demographic groups that historically have been excluded, whether intentionally or unintentionally, in STEM fields across dimensions of race and ethnicity (Alaska Natives, Native Americans, Blacks or African Americans, Hispanics, Native Hawaiians and other Pacific Islanders), gender (women), and disability. Underrepresentation in STEM should be understood within the context of efforts to "broaden participation" in STEM (NSF, 2008), and it should be noted that the identification of a specific group as "underrepresented" may vary by discipline and may include additional groups such as non-traditional aged college students.

Persistence in STEM is a continuous learning process that influences the educational goal aspira-

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tions of an individual (NRC, 2012). Here, we define "persistence" as the progression of an individual through education, including critical transition points, to graduation or degree completion. Persistence may include retention but goes further to stress educational attainment. In addition, the federal initiative "Pathways to Success" identifies the significant role of higher education in the educational attainment of underrepresented populations (Advisory Committee on Student Financial Assistance, 2012), including the imperative of addressing barriers to persistence faced by academically vulnerable populations. Research has documented the high correlation between persistence and a learner's academic performance (Kahn & Nauta, 2001). However, identifying specific academic indices (e.g., GPA) to measure persistence outcomes has generated inconsistent evidence (Bergman, Gross, Berry & Shuck, 2014; Gigliotti & Huff, 1995). Contemporary researchers of motivation recognize the importance of the learner's environment, relationships, and broader social and cultural experiences in affecting persistence and suggesting constructs with greater depth than only GPA (Anderman & Anderman, 2000; Markel, 2015).

Electronic mentoring (e-mentoring) represents one effective practice for supporting the retention, persistence, and graduation of underrepresented postsecondary students with disabilities in STEM majors (Sowers, Powers, & Shpigelman, 2012). As more students use online learning for instruction, virtual student support services such as e-mentoring may improve student engagement and retention (Britton & Rush, 2014). How best to provide a socially valid means of defining e-mentoring continues to be a challenge for researchers (Crisp & Cruz, 2009; Jacobi, 1991) . In particular, defining e-mentoring requires researchers to incorporate ever-changing communication platforms (Headlam-Wells, Gosland, & Craig, 2006). Recently, Dawson (2014) suggested that the best means to circumvent this "definitional crisis" reported across the literature is for researchers to describe the framework identifying their mentoring intervention. As she notes, providing a "framework for designing, communicating, and studying mentoring may advance research beyond generically *defining* mentoring toward concisely *specifying* it" (p. 144).

The prevalence and positive outcomes of mentoring, in general, have resulted in a significant body of research (Crisp & Cruz, 2009). Evidence suggests that effective mentoring experiences are influenced by multiple factors, including the purpose (Eby, Allen, Evans, Ng, & DuBois, 2008), the relationship between the mentor and the mentee (Schwartz, Rhodes, Chan, & Herrera, 2011), the consistency in the mentoring relationship (Grossman & Rhodes, 2001), and the mentoring objectives (DuBois, Holloway, Valentine, & Cooper, 2002). Factors such as gender, race/ethnicity, and disability can also influence the mentoring relationship (Headlam-Wells, Gosland, & Craig, 2005). Taken together, evidence suggests that mentoring may be a key strategy for support educational persistence, including within STEM for students with disabilities.

But less is understood about e-mentoring, specifically, and the potential advantages and disadvantages of e-mentoring versus face-to-face mentoring have received minimal attention (Ragins & Kram, 2007). Ensher and colleagues (2003) identify some advantages associated with e-mentoring: (a) access to mentors, particularly where geographic and time barriers are concerned; (b) reduced cost; and (c) equalization of status and decreased stereotype threat. Regarding disadvantages, Ensher et al. recognize the following challenges: (a) difficulty communicating nonverbally; (b) slower development of relationships; (c) wide-range of written communications skills; and (d) technology barriers. However, there presently are no randomized controlled studies investigating the differences between these two types of mentoring for populations with or without disabilities.

STEM learning environments present students with expectations and demands unique to other disciplines. Recognizing the possible relationship between STEM environments and student persistence, Toker, Yonca, and Ackerman (2012) investigated specific constructs critical to student retention in STEM. They found that associations with intention to persist, intention to choose a complex occupation, college major satisfaction, and STEM-related GPAs were associated with STEM persistence. However, their sample population consisted of very few underrepresented groups (e.g., non-traditional age, disability). This study builds upon those findings to explore factors influencing the participation of underrepresented community college students with disabilities in a STEM e-mentoring program.

Methods

The authors have led a five-year, multi-institutional project to implement and determine the efficacy of e-mentoring for students with disabilities. This article presents the findings from one of the project's studies, which examines a cohort of underrepresented community college students with disabilities enrolled in STEM majors. To augment project data focusing on e-mentoring efficacy and changes in internal characteristics related to educational persistence, we undertook a qualitative case study methodology (Yin, 2009). A qualitative multiple case study approach and the content analysis it offers have allowed us to gain a deeper understanding of the associated factors that influence the persistence of students with disabilities in STEM majors participating in an e-mentoring program. The study received institutional review board approval.

E-Mentoring Program

Study participants were selected from the aforementioned project to provide e-mentoring to students (*n*=188) in order to increase their persistence in secondary (three school districts) and postsecondary settings (one community and two research universities) within STEM disciplines. Mentors were recruited from postsecondary faculty, staff, graduate students, and business leaders. All mentors had expertise in a STEM field. The project staff matched mentors to students based on a set of criteria: STEM interest and experiences of mentor with diverse learning styles (disability consideration; expertise of mentor in STEM academic coursework; mentor preference for secondary or postsecondary). In addition, all the candidates selected to participate as mentors underwent an application process that included a telephone interview. Upon acceptance as a project mentor, all mentors were required to complete two online mentor training modules. The criteria for mentee selection for this study required that a student be enrolled in a community college, have a documented disability, and demonstrate an interest in pursuing a STEM major.

The key components of the e-mentoring intervention included provision of online learning and training practices, access to virtual environments, use of social media platforms to promote networks of support, and virtual linkage to STEM resources. All mentors and mentees were required to virtually meet with each other at least 10 times per semester, complete required project modules, return online survey evaluations, and participate in all virtual group activities. Essential to the mentor and student engagement was the collaborative use of the online STEM learning modules. All modules included universally-designed online, mobile device, and Second Life formats. An e-mentoring session was defined and recorded using the following standardized criteria: (1) digital voice communication was the length of time in Second Life, phone, video chat; and (2) text-based communication was a progressive communication interchange addressing a relevant mentoring subject (i.e., dialogue sequence of emails or social media posts, SL chat posts, text message conversation threads).

Research Study Participants

The research reflected in this article focuses on a subset of community college students who participated in the e-mentoring project during the 2013-2014 academic year. The community college partnering with the e-mentoring program is an open-enrollment two-year institution (or "access college") with approximately 26,000 students located within a few miles of a large southern city. In line with this article's concern about addressing barriers faced by students belonging to multiple underrepresented groups, 68% of the students belong to a minority race or ethnic group.

Mentor/mentee pairs for this study were selected as participants based on purposive sampling (Merriam, 2009). Pseudonyms were used for the participants. Four mentor/mentee pairs (n = 8) were recruited to participate in the study. Table 1 provides descriptive information for the mentoring pairs participating in the study.

Two of the mentees demonstrated learning disabilities, one visual impairment, and one a physical disability (rheumatoid arthritis). Three of the mentees who participated were female and one was male. Three of the four mentees were nontraditional age students. Nontraditional status was defined by the single criterion age (i.e., 25 years and older) as supported by previous research (Markel, 2015). Two of the mentors and three of the mentees represented minority backgrounds. In addition, there were two male and two female mentors who participated in the project. The mentors were adult professionals working in STEM including academia, engineering, and consulting.

Persistence Survey

As part of the broader project, all mentees were administered a survey prior to beginning any of the e-mentoring activities and again at the end of the second semester. The survey provided a measure of five constructs strongly related to persistence in STEM and self-determination related to pursuit of learning (Toker, et al., 2012; Shogren, Palmer, Wehmeyer, Williams-Diehm, & Little, 2012). The program staff drew upon an extensive literature to develop scales measuring the five constructs, which have been tested for validity and reliability. Individual items were chosen for their relevance to the design and goals of the program and the age range of the participants.

1. Intent to Persist: the likelihood to persist by pursuing further education or a career in STEM. The eight-item scale was adapted from Toker (2010) and Williams, Wiebe, Yang, Ferzli, & Miller (2002).

2. Self Determination: the ability to act as the primary causal agent in one's life and set goals and make decisions that are free of undue external influence or interference. This also involves making informed decisions and taking responsibility for those decisions (Wehmeyer, 1996). The 17 items in this construct were drawn from the work of Wolman, Campeau, DuBois, Mithaug, and Stolarski (1994) as well as Field and Hoffman (1994).
3. Self-Advocacy: the ability to effectively communicate, convey, negotiate or assert one's interests, desires, needs, and rights. The 12 items on this scale were primarily drawn from Miller (2006).
4. Science Affect: feelings associated with science. Previous research has found significant positive correlations between science affect and reported high school preparation in science and college science GPA (Glynn & Koballa, 2006).
5. Math Affect: feelings associated with mathematics. Math affect has been shown to involve complex factors such as feelings of pressure, performance inadequacy and test anxiety that interfere with solving math problems (Bai, Wang, Pan, & Frey, 2009).

As a measure of reliability to assess the internal consistency of the Persistence Survey, Cronbach's alphas were computed for each of the five scales. In addition, the "Cronbach's Alpha if Item Deleted" effect on the scale was examined for each survey item. This represents the scale's Cronbach's alpha reliability coefficient for internal consistency if the individual item is removed from the scale. An alpha of .80 or higher is considered to have achieved very good measurement reliability; an alpha of .65 is considered acceptable (Field, 2009). Each scale achieved very good reliability. The positive science affect scale ($\alpha = .827$) had the lowest alpha and negative math effect ($\alpha = .924$) had the highest. The item deletion analysis revealed that removing any of the items within a scale would not lead to a large increase in the Cronbach's alpha for any of the scales. At the time of the analyses, 146 mentees had completed the survey.

Mentee Semester Survey

The Mentee Semester Survey was an online instrument developed and administered to the mentees at the end of each of the semesters in this study. The purpose of this survey was to evaluate mentees' interactions with the e-mentoring experience across five different constructs; (1) satisfaction: mentees' sense of fulfillment in the relationship; (2) support seeking: how much mentoring provides academic and personal support; (3) personal responsibility: how much mentors value activities focused on mentees' maturation and psychosocial development; (4) communication: how satisfied the mentor and mentee are with frequency and duration of their communications; and (5) engagement: what types of communication platforms are utilized, with what frequency, and with what level of satisfaction with the medium. The instrument reliability was examined by measuring internal consistency of scales using Cronbach's alpha. Analyses of data from two semesters (Fall 2012 and Spring 2013) reveal very good measurement reliability using the mentee survey. The lowest Cronbach's alpha was .87 for the personal responsibility scale and the highest was .98 for the communication quantity scale.

Mentor Monthly Survey

All mentors were required to complete a Mentor Monthly Survey providing feedback about each of their assigned mentees. The primary purpose of this survey was to investigate the number of mentoring sessions, the communication platform mediums used for mentoring, and the length of mentoring sessions when certain mediums were used. Mentors also reported on mentees participation in other project activities.

Interviews

Interviews specific to the study presented here were conducted with the four mentors and four mentees selected. The interviews followed a semi-structured format with opportunities for open-ended responses and follow-up questions. Each participant was interviewed individually for 40-90 minutes. Interviews were audiotaped and transcribed verbatim. We engaged in frequent member checking (Patton, 2002).

Data Analysis

Following data collection, all interviews were transcribed and read again using close reading. To move from one stage of analysis to another, researchers identified potential items "of interest" and noted these with memos to assist in the coding and characterization process (Maxwell & Miller, 2008). Transcripts were coded using summative phrases. We then used a constant comparative analysis in order to yield an accurate portrayal of the mentoring. After each interview, the interview data were analyzed amongst the other sets of data to find comparable and tentative categories (Maykut & Morehouse, 1994). The initial coding and categorization of the data were subjected to a thematic analysis. We strictly adhered to case study procedures for reliability (Merriam, 1998). The participants reviewed their individual data. Survey data for each of the participants were collected and used as a form of data triangulation (Denzin, 2012).

Interview Findings

Factors Associated with Student Choice of Virtual Environments and Social Media Settings

Since we were interested in understanding more about mentor/mentee relationships within the context of e-mentoring, investigating how virtual environments and social media tools influence the mentoring relationship was essential. The e-mentoring sessions were provided through either digital voice communication platforms (e.g., Second Life voice, smart phone, video calls) or text-based communication platforms (e.g., emails, social media posts, Second Life chat posts, text message conversation threads). We examined the reflections of the participants across these different communication platforms. Table 2 provides the participants tool usage data.

Digital voice tools-Second Life. The e-mentoring island in Second Life is a virtual platform where individuals interacted with each other through avatars. Avatars communicated through voice (use of a microphone) or by chat threads (written communication). The e-mentoring island was an environment with small mentoring nooks, large classrooms, amphitheater, floating cafes and lounge areas, STEM related resources, internet access points, and green space. To ensure that mentors and mentees had access to communication platforms other than the e-mentoring island, participants were provided options for social network sites such as Facebook, Google, Skype, Twitter, YouTube, and/or a virtual learning environment on the program website, including virtual learning modules, a blog, and other support resources. Mentoring pairs were encouraged to find a platform that was beneficial to their mentoring activities.

The participants reported that the e-mentoring island initially presented challenges. Learning the keyboard and mouse commands for avatar movement, camera controls, and communication tools posed learning barriers for some of the participants. Although the interaction with the avatar is based on uniform video game commands, several of the study participants did not have video game background to make interaction within the e-mentoring island more user-friendly. The participants reported on ways that they integrated a variety of social media platforms into their e-mentoring sessions. Selecting a communication platform for e-mentoring was a decision made by each mentoring pair, and the platform often changed depending on personal preference, availability, ease of use, and convenience. Given the initial learning curve required to easily participate on the e-mentoring island, it is interesting that this experience provided an impetus for relationship building for many of the participants. They reported that working together to learn the e-mentoring island prompted open discussions and the decision to incorporate other social media tools into e-mentoring activities.

The decision whether to use the e-mentoring island often varied by a student's functional limitations. One of the study participants (Mahalia), who maintained a high level of island activity, valued the platform because it allowed her not to be hindered by a physical disability. Another participant, Karen, chose not to use the e-mentoring island (Second Life) due to the platform's incompatibility with the assistive technologies she used to accommodate her blindness. Several of the mentor/mentee pairs made the decision to use the e-mentoring island for group training activities, but chose different social media sites for other e-mentoring functions. As the mentoring relationships progressed, many of the mentors and mentees found the social media tools that were the best fit for the aims of their e-mentoring activities (see Table 3). Some mentees did, however, choose to increase their participation on the e-mentoring island suggesting that the platform was effective for them. Interestingly, Mahalia, who is a non-traditional age student, became proficient on using the e-mentoring island. Age-bias did not appear to hamper her learning and use of such a communication platform.

Text-based tools. Text-based communication tools are electronic messages that are typed and sent to another user. Formats like email, Facebook chat, Twitter, text messaging, and blog posts are among the most common. Given the availability ease of these platforms to participants, it is important to examine their use of text-based media. All of the participants with the exception of one mentor/mentee pair transitioned to using digital text-based tools as their primary means of conducting e- mentoring activities. The quick accessibility and familiarity with digital text made the process of contacting mentors and mentees less cumbersome than the e-mentoring island.

The mentors' monthly surveys provided evidence that text-based tools were often the most frequently used e-mentoring tools across both social and academic activities. It appears that one of the main reasons for using text-based tools was the practicality, user friendliness, and availability of the platforms. Several of the participants also remarked about the reliability of texting, email, and Facebook chat feature for allowing them to have access to their mentor or mentee. Email and chat platforms offered instant access to the participants, and their monthly surveys revealed that mentors and mentees spoke regularly though these mediums.

Due to the ease of connecting on social media platforms, many of the participants reported that the closeness of the e-mentoring relationship tightened, and the frequency of contacts increased across semesters. The majority of the participants chose digital tools that were easily accessed on their smart phone. For instance, the chat feature on social media sites such as Facebook was used frequently as a way to type quick messages between participants. Those messages, whether engaged in a real time chat or for leaving an electronic message, allowed the participants to engage in unscheduled, quick-response, and private one-on-one mentoring. One mentor reported that he used Facebook's chat feature (i.e., digital text tool) immediately at the beginning of the e-mentoring relationship with his mentee. As the relationships progressed, the mentor reported a substantial increase in the digital voice features of Facebook. This mentor talked about an interesting advantage using the chat feature to talk with his mentee:

> Bob (Mentor): And using something like Facebook, as opposed to Second Life, I have a log of everything that we've ever discussed. So I can always go back and look at my previous notes.

By having a log of "everything," this mentor was able to recall conversations, comments, and guidance that could prove to be helpful and consistent throughout the mentoring process.

The interview and mentor survey data indicated that the participants chose communication platforms and specific features of social media tools that best fit specific e-mentoring activities. Ease of use, availability, and disability accommodation needs all played a role in the determination of what type of communication tool to use and when to use it. Age, race/ethnicity, or gender did not appear to factor into the choice of a specific communication tool. Platforms such as Skype, the e-mentoring island, and Google Hangout have both text-based and voice communication functions that allowed participants to have real-time conversations. When asked what social media tools they used most frequently, participants referred to multiple platforms and specific features within a platform, again indicating that e-mentoring pairs used more than one type of platform to connect:

> Billy (mentor): I use Skype and now Google Plus. I had too many issues with Second Life.

> John (mentee): I typically like Skype. For me, I talk more than I do write. But, you know, it kind of allows, you know, flexibility in terms of time.

> Mahalia (mentee): You just go, and you know, you load it. You know, like there's ways you can record in Skype, you know. And there's ways you can send stuff out. There's ways you can bring up your desktop. You know, and let people see what you're doing… And I can see where it would come in handy.

> Karen (mentee): With this one in particular (Skype), I think it would be a fun way for us instead of like replacing our phone call, we could like see each other's face.

The interview and survey data suggests that while the mentoring pairs decided on a primary platform for communication, all made use of the variety of text-based and voice communication tools across many platforms. Table 3 documents the usage patterns for the participants across digital voice and text-based communication tools. All the mentees chose to use a wide range of both digital voice and text-based communication tools to connect with their mentor. This finding suggests that no one type of communication tools is effective for all e-mentoring activities. However, the smartphone appears to be the most frequently used communication tool.

Factors Associated with Development of Mentor/Mentee Relationships

Our e-mentoring program was designed to foster a relationship through which experienced persons share knowledge and perspective, and to encourage students with disabilities to persist in STEM majors. We observed that the mentoring roles described by the participants appear complex and multifaceted, contributing to a dynamic rather than static mentoring model. The implicit and explicit roles defined by the mentor and mentee, the closeness of their relationship, the regularity and the quality of the e-mentoring contacts all contributed to the successful outcomes. One participant in the study, Bob, a STEM professional and mentor in the study, remarked that he has had worked with a variety of mentors through different developmental periods of his life.

> Bob (mentor): While I was a college student. While I've been an undergrad, you know. When I've been in grad school, of course. You have very strong mentorship...they're there to listen. They're there to help. They're there to give, you know, advice. But of course, limited advice.

Bob explicitly recalls that the prior experience with having a mentor directly influenced how he mentored others. He was very careful to mention his past mentors provided "limited advice" to him. His belief that mentors should only "give assistance, not direct advice" is congruent with the same practice he offers to his mentee.

As noted by the mentee comments below, the e-mentoring experience braided together many different aims and purposes for the participants.

> Karen: Oh. It's helped me as far as studying because I used to try to do it all at one time. And then I would get horribly depressed about it and I wouldn't do anything else.

> Mahalia: I would not be where I was today if people hadn't mentored me, believed in me, and didn't see me as a …person with a disability whose life was ripped off. You know, but they saw who I was inside. What my vision was.

> John: You know, I really wouldn't be, I don't think I would be in school today, you know, if somebody hadn't, you know, talked me through and said basically, you know you can do whatever the…heck your mind, you set your mind to.

These mentees were clear that the presence of a mentor greatly impacted their personal and academic lives. Each participant reflected on different aspects of e-mentoring such as developing better study skills, living successfully with a disability, and continuing to persist in their major. However, they all mentioned the importance of having a close mentoring relationship. From the survey data, both the mentors and mentees reported strong satisfaction with the quality and quantity of their communication.

The participants also reflected on their definition of a mentor, and how mentors fulfill their roles within a mentoring relationship. They frequently mentioned that trust and support were essential for building strong learning experiences. In the excerpts below, trustworthiness and support come in the form of approachability of the mentor, and relevant advice shared reciprocally from the mentor to the mentee.

> John (mentee): Somebody you can, you know, go to and ask, you know different questions, you know, about a variety of different subjects and kind of receive advice from a different point of view.

> Michelle (mentee): That's somebody who believes in you. And encourages you, you know. And really is in your corner for you to succeed.

> Karen (mentee): Someone that you can talk about different things and get decent advice...like you can look up to them. It's like -- it's knowing that it's advice that you can actually follow.

Mentees expressed different but specific aims necessary for successful participation in e-mentoring. Those aims differed as it related to academic and personal advice. Through the growth of the e-mentoring relationship, the mentor became more aware of the needs of the mentee and tailored their advice to match those aims. In recognizing the needs of a mentee, the mentors were able to quickly assess whether their mentoring experiences were effective. While the majority of participants said that they discussed topics connected with major or study habits, they also used the mentoring time to give advice about personal matters. It appears that the mentors in our study often positioned themselves as listeners. One mentor reported:

> Billy (mentor): Generally, a lot of times they just kind of want to vent to me. I'm totally fine with that, and you know when they want to vent, I let them air it all out, and then I just give them a lot of inspiration to keep moving forward. Another mentor talked about finding balance between providing mentoring advice that she thought would be effective for her mentee,

> Katherine (mentor): Whether a professor didn't understand that she was having difficulty, or what her disabilities were, and you know, how to make sure that they knew that she wasn't trying to slack because she had a disability.

Mentors served in the capacities that their mentees identified important for academic and/or developmental needs. Whether it was to be a listening ear or to teach the intricacies of dealing with STEM professors, the mentors were able to assist their mentees with advice that served their mentees' needs. Although the mentor and mentee entered into the dynamic of a mentoring relationship, those roles, at times, were reversed. In one mentoring pair, the mentee took on the position of mentor when the subject of her particular disability entered into conversation. The participant said:

> Mahalia (mentee): She's [Karen] has been open to me coaching her [laughter]. Some things she may suggest to me, you know, I will look at. And especially around assistive technology because that's my forte. I had to...coach her on to how that was going to factor into my success.
>
> Katheryn (mentor): I have learned that I felt like she [Mahalia] challenged me in my perception of disabilities. And my perception of student's difficulty in school. It even encourages me to like, design with all people in mind.

Within this exchange, the mentor and mentee describe how the mentee's abilities and perspectives make the mentor and mentee switch roles. The mentor role appeared fluid during the e-mentoring process as evidenced by a shifting position between the participants. This fluidity is dependent upon who is more knowledgeable about the content of the conversation.

Factors Associated with the Increase of Mentee Persistence in STEM

Motivation, persistence, and engagement are terms defined differently across the literature depending upon a researcher's theoretical perspective. As previously noted, both the project and study emphasize persistence because of its emphasis on measurable progression to graduation or degree completion. Two indices often reported in the literature to measure academic persistence are GPA and degree completion (Markel, 2015). Over the year that the students in this study participated in e-mentoring, their GPA remained stable. One would not expect GPA to change significantly within one academic year. At the end of the e-mentoring data-collection, two of the students (Mahalia and Michelle) had graduated in a STEM major. The other two students (John and Karen) were still completing their coursework and continue to participate in the e-mentoring program. While we consider GPA and graduation rate important markers related to persistence in a STEM major, we were most interested in which specific psychological constructs influenced the students participating in the e-mentoring intervention. The five persistence constructs we explored included: intent to persist, self-determination, self-advocacy, science affect, and math affect. For this subset of students across two semesters, there were pre-to-post gains in self-determination ($p<.23$) and self-advocacy ($p<.27$). These findings may not meet the criteria for statistical significance, due to the small sample and limited terms. As a group, however, the e-mentoring participants in our program consistently demonstrated greatest pre-to-post gains on the self-determination ($p<.01$) and self-advocacy constructs ($p<.001$) while meeting the standards of statistical significance.

Intent to persist. The intent to persist construct was defined as the likelihood to persist by pursuing more education or a career in STEM. Three mentees, Mahalia, John, and Karen, rated themselves low on the intent to persist construct while Michelle rated herself very high on intent to persist. This finding provides support for the need of mentoring as a resource for supporting college students with disabilities engaged in STEM learning environments. One mentee, John, revealed that he was not going to persist in his STEM major, but he still wanted to maintain a connection to the STEM field. John, a student with a learning disability, could not complete the math requirements of his major even with accommodations and e-mentoring. His difficulty with the math requirements might reflect the academic demands of a STEM major, the effectiveness of his accommodations, and critical e-mentoring practices for students with cognitive-based disabilities (Gregg, 2009). Interestingly, despite changing his major, John plans to persist in a career that will still incorporate his interest in STEM. He plans to graduate with a business degree but seek a job in a STEM-related company.

Self-Determination. Self-determination was defined in this study as the ability to act as the primary causal agent in one's life, to set goals, and to make decisions that are unrestricted from undue external influence or interference. On our persistence survey, all the mentees rated themselves very high on self-determination. In addition, all four of the mentees discussed during the interviews about making informed decisions related to their disability, and described how they participate in a world that often does not accommodate individuals with disabilities. Two of the participants reported using accommodation features built into the digital voice and text communication tools that were examples of universal design features providing greater access to learning.

One mentee, Karen, is legally blind. As a nontraditional student who attends a two- year community college, it became critical for her to pursue outside work while still attending school. However, she had great difficulty locating work as a result of discrimination and barriers due to her disability. Both mentor (Lucy) and mentee (Karen) are African American women of approximately the same age. Lucy reports in the monthly surveys that Karen is determined to find suitable work and continue in school with the goal of graduation in a STEM major. Lucy provides a glimpse of Karen's attempt to find work:

> Lucy (September survey): Karen got a lead for a job with Rivers Bank. This has helped her confidence.

> Lucy (October survey): Karen passed her evaluation and will be training to work for Rivers bank next year.

> Lucy (November survey): Karen is excited about the opportunity. She is also reevaluating her career plans and options.

> Lucy (January survey): Karen is back in school and taking courses.

Based on these excerpts, it is clear that Karen is demonstrating many of the persistence constructs we have discussed throughout this article (i.e., intent to persist, self-determination, and self-advocacy) despite stereotype threats and barriers.

Self-Advocacy. Self-advocacy was defined in this study as the ability to effectively communicate, convey, negotiate or assert one's interests, desires, needs, and rights. All four mentees rated themselves as very high on self-advocacy. Mentees often referred to themselves as disability advocates during the interview process. Self-labeling as a disability advocate was instrumental to how mentees viewed themselves and could possibly be attributed to their successful mentoring relationships and persistence in school. During the interviews, participants described how they provide support for another student who shared the same disability.

> Karen (mentee): For me, I feel like I'm a good person to talk to. I don't like dwelling on a problem. I'm more of, 'Okay, we know what the problem is now so let's find a solution to this thing.' So I could be of help to another disabled person. I'm kind of like a blind advocate in a way. So if I did do it I'm sure I would do that one because I feel like that's where I can be the most help.

> Mahalia (mentee): And my interests is to make sure, you know, be a vehicle and an advocate, you know, a peer advocate for users of informational, you know, services.

Both Karen and Mahalia presented themselves as a potential resource for others who need assistance with locating services or advice on how to deal with certain problems. This ability to reflect on what others in similar situations may need could come from their previous experience as mentees. According to survey results and interview data, the participants often expressed a desire to continue in mentoring by becoming a mentor to other students who identified as having a disability and are attempting to attend college. Moving towards advocacy is one way that these students are persisting in their studies as STEM majors.

The interviews revealed that both the mentors and mentees frequently brought up issues surrounding the topic of disability. These discussions about disability could best identified as a discourse of disability (Bakhtin, 1986). While mentees were not obligated to speak in detail about their disabilities with their mentors, the discourse of disability became part of their regular conversations. These conversations happened in various times throughout the course of the relationship.

> Bob (mentee): I knew I was going to be working with, like, individuals who had some kind of disability. I think that he actually told me in his email. Basically when we first started, we had to send letters to each other.

Others decided to wait until the relationship progressed before divulging their disability.

> Katherine (mentor): I wouldn't say that she brings it up freely. I think she's one of those people who likes to not be associated based on her disability. I don't even know if she really addressed it until I finally met her, and then she – afterwards –she started to talk more openly about it.

The constant exposure to students with disabilities and the services they receive are helpful to mentors and how they address these topics with their mentees. In one situation, a mentor also revealed that he had a learning disability, and expressed how this shared experience influenced his mentoring strategies.

> Bob (mentor): I have an accommodation plan for myself. So when they come to me with that paperwork, I know what it's all about. I've been there. I'm going to be the one that says, no, you can't do this.

In another case, a mentor discussed how she worked with the mentee on learning how to ask a teacher to help access an accommodation needed for a class assignment.

Katherine (about Mahalia): Receiving extra time on assignment because she spoke to a teacher about needing accommodation.

In a variety of examples, participants divulged specifics about their disability as the relationship progressed. Once the discourse of disability was introduced, the mentors and mentees exchanged ideas, initiated discussions, and shared personal instances of how their disabilities were reflected in their personal lives.

Science and math affect. Each of the mentees provided a self-report of their affective perceptions of science and math. None of the mentees reported significant anxiety, general confusion and/or uneasiness related to solving math problems despite the fact that John changed majors as a result of difficulty completing a math requirement. Only one mentee (Karen) had a negative perspective on the usefulness of math in her future career. In relation to science anxiety, three of the mentees reported significant anxiety related to performing well in science exams, reported uneasiness when doing science experiments, and described science to not be useful for their career goals. Only Michelle, an African American engineering student, did not report science anxiety and found science useful for her career.

Discussion

Identifying practices to enhance the persistence of underrepresented community college students with disabilities in STEM careers is critical for their success in the workforce. We were interested in one such practice, e-mentoring. A growing literature base is available describing e-mentoring programs and their usefulness in educational, business, human resources, and social environments (Single & Single, 2005). Scholars taking a sociocultural perspective have established a number of basic learning principles relative to the outcomes of our e-mentoring study. First, learning is enhanced when it is embedded in practices such as individuals working together to solve problems during STEM e-mentoring activities. The evidence for this conclusion is robust (NRC, 2012). Second, learning typically depends on interactions with more knowledgeable others (Vygotsky, 1986). This interaction may take the form of explicit apprenticeships or knowledge may be acquired as novices interact with a diverse population of experts and peers, wherein the novices observe the practice of experts and slowly take on tasks over time (Lave & Wenger, 1998). Through our interviews with the STEM mentors and mentees, we observed each of these learning principles.

Investigating the usage patterns of different communication platforms during e-mentoring provides one means of better understanding the specific resources critical for such a practice. Our findings strongly suggest that a variety of social media platforms are easily utilized during e-mentoring. Virtual worlds (e.g., Second Life) require more advanced skills and resources to use successfully during e-mentoring (Edirisingha, Salmon, & Nie, 2009; Gregg, Galyardt & Todd, 2015; Warbuton, 2009). Yet, our e-mentoring island, equipped with mentor lounges, study rooms, auditoriums, and many other STEM resources, often provided opportunities not available on the other platforms. The participants discussed how relationships became richer as mentors and mentees spent time together on the e-mentoring islands. However, the participants increasingly turned to mobile computing platforms to stay connected, with the most commonly-used devices being smartphones. Smartphones provided the students 24/7 Internet access to their course work, libraries, support services, and discipline resources. In addition, students used other features such as instant messaging (IM), e-mail, video, and chat capabilities in and outside of their STEM classrooms.

Race, gender, and disability often have different effects on the ability of individuals to attract mentors (Ragins, 2007). An e-mentoring program provides a means to cross the barriers of demographics and geography. However, the matching of the mentors and mentees is one of the most critical factors for relationships to have successful outcomes (Ensher & Murphy, 2007). The criteria we followed for matching the mentors and mentees was important to the quality and quantity of the mentoring experience. Interestingly, the mentees often took on the role of mentor in relation to discussions surrounding disability access and accommodations. Past experience with mentoring is a strong predictor of an individual seeking future mentoring relationships (Ragins, Cotton, & Miller, 2000). One of the essential outcomes of the study was the recognition that the mentees gained a number of positive benefits during the mentoring, including the development of trusting and supportive relationships. On the mentor surveys all of the participants reported that the e-mentoring experience helped them learn and grow as a STEM student. As a result of their e-mentoring experiences, the mentees in this study might be more willing in the future to seek out opportunities for engaging in e-mentoring programs throughout their STEM academic and work environments.

The five STEM persistence constructs (i.e., intent, self-determination, self-advocacy, and anxiety) we investigated provide support for future research with underrepresented community college students with disabilities, particularly nontraditional age individuals. Interestingly, the students interviewed identified self-determination and self-advocacy skills as strengths for them prior to beginning the e-mentoring program. Such a finding might be the result of participant selection bias as all of the mentees were referred through disability service offices, and all had long histories working with support services where self-advocacy and self-determination is often discussed. However, all the participants reported the greatest pre-to-post gains on the self-advocacy and self-determination constructs of our survey, indicating the e-mentoring experience did influence their growth as a STEM student. There is a significant amount of research documenting that promoting self-determination and self-advocacy has positive academic and career benefits for students with disabilities (Shogren, et al., 2014).

Limitations

As a single-site study drawing upon students from one community college, there may be limits to the generalizability of the research findings. Reliance upon this one site, as well as the limited number of underrepresented students with disabilities who fit the criteria, directly informed our selection of a qualitative research method designed to provide contextually rich data. We note the difficulty in undertaking rigorous studies that include postsecondary students with documented disabilities utilizing randomized controlled or even quasi-experimental designs. We offer these findings as starting point in the hopes that the field-at-large may be able to build upon them and confirm or disconfirm our conclusions about the efficacy of e-mentoring practices.

In addition, we note the study's reliance upon self-report measures collected using an online survey instrument. The lack of real-time measures not dependent on recall, linguistic skill, and interest could have influenced the responses from both mentors and mentees. In addition, the higher ratings of the students on several of the persistence constructs could be a function of the tool and/or issues related to stereotype threats (Inzlicht & Schmader, 2012). The suggestion that over-estimation of academic and social competence is related to ego protection has received attention in the literature and illustrates the correlation between self-efficacy and self-concept (Alvarez & Adelman, 1986). At the same time, however, we stress that e-mentoring is intended to address students' internal characteristics related to persistence rather than STEM content knowledge, and that self-report measures remain appropriate.

Broader Implications

The implications from this research to disability service providers working daily with postsecondary students with disabilities are important findings from the study. From a research standpoint, this study seeks to inform approaches to motivate engagement and persistence in STEM learning for postsecondary students with disabilities, especially those students from other demographically underrepresented groups. From a practitioner standpoint, however, this study also underscores the need to appreciate the mentoring relationship as key to efficacious e-mentoring practices. Prescriptive practices for e-mentoring have placed more emphasis on technology considerations, such as selection of social media tools and virtual platforms. While important, affect and motivation to persist even in the face of physical, linguistic and cognitive challenges are important considerations. However, equally important is recognizing the strong relationship between aspects of persistence (e.g., self-advocacy, self-determination, anxiety) and academic performance.

Finally, the results of this study certainly provide support for the importance of e-mentoring relationships and other similar student virtual support systems for motivating students with disabilities to persist and succeed in academic and career environments. Disability service providers in postsecondary educational settings generally have been concerned with the provision of classroom and testing accommodations. However, e-mentoring programs may create an opportunity to take a more inclusive, holistic approach to student success. Certain accommodations are just that—accommodations—designed for overcoming specific barriers encountered because of a student's disability. However, the broader goal of supported, inclusive learning through the provision of e-mentoring may address barriers to persistence, such as self-advocacy and self-determination, which are no less important. Based on the important findings surrounding self-advocacy and self-determination in this study, postsecondary disability service professionals may want to consider integrating a formal approach to developing self-determination and self/advocacy skills into their service operations. As online learning opportunities increase, student support for virtual learning and social media settings requires on-going change and modification specific to the needs of students with disabilities across STEM disciplines.

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Table 1

Mentorship Pair Descriptive Characteristics

	Mentor	**Mentee**
Pseudonym	Katherine	Mahalia
Gender	F	F
Race	White	Black
Age	29	67
College Major	Assistive technology	Science technology
Pseudonym	Bob	Michelle
Gender	M	F
Race	White	Black
Age	34	38
College Major	Bioengineering	Engineering
Pseudonym	Billy	John
Gender	M	M
Race	Black	White
Age	32	21
College Major	Computer engineer	Electrical engineer
Pseudonym	Lucy	Karen
Gender	F	F
Race	Black	Black
Age	24	27
College Major	Engineering	Science education

Table 2

E-mentoring Communications Tools reported by Mentees

	Digital Voice Tools			Text-based Tools		
	Second Life	Smart Phone	Skype	Text	Email	Facebook
Michelle	√	√	√	-	√	√
John	√	√	√	√	√	-
Karen	-	√	-	√	√	√
Mahalia	√	√	-	√	√	√

Note. Data analyzed from the Mentee Semester Surveys.

Table 3

Number of Mentoring Sessions by Communication Platform

	Digital Voice Tools			Text-Based Tools	
	Second Life	Smart Phone	Skype	Email	Facebook
Michelle	-	-	-	2	13
John	-	-	2	36	-
Karen	-	38	-	-	-
Mahalia	21	13	-	29	-
Total	21	51	2	67	13

Note. Data analyzed from the Mentor Semester Surveys.