A qualitative investigation of factors promoting the retention and persistence of students of color in STEM

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A Qualitative Investigation of Factors Promoting the Retention and Persistence of Students of Color in STEM

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The literature on science, technology, engineering, and mathematics (STEM) is abounding with the importance of increasing college access, retention, and persistence among students because of implications for America’s global competitiveness. Particular emphasis has been placed on college students of color who remain underrepresented in STEM education. Therefore, increasing college access, retention, and persistence for students of color in STEM is not merely a matter of United States’ economic competitiveness, but also a matter of equity. Using in-depth interview methods, this article delineates factors facilitating the retention and persistence of students of color in STEM education at a predominantly White institution. Implications for institutional practice and research are provided.

Keywords: STEM, students of success, academic success, minority scholars

Various reports, researchers, policymakers, and national leaders have expressed the importance of the United States increasing its production of workers skilled in science, technology, engineering, and mathematics (STEM) to be competitive in the global economy (Dancy, 2010; Fries-Britt, Younger, & Hall, 2010; Guess, 2008; Moore, 2006; Museus, Palmer, Davis, & Maramba, 2011; Öztürk, 2007; Palmer, Davis, Moore, & Hilton, 2010; Palmer, Davis, & Thompson, 2010). With its current rate of workers skilled in the STEM field, the U.S. may not be able to compete with other countries in the global marketplace (Öztürk, 2007).

According to the Organisation for Economic Co-operation and Development (OECD), many OECD member countries have experienced significant growth in the number of researchers, (an indication of skilled workers in STEM), even surpassing the U.S. For example, while the number of researchers increased in OECD countries by 23.0% from 1993 to 1997, researchers in the U.S. increased only 11.8% (National Science Foundation, NSF, 2003). Furthermore, thirteen countries currently outrank the U.S. in the ratio of students who receive their first degree in natural science and engineering (NSF, 2003). Degree attainment in science and engineering fields among students in the U.S. has dropped in many areas of the physical sciences, engineering, mathematics, and computer science at the undergraduate and graduate level (NSF, 2003).

Given the need to increasing its production of STEM workers, America must focus on increasing college access, retention, and persistence among traditionally underrepresented groups (e.g., Black, Hispanic, Native American, and Southeast Asian American) pursuing STEM education in college (Dancy, 2010; Museus et al., 2011; Perna et al., 2009). According to another report by NSF (2010), despite some progress, students of color continue to experience problems accessing higher education and persisting to graduation (Maramba, 2008; Museus, 2008; Palmer, Davis, & Hilton, 2009; Strayhorn, 2008) especially in STEM (Moore, 2006; Museus et al., 2011; Öztürk, 2007). For example, between 1995 and 2007, the proportion of science and engineering degrees awarded to Asian Pacific Islanders, Blacks, Hispanics, and Native Americans increased from 8% to 9%, 7% to 8%, 6% to 8%, and 0.5% to 0.7%, respectively (NSF, 2010).

Nonetheless, Blacks and Hispanics are particularly underrepresented in relation to their proportion in the total population (NSF, 2010). Moreover, while the “Model Minority Myth,”
which espouses a perception that Asian Americans are academically talented and hardworking compared to other populations of group, promulgates the assumption that Asian Americans are overrepresented in higher education (Maramba, 2008; Museus, 2008; Palmer, 2010), particularly in STEM education (Hurtado, Cabrera, Lin, Arellano, & Espinosa, 2009), within-group disparities in college enrollment and persistence are noticeable among subgroups, especially Southeast Asian Americans (e.g., Vietnamese, Laotian, Cambodian, and Hmong) in STEM (Museus et al., 2011).

U.S. Census Bureau (2008) projections have Black, Hispanic, Asian, and Native American populations expected to grow rapidly over the next few decades. In fact, those populations will comprise approximately 50% of the total U.S. population by 2050. Given this projected growth, it is imperative that the U.S. place a concerted effort on increasing college enrollment, retention, and persistence of students of color in STEM education (Hurtado et al., 2008; Museus et al., 2011). Notwithstanding, the success of students of color in STEM education is a moral and ethical imperative (Museus et al., in press).

This study examined salient factors of retention and persistence among college students of color enrolled in STEM education at a predominantly White institution (PWI). While many researchers (e.g., Chang, Cerna, Han, & Sàenz, 2008; Cole & Espinoza, 2008; Hurtado et al., 2007, 2008; Leslie, McClure, & Oaxaca, 1998; Simpson, 2000) have used quantitative methods to examine success factors for students of color in STEM education, this study employs qualitative methods. Qualitative studies provide a richness and depth often missed by quantitative studies (Charmaz, 2000). Therefore, the study’s findings may inform research on STEM students’ as well as the practices of college personnel who serve such students.

**REVIEW OF LITERATURE**

Research has shown that supportive educational environments during college are positively linked to retention and persistence for students of color in STEM education (Bonous-Hammarth, 2000; Cole & Espinoza, 2008; Fries-Britt et al., 2010; Gloria & Kurpius, 2001; Grandy, 1998; Hurtado et al., 2007; Leslie et al., 1998). More specifically, support for students of color include role models of color, knowledge and lesson sharing from advanced students of similar ethnic groups, and relationships with staff of color. Furthermore, support that students of color receive from peers, mentors, and faculty are critical to success in STEM education (Bonous-Hammarth, 2000; Fries-Britt et al., 2010; Grandy, 1998; Hurtado et al., 2007; Seymour & Hewitt, 1997). In particular, Bonous-Hammarth (2000) explained that students of color, who receive mentoring during high school and college, are more likely to succeed in STEM education during college. Nonetheless, Grandy (1998) emphasized that the support students of color receive from faculty may have little impact on their grades, but it is positively related to their commitment to STEM education.

Summer pre-college programs have been found to enhance the retention and persistence of students of color in STEM education. According to Palmer and colleagues (2010), the Pre-Accelerated Curriculum in Engineering (PACE, http://ess.eng.morgan.edu/prospectivestudents/pre_freshman_programs/pace/html) program, a six-week intensive pre-college summer program at Morgan State University, exposes engineering students to critical thinking skills, advanced mathematics courses, English courses, mandatory tutorial support, and research/training. PACE introduces students to the engineering curriculum and facilitates engagement with engineering undergraduate students and faculty. The engineering program also provides students with peer tutoring/mentoring. Accordingly, upper-class students assist faculty in providing freshmen and sophomores with the academic support to help them develop the self-efficacy and academic skills required to successfully complete the engineering courses. Research has shown that this program is correlated with increased persistence for STEM students (Palmer et al., 2010).

Similarly, the Pre-Freshmen Academic Enrichment Program at the University of Maryland, College Park (Ternes, 2001) had higher retention and graduation rates for science majors of color compared to non-participants (Museus et al., 2011; Perna et al., 2009). Additionally, the Meyerhoff Scholars Program at the University of Maryland, Baltimore County (www.umbc.edu/meyerhoff)
has enjoyed notoriety because of its ability to diversify the STEM pipeline (Maton, Hrabowski, & Schmitt, 2000; Museus, 2008). Specifically, participants who engaged in Meyerhoff have achieved higher grade point averages and earned admissions into graduate programs at higher rates than non-participants (Perna et al., 2009).

Another factor promoting the retention and persistence of students of color in STEM education is participating in research experiences as undergraduates (Barlow & Villarejo, 2004; Hurtado et al., 2008). The literature is replete with the benefits of students of color engaging in research and its impact on their success in STEM education. For example, not only does participating in research help attract and retain students in science, but it also enhances the educational experiences of undergraduate students, and serves as a linchpin to careers in science. Moreover, undergraduate students engaging in research have been shown to enhance knowledge and understanding of STEM disciplines, have greater contact with faculty, foster problem-solving, technical and presentation skills, facilitate self-confidence, and provide greater insight and clarification of career goals (Carter, 2002; Hurtado, et al., 2008; Kardash, 2000; Lopatto, 2003, 2004; Mabrouk & Peters, 2000).

Some research has shown that there is a small, but negative relationship between retention and persistence for students in STEM and advisors (Cole & Espinoza, 2008). Specifically, Grandy (1998) reported that because students had contact with advisors who were more knowledgeable in fields outside of science and engineering, they may be more inclined to switch to another major they perceive as enhancing their ability to contribute to society. Moreover, Bonous-Hammarth (2000) found that active involvement on campus outside of STEM related activities can have a negative impact on persistence for students of color. Involvement of this sort can impinge upon students’ ability to engage fully in their disciplines. Additionally, the availability for financial aid can be a hindrance or facilitator of persistence for all students (Palmer et al., 2009), specifically, students in STEM (Fenske, Porter, & DuBrock, 2000). According to Fenske and associates, “The National Action Council for Minorities in Engineering states the availability of adequate financial aid resources is among the top five factors related to minority persistence in Engineering” (p. 69).

Furthermore, while minority serving institutions (e.g., historically Black college and universities (HBCUs) and Hispanic serving institutions, Hurtado et al., 2009; Perna et al., 2009) have been found to facilitate persistence for students of color in STEM education, the ‘chilly campus climate’ of PWIs, specifically in the classroom, has been linked to attrition for students of color in STEM (Cabrera, Colbeck, & Terenzini, 2001). Specifically, Cabrera and colleagues explained that

a classroom . . . permeated by prejudice . . . on the part of faculty and peers has emerged as [a] . . . factor accounting for differences in college adjustment, majoring in hard science, and persisting in college between White men, women, and minority students. (p. 334)

**METHODOLOGY**

The authors conducted this study at a public, mid-size research intensive PWI, located in the northeast region of the United States. Approximately 12,000 students were enrolled when data were collected. Forty-five percent of students enrolled at this institution are White, and their Asian, Black, Hispanic, and their racially/ethnically unknown counterparts comprise 13%, 6%, 7%, and 22%, respectively. Approximately 46% of White students matriculating at this institution complete a baccalaureate degree within 6 years, while that figure is 13% for Asian, 9% for Black and Latina/o students, and 25% for racially/ethnicity unknown students.

Using in-depth interview methods, the authors sought to explore the academic and social experiences of a particular group of students situated in a particular context (Lincoln, 2002). Therefore, the study’s epistemological approach was anchored in the constructivist tradition to construct knowledge, understanding, and meaning through human interactions (Lincoln, 2002). To some extent, grounded theory strategies were incorporated into the research process. These strategies were not confined to the interview process, but rather occurred throughout the entire
research process. Specifically, strategies of continuously asking questions, using research notes, exploring hunches, making constant comparative analysis, and memo writing were employed (Charmaz, 2000).

**Participants**

With the help of university administrators, the authors recruited students of color who majored in STEM, specifically, focusing on juniors and seniors who had attained a grade point average (GPA) of 2.5 or above. Additional participants were recruited through snowball sampling. Snowball sampling is the process of asking those who have participated in the study to refer others who meet the study’s criteria (Creswell, 2003). The authors focused on upperclassmen students because they would be more in-depth about factors promoting their success in STEM. It is important to note that this is an on-going study. Thus far, 6 students whose experiences will be shared in this current study were recruited. Table 1 provides details about the participants. Pseudonyms were used to maintain the anonymity and confidentiality of each participant.

<table>
<thead>
<tr>
<th>Name (pseudonym)</th>
<th>Age</th>
<th>Classification</th>
<th>Major</th>
<th>GPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kevin</td>
<td>21</td>
<td>Senior</td>
<td>Bioengineering</td>
<td>3.1</td>
</tr>
<tr>
<td>Catherine</td>
<td>20</td>
<td>Junior</td>
<td>Biology</td>
<td>3.3</td>
</tr>
<tr>
<td>Darrell</td>
<td>21</td>
<td>Senior</td>
<td>Biology</td>
<td>3.5</td>
</tr>
<tr>
<td>Kelly</td>
<td>21</td>
<td>Senior</td>
<td>Psychobiology</td>
<td>3.9</td>
</tr>
<tr>
<td>Larry</td>
<td>21</td>
<td>Senior</td>
<td>Computer Science</td>
<td>3.5</td>
</tr>
<tr>
<td>Tiffany</td>
<td>21</td>
<td>Senior</td>
<td>Psychobiology</td>
<td>3.8</td>
</tr>
</tbody>
</table>

The sample consisted of one junior and five seniors. Specifically, the study included three Black males and three Southeast Asian females. Their majors ranged from biology to computer science. The average participant age was 21 years and the average GPA was 3.5.

**Data Collection**

One face-to-face, in-depth interview was conducted, which ranged from 90 to 110 minutes with each participant. As an incentive and recruitment method, all participants received a $10 gift certificate for their participation. Prior to beginning these interviews, participants signed a consent form, completed an open-ended questionnaire, and completed a demographic form. During interviews, the participants were asked about their academic and social experiences as they relate to STEM at the institution. The authors recorded observations regarding the ways in which participants responded to questions and their willingness to engage in the interview. Follow-up telephone interviews were also conducted with participants to ask them to elaborate on themes discussed or clarify issues that emerged during the interviews. All interviews were audio-taped and transcribed verbatim.

**Data Analyses**

The authors used constant comparative analysis on research notes, observations, and interview transcripts to identify recurring or unique topics (Strauss & Corbin, 1998). According to Jones, Torres, and Arminio (2006), constant comparative analysis engages the researcher in a process of collecting and analyzing the data simultaneously at “all stages of the data collection and
interpretation process, and results in the identification of codes” (p. 44). Specifically, as the data were collected and transcribed, the authors read through the research notes and made self-reflective notes in the margins to help form initial themes. These notes included questions and speculations about the data and themes that emerged. As the data became increasingly voluminous, ATLAS-ti (5.0), a qualitative data management software program was used, to organize, manage, and code the data. The authors used open coding, which involved analyzing the data line by line, to identify themes. The line by line coding allowed for themes to emerge from the data and become aggregated into response patterns (Strauss & Corbin, 1998). This process continued until the data reached a point of saturation—which is when it becomes redundant (Bogdan & Biklen, 1998). Furthermore, memo writing allows one to not only refine the categories, but also to understand the relationships among them. In discussing the findings, excerpts are presented from the participants’ responses verbatim to preserve the essence of the participants’ voices.

**Credibility and trustworthiness.** Several techniques were employed presented by Merriam (1998) to ensure credibility of the study. For example, the authors provided “thick description” so others interested can draw their own conclusions from the data. Moreover, providing thick description enables the reader to vicariously experience the participants’ social reality at the institution.

To ensure the data’s trustworthiness, member checks were conducted by returning the transcribed interviews to all participants so that they could review them for accuracy and clarity following the interviews (Jones et al., 2006). Specifically, participants were invited to add, delete, or otherwise comment on the transcriptions. Their feedback was used to enhance the integrity and preserve the authenticity of the participants’ voices. Lastly, these authors used feedback from five peer-debriefers, who held expertise in qualitative methods and are researchers on students of color in STEM, to ensure credibility. Debriefers were provided with raw transcripts from each participant. These debriefers engaged the researchers in a series of on-going discussions about the tentative meanings made of the participants’ experiences throughout the research process (Jones et al., 2006).

**Limitations.** Several limitations in this study are readily apparent. First, this study was conducted at one PWI with a small sample size. However, the authors provided thick descriptions so others can decide the transferability of this study to their institutions. Furthermore, interviews may not be an effective way to collect reliable information when the questions pertain to matters the participants perceive as personally sensitive. Notwithstanding, the authors proceeded with this approach because researchers (e.g., Guiffrida, 2004; Kuh & Love, 2000) explained the importance of qualitative inquiry when investigating the experiences of students of color. Finally, the accuracy of the findings is contingent upon how well the data were analyzed, although this is true for all research studies.

**FINDINGS**

In this section, three main themes are summarized, which emerged from the interviews: (a) peer group support, (b) involvement in STEM related activities, and (c) strong high school preparation. The first theme includes participants’ descriptions of the value of peer group support and the positive influence peers have on academic success. The second theme explores the importance of involvement in STEM oriented activities on and off campus. In addition, their involvement in these specialized activities helped them expand their understanding of the STEM professions and opportunities. The third theme discusses the participants’ strong preparation in high school with science courses and the high expectations that their high school teachers placed on them. In the following section, themes are delineated and quotes from participants are presented to preserve the essential aspects of their experiences.
Peer Group Support

The participants spoke in-depth about the peer support they received in college. All of the participants mentioned that it was important to have peers who had the same goal of doing well and supporting each other in their STEM major. Peer support was described in two different ways: (a) served as support for their academic work and (b) provided a positive social network.

First, all of the participants discussed the importance of peer support groups and their positive connection to academic success. In particular, participants mentioned that studying together helped them comprehend and retain class material more effectively. Because much of the coursework involved complex equations and vast amounts of memorization, such groups helped tremendously in their pursuit to do well in their classes. For example, Catherine, a 20-year-old junior, biology major, whose goal was to apply to medical school, shared that her study group helped explain course concepts that she did not understand in lecture and helped with putting together everyone’s ideas to understand a concept. She added that her peer support group also reaffirmed class material in which she already had a firm grasp. Specifically, she shared the following:

Group studying helps out a lot. For example, when there is a concept I thought I understood, but it turns out I really didn’t, someone in the group ends up explaining it better for me. And sometimes you think you know something and three people in your study group have a different idea about it. Then, you just put all the ideas out there and you just try to piece it together to see what makes sense.

All the students talked about the intense pressure to do well on exams. Studying in peer groups helped alleviate the pressure because it gave students confidence in taking the exams. For example, Tiffany, a 21-year-old senior, psychobiology major, explained that studying in a group allowed her to feel self-assured when she took exams. It also helped her study material that she would have never considered as important had it not been for her study group. She noted:

you know in a study group, they bring out stuff that you never even thought about and then it ends up on the exam . . . then you’re just like, “Yes, thank goodness that person studied that or else I never would have realized.” So some groups really help a lot and I feel good about it. I guess peers are very important when it comes to really helping each other out especially in STEM.

The students discussed the importance of having their peer support group consist of students in similar classes who are also goal-oriented. For example, Kelly, a 21-year-old senior, psychobiology major, shared that having the same classes with a group of students helped because she could then study with them. She said that because some students in the class had the same goal as her of keeping up with the work and doing well, study groups helped because they could also teach each student to understand the material better. Specifically, she stated:

Because they’re in your class, you’ll know in your discussions, it makes things a lot easier because you know if you don’t understand something maybe they’ll know it . . . I feel like teaching someone else really helps you with learning the topic better . . . me and my friend have the same classes together because we’re both bio majors so I tell him about assignment deadlines and that stimulates him to be like, “we have a quiz coming up, so do you want to get together to study?” And that really helps. It sort of keeps me in check and I keep him in check.

Kevin, a 21-year-old senior, bioengineering major, agreed with the other participants about peer interaction and its relationship to studying. In fact, Kevin explained that as a student of color in STEM, he believed that studying in peer group is extremely important. He also mentioned the value of the social aspect of studying together. He shared that he was saddened to see a number of students of color in his classes at the beginning of his first year and by the end of his first year he observed that more than one-half dropped out or changed to non-STEM majors. He believed that study groups help students manage the large amounts of material they must retain. He mentioned...
that study groups are important in retaining students in STEM majors and he valued the social aspect of studying together. As such, he explained:

Forming study groups for students of color in STEM can actually [help them] understand how much they should be studying. You go to class everyday and you realize a test is coming up, but you don’t realize the sheer volume of information that is going to be tested in the intro to bio and intro chemistry courses. Having more study groups that’s going to intensify studying [is important]. Somehow it also combines social aspects [too].

Similar to other students, Larry, a 21-year-old senior, computer science major, shared that he owed much of his success to his supportive friends, who helped him get through his classes. During his freshman year, Larry felt intimidated and felt “like I was behind, didn’t fit in . . . like everyone knew so much . . . it wasn’t easy for me to meet people to study with.” He mentioned that he studied with the few students of color in his classes, which allowed him to feel more comfortable in his computer science major. Larry explained that the ethnic makeup of his study group was Chinese, Black, Hispanic, and Native American students. He said that they are “almost like family, so we kind of built a family atmosphere you know. I kind of surrounded myself with the same people throughout college.” Upon reflection, Larry believed that the support kept him going and that they were “all born in a position to graduate.” Currently, his friends, including himself, all have job offers. This student also discussed how he and his support group helped each other. There were times where he just wanted to go home after group meetings but instead, he stayed in the library to get more work done. “I learned a lot from them and about the kind of work ethic it really takes [to succeed].”

**Involvement in STEM-related Activities**

The second theme was the value that the participants placed on being involved in STEM-related activities. Being involved in extracurricular activities gave students a chance to extend their science knowledge to practical knowledge. Extracurricular activities included involvement in STEM student organizations, being a teaching assistant, participating in STEM summer programs, and interacting with alumni and those currently in STEM professional fields. All the students felt that these activities complemented their STEM courses. For example, Kevin described his experience in a summer research fellowship program. He believed that being a participant in the program served as a turning point for him. Before he entered the summer program, he was feeling discouraged because of the pressure of demanding chemistry and physics classes and studying for the Medical College Admission Tests (MCATs). After his summer experience, he felt the program positively reinforced his decision to be in the science field. He was excited to have hands-on experience such as taking part in surgeries, interacting with medical residents, and conducting rounds with them. He shared:

I had a chance to work with residents everyday and see patients and it kind of showed me the light at the end of the tunnel . . . so I knew that this is what I wanted to do and I became even more focused . . . My doctor [with whom he did rounds] was a neurologist. He would take me on rounds . . . and I got to see a lot of patients and a lot of different cases.

Participants also stressed how being involved in lab experiments was enjoyable and helped them learn about hands on research. Darrell, a 21-year-old senior, biology major, for example shared that his research lab gave him another perspective on how to effectively investigate experiments similar to that of a principal researcher. He believed he gained valuable experience that would help him successfully apply for medical school. Specifically, he noted:

My independent research lab . . . that’s what absolutely opened my eyes to the field of research. What I took away from that was just how important research is and exactly why med schools are looking for
research experience. Not just because they want you to contribute to the field of research but it is more about being a doctor. You have to have that investigator’s mind to figure out problems like a principal investigator of a research lab.

The participants’ involvement in student organizations was also important, particularly pre-med or pre-health ethnic minority-oriented groups. These organizations not only provided more information about opportunities available to enhance the participants STEM experience but also engaged them in leadership roles. Some of the students held leadership positions in these organizations, which allowed them to gain skills valuable toward achieving their future goals. For other students, these student organizations provided information that would not normally be presented in their courses. For example, Darrell discussed a number of benefits students received from their involvement: “We got to attend a national medical association conference, network with doctors, and did clinical workshops.” Moreover, Catherine, who was the secretary of the pre-health society, felt her involvement reinforced her decision to become a doctor. She also shared that her experience expanded her understanding of medical school admissions process and meeting current medical students:

Right now I’m the secretary [of a pre-health ethnic organization]. One of the things I got involved with [help planning] was a conference in New York City. We got to meet medical school admissions and people from various other medical schools, you get to meet med students and get all these freebies. It was a lot of fun and I think that really, you know, propelled my career in medicine. I met all the students there and discuss a lot of different things like careers in health care, health care disparities.

These pre-health, pre-med organizations also increased students’ awareness of other STEM career options. For example, Tiffany shared her positive experience of getting involved in these types of organizations and expanding her career options in STEM:

I went to a general interest meeting and [they talked about] options if you get rejected from medical school. That’s why I began to look into optometry school because besides medical school I can have that option as a Plan B . . . I didn’t think about optometry school before then.

A few other students, however, did not get involved in extracurricular activities their first year because they felt that it might deter them from focusing on their courses. For example, Kevin admitted that he did not join any activities during his freshman year because he felt he just needed to “do his homework.” But he soon realized that joining a club might make him feel more comfortable with his major, therefore, he joined the National Society of Black Engineers (NSBE). He described that he felt he “could go there and people are willing to outreach to me, people want to hear what I have to say . . . and I didn’t ‘stick out.’” Being part of NSBE felt like he could “be himself” and provided a high level of comfort in the university that he did not have before joining the student organization.

**Strong High School Preparation**

All of the participants discussed the strong preparation they had in high school. They described both their participation in advanced science classes and the teachers who invested time to encourage them to pursue science-related fields. Others shared their involvement with high school programs that exposed them to health and medical disciplines. Still, others had parents who moved in order for their children to attend a science intensive high school. The following are some of the students’ descriptions of their intensive preparation for college in their high school years. Specifically, Larry shared:

We had a lot of AP courses. I would say [they had] goals to prepare you for college and I remember my AP high school teachers always saying “Well in college you’re going to have this amount of work so you’d better deal with it now.” In a sense it did help because I know my AP psych teacher made these
really extensive outlines of chapters. In a sense, it prepared me ‘cause the AP courses were a lot harder than regular high school courses.

Furthermore, Darrell shared that his mother moved the family because she wanted him and his brother to attend a “very good high school” that eventually prepared him well for college. This high school offered courses that allowed him to build a firm foundation for his science courses he would later take in college. He shared the following:

I think it [high school] prepared me very well. . . . In physics, I think I did really well because I had a really amazing physics teacher in high school, same in biology. . . . It [basic concepts] helped build upon it much faster than my other [college] classmates who maybe didn’t have a good physics or biology background . . . so that [AP classes] helped me when I came to the university.

In addition to Larry and Darrell, Kelly spoke of the various college preparation activities and programs that she attended during high school. She reflected on a discussion she had with a college student who gave her valuable advice about college study tips. She proudly shared that she continues to apply his advice to her current study regimen. She also described her experience in her high school that heavily emphasized college preparation:

I remember a lot of times there would be someone from some school or program that came into classes and would discuss interviewing techniques, how to write a college essay. So I would say that my high school was so focused on getting us into college . . . I met a med school student at a high school program. He said when he first got to college he shared that he thought that he can just have the weekend to study and he ended up getting a “D” on the exam . . . and I was like that’s not going to be me. He said the next time he used two weeks to study and got an “A.” So [I said to myself] two weeks before is a good time to study. When I went into college, that’s what I used and still use it now. It helped a lot. It keeps you from cramming.

Additionally, students spoke of particular teachers who encouraged them to prepare well for the future and what careers they might consider. For example, Darrell described his discussions with his law teacher in high school and how she helped him decide to get into the medical field. He shared:

I knew when I was in high school that I wanted to be a doctor or a lawyer after talking with my practical law teacher. She had her law degree from a really good law school and she passed the bar. [Through our discussions], I decided that I wanted to do something where I was going to be helping someone every day, so I chose medicine.

Students also discussed their extracurricular high school involvement that prepared them for science related fields. Some of these activities included volunteering at hospitals or participating in medical school career recruitment programs. These activities helped to reinforce their decision to enter health and medical related careers. For example, Tiffany engaged in an activity at Cornell Medical School. Her participation helped in her decision to pursue medicine as a career.

In high school, I participated in a program at Cornell Medical School. It was the health career recruitment and education, exposure program. They showed their gross anatomy lab and what it’s like to be a med student. Then they guide us into the whole college application process. It was like a mentoring program and that’s how I got interested.

Students also shared their positive experiences with guidance counselors at their high school. Although these counselors did not necessarily assist with academic concerns, guidance counselors helped facilitate the preparation for those who wanted to be STEM majors. Students mentioned that they met with these counselors on a regular basis. This sentiment was shared by a number of the participants. For example, students mentioned that because they were in honors classes, they had
counselors who made sure that they were on the college track, more specifically the STEM track. As Larry shared, “If you were lucky enough to be in the honors classes and have a good guidance counselor, like mine, she was helpful, approachable and always willing to talk and help you with anything.”

**DISCUSSION AND IMPLICATIONS**

In conducting this study, the authors sought to improve the understanding of factors that promote the retention, persistence, and success among college students of color pursuing degrees in STEM fields. The students who participated in this study identified pre-college academic outcomes and social experiences pertaining to their STEM fields of choice. These experiences centered more specifically on solid academic preparation in high school and additional formative experiences provided by peer engagement and participation in STEM-related activities. This study was advanced by analyzing interview data on secondary education preparation, personal and educational factors that both support and challenge desired academic outcomes, and collegiate opportunities to further foster the development study participants identified.

This study yielded three themes. First, the results indicate that peer support matters to participants’ success in critical ways both academic and social. With respect to academic engagement, participants likely mastered course content when lessons were reinforced in peer groups. The groups fostered safe, engaging climates for asking questions that participants did not, or were reticent to, ask during class. Participants also identified peer groups as providing healthy balance in a world where academic performance anxieties are normalized as participants feel pressured to master material to achieve educational and career-related goals. Participants also noted social benefits involved with peer group support among STEM students. Social benefits largely involved encouragement and motivation which participants felt was important to their constructions of self-efficacy and reinforced decisions to pursue STEM majors.

Second, study results showed that participants value involvement in STEM-related activities. Accordingly, these students suggest that college student affairs has an important role to play in facilitating this involvement given emphasis participants placed on STEM-related student organizations on campus (e.g. Pre-med club, Biology club). Out-of-class engagement in these ways promotes community among like-minded students as well as communication skills which hold practical relevance to students’ STEM-related goals. Similarly, practical experiences during matriculation were salient to how study participants’ made meaning of themselves as students of color in STEM.

One way practical experiences mattered involves if and how academic programs connected philosophical foundations of the STEM fields to practice. According to participants, these experiences showed great promise in expanding their purview of the field and career options. Also, study participants felt that practical experiences around their STEM majors improved their senses of self-efficacy. Therefore, colleges and universities were in a valuable position to shape participants’ understandings of whom and what they can become professionally. Pairing academic work with a range of practical and extracurricular experiences (e.g. site visits/field trips, guest speakers, speaker panels, practicum experiences, internships) gives these students a more well-rounded experience in their academic programs. In addition, study data suggest that colleges and universities needed to meaningfully situate all STEM experiences in the broader career trajectory of these students. In other words, practical experiences are not only important for fulfilling course and major requirements, but are also valuable for building a future in students’ fields and knowledge of selves as professionals.

Third, participants indicated that retention and success in STEM is connected to elementary and secondary preparation. Accordingly, students of color credited their success to the strong academic preparation that they received in K-12 educational contexts. Furthermore, these students were exposed to school activities which only served to increase their awareness about STEM fields and how success in STEM subjects in schools matter for postsecondary and career success.
Colleges and universities have opportunities to team with schools in developing STEM pipelines which are not only important for enrollment but retention. Successful programs exist at universities including, The University of Michigan, Rochester Institute of Technology, University of Arizona, and New Jersey Institute of Technology. Many of these programs embed summer enrichment components, skill-building workshops, and tutoring programs.

Study participants remind colleges and universities that they must focus beyond enrollment and on issues of retention and graduation of students of color enrolled in STEM majors. Participants’ statements about their experiences as STEM majors in college align in many ways with STEM majors in college generally. Specifically, study data support that these students require proactive student support services (e.g. tutoring, peer networks) and creative experiences to retain and succeed in STEM majors. Students’ words suggested that senior-level administrators must express commitment to not only recruitment but also retention of students of color in STEM. Subsequently, they must support accountability-based plans of assessment and action. These devices are possible, and according to participants, colleges and universities are in position to build confidence, particularly among students of color in STEM majors.

The participants in this study would benefit if colleges and universities attempted to deconstruct climates of intimidation in which study participants felt their confidence in their abilities is challenged. Study participants suggest that these climates are fostered by complex and rigorous content, competition among students, and pressures to show they belong in the majors they declared. Faculty are encouraged to develop inclusive pedagogies which acknowledge for the different ways in which students learn and also help disrupt student feelings of intimidation (Fries-Britt et al., 2010). Similar efforts are also required in K-12 contexts in which these students began preparation for successful STEM careers. The data also suggest additional efforts colleges and universities may develop toward engaging students of color in STEM.

Finally, the students in this study would feel more engaged in STEM programs that fostered a sense of community among faculty, students, STEM alumni, and professionals in STEM fields. The students of color in this study felt validated within a community that affirmed their presence and abilities to succeed in fields they select. Personal, social, and academic supports were embedded in peer groups and in the work of mentors or advisers who helped move students through the pipeline. Although this study found factors, additional areas for research are apparent.

While the study described is qualitative in scope, large scale studies of students of color in STEM fields are also required to present a generalizable picture of students’ experiences. All studies, whether quantitative or qualitative, should investigate successful pipeline programs in STEM that effectively transition students of color from secondary to postsecondary contexts. In addition, empirical study is needed on student background, particularly on how families and communities influence students’ attitudes toward pursuing STEM fields.

**CONCLUSION**

College access and success among students of color in STEM is critically important to the nation’s economic competitiveness in the global economy as well as higher education equity agendas. These agendas require attention to the severe underrepresentation of students of color in higher education, specifically STEM fields. This article has discussed factors critical to the success of students of color in STEM at a PWI and provided recommendations for institutional practice and future research. While this article is predicated on one PWI with a modest sample size, institutional leaders, policymakers, and student affairs practitioners may find the recommendations significant in supporting access, retention, and persistence among students of color in STEM disciplines.

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