Research Environments as Counterspaces? Examining Spaces that Inhibit and Support Science Identity Development for Black Students in STEM

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Using data generated from semi-structured interviews, the present study explored the experiences of 23 Black collegians and recent baccalaureate recipients who participated in a structured undergraduate research program, as part of a science, technology, engineering, and mathematics (STEM) enrichment program. Specifically, this study investigated how Black collegians described their undergraduate research environments compared to traditional STEM classroom environments. While their research environments were engaging and confirmatory of their decisions to pursue a STEM degree, the STEM classroom environments exposed students to racial microaggressions and a need to prove their intellectual worth. Findings suggest that undergraduate research environments may provide necessary counterspaces for science identity amidst racist and hegemonic academic environments.

Keywords: counterspaces, Blacks, STEM

Current changes in undergraduate enrollment depict the growth and shifts in demographics of the U.S. college-age population (National Science Foundation [NSF], 2013). Although underrepresented minorities are less likely to attend college or graduate, they have a steadily increasing presence in higher education (NSF, 2013). Additionally, despite the numerous efforts geared towards addressing STEM degree attainment among Blacks in the United States, their graduation rates have remained stagnant or continue to decline in many disciplines (NAS, 2010). For instance, in 2006, African Americans garnered 5% of engineering degrees while representing 12% of the total U.S. population (NSF, 2008). Throughout the STEM disciplines, Black students graduate in small proportions compared to White and Asian American students. Black students lag behind their White and Asian American counterparts. For example, Pryor and colleagues (2009) reported wide gaps in the four and five year STEM completion rates. Whites and Asian Americans who started as STEM majors have a four-year completion rate of 24.5% and 32.4% respectively and African Americans are 13.2%. Five-year graduation rates of Whites and Asian Americans are 33% and 42% respectively with only 18.4% of African Americans earning degrees within the same time period (Pryor, Hurtado, DeAngelo, Palucki Blake, & Tran, 2010). These trends suggest the need to understand the experiences of Black students in the STEM disciplines, including factors that inhibit or support their retention and persistence.

There are a growing number of studies identifying the importance of undergraduate research involvement in strengthening science identities and commitment to and persistence within STEM disciplines for students of color (Carter, Mandell, & Maton, 2009; Jones, Barlow, & Villarejo, 2010). Some researchers suggest establishing a science identity may be more important for students of color than their White and Asian counterparts (Hurtado, Cabrera, Lin, Arellano, & Espinosa, 2009). In a study with urban youth of color who were instructed to draw images of scientists, their pictures often resembled White, nerdy, male caricatures with white lab coats (Shannon, 2010). If students experience incongruence with a certain professional identity, they may be more likely to leave the major (McGee, 2009; Seymour & Hewitt, 1997). In addition to identity complications, attrition rates of Black students are often exacerbated by negative interactions and poor faculty and peer dynamics within classroom settings (Seymour & Hewitt, 1997; Strayhorn, 2012). Thus, exploring the role of various curricular and co-curricular spaces within the collegiate environment may provide insight concerning factors that support science identity development and increased retention, persistence, and graduation rates among Black collegians in STEM. Recent scholarship suggests more empirical research is needed in this area (McGhee & Martin, 2013). Further, the purpose of the current study was to understand how classroom and undergraduate research environments influenced science identity development among 23 Black students at a large, public, predominantly White institution (PWI).

Literature Review

There are number of context-specific factors that can shape how Black students develop their science identities: teaching and learning practices, faculty and student interactions, peer dynamics, institutional and departmental climate, programs, services, and co-curricular opportunities (e.g., undergraduate research) (Carlone & Johnson, 2007; Eagan et al., 2013; Hurtado, et al., 2011; Ong, Wright, Espinosa, & Orfield, 2011; Strayhorn, 2012). Due to the constraints of this article, two different spaces (and subsequent factors) that can influence identity development will be discussed: (a) STEM classroom environments, and (b) undergraduate research environments.

Experiences within STEM Classroom Environments

Many Black STEM majors at PWIs must negotiate a disciplinary culture that may be inconsistent with their personal norms and values of collaboration and cooperation (Seymour & Hewitt, 1997). This system is often referred to as the culture of STEM. Many of the elements that contribute to the culture of STEM manifest in academic contexts, namely the classroom setting. Black students often report that classroom spaces are unwelcoming, competitive, and discriminatory against students of color and women (Fries-Britt, Johnson, & Burt, 2013). Regardless of preparation and performance, Black students often have to prove their intellectual prowess to faculty and peers (Fries-Britt & Griffin, 2007; McGee & Martin, 2011; Moore, Madison-Colmore, & Smith, 2003). Such experiences can be emotionally taxing (Fries-Britt & Griffin, 2007; McGee & Martin, 2011) and off-putting to individuals still developing their science identities (Carlone & Johnson, 2007). For instance, Fries-Britt and Griffin (2007) postulated that the amount of effort Black students exerted to disprove racialized stereotypes could have been used for studying. In a study comprised of STEM and non-STEM majors, students shared a variety of tactics they consciously employed to minimize biased perceptions about Blacks (Fries-Britt & Griffin, 2007). Because intelligence (and the ability to demonstrate it) is a valued commodity in STEM environments, misappropriated time and energy—not spent doing academic tasks—does little to earn rewards with peers or faculty.

Black students also experience isolation, alienation, and tokenization in STEM classroom contexts. Because there continues to be a lack of critical mass in the STEM disciplines, especially at PWIs where underrepresentation of ethnic minorities is highly evident, Black students often find it difficult to build community in the STEM disciplines (Strayhorn, 2012). For students who do persist, attempts to engage in classroom activities may go unnoticed. In a national study exploring the experiences of Black students in physics, Fries-Britt and colleagues (2010) found that faculty occasionally failed to acknowledge Black students who attempted to respond to questions in class. As will be discussed later in this paper, recognition is an important aspect of science identity development. Thus, the lack of recognition in an academic space can contribute to missed opportunities to positively self-promote or decisions to disengage in class altogether (Carlone & Johnson, 2007; Seymour & Hewitt, 1997).

Undergraduate Research Outcomes

Students of color face a variety of barriers to persistence in STEM and subsequent opportunities to hone their science identities (Gasiewski, Tran, Herrera, Garcia, & Newman, 2008). Structured undergraduate research programs have been known to address these barriers and facilitate positive outcomes for underrepresented students (Gasiewski et al., 2008). Students who engage in undergraduate research have benefited from increased persistence (Chang, Cerna, Han, Saenz, 2008), stronger interests in graduate studies (Hurtado et al., 2011), access to supplemental academic resources (Gasiewski et al., 2008), better GPAs and graduation rates than non-participants (Barlow & Villarejo, 2004), expansion of social networks (Gasiewski et al., 2008), and exposure to a variety of STEM career paths (Gasiewski et al., 2008). Despite these contributions, there is a gap in the literature concerning psychosocial benefits (e.g., potential minimization of racism or sexism) of engaging in undergraduate research. Most studies underscore intellectual and other disciplinary-specific gains, but few studies consider the influential role of space to identity development in STEM settings (Hurtado et al., 2011). For example, notions of undergraduate research environments as counterspaces that affirm intellectual abilities for marginalized groups remain an understudied area of research (Carter, 2007). Additionally, many of the aforementioned studies do not center the experiences of Black STEM students.

The purpose of this qualitative case study was to examine how classroom and undergraduate research spaces influenced science identity among a sample of Black students at a PWI. The following research questions undergirded this study: (a) how do Black students majoring in STEM describe their classroom setting in comparison to their undergraduate research sites, (b) what factors may be a hindrance to their science identity development, and (c) what factors may be supportive to their science identity development?

Theoretical Framework

This study utilized an integrated framework comprised of the science identity model and notions of counterspaces. Carlone and Johnson (2007) first conceptualized science identity from their study investigating successful female undergraduate and graduate students of color. Their study explored how women of color negotiated and made meaning of their experiences in the STEM disciplines with attention to their racial, ethnic, and gender identities. Findings revealed three components that contributed to a salient science identity: performance, recognition, and competence. Performance is the ability to conduct "relevant scientific practices" such that one demonstrates acquisition of academic language (e.g. scientific or professional terminology) and use of tools (e.g., laboratory materials, apparatuses). Recognition entails being acknowledged as a "science person" by oneself and "meaningful others" such as faculty or scholars in the field. Competence consists of knowledge attainment and comprehension of science content (Carlone & Johnson, 2007).

Carlone and Johnson (2007) noted "identity arises out of constraints and resources available in a local setting" (p. 1192). This statement illuminates the importance of space in science identity development. Since the framework does not account for the development that takes place in space(s), I used notions of counterspaces to further analyze how the students discussed what was happening to them in various disciplinary-related settings.

Counterspaces are environments that facilitate psychological well-being among marginalized individuals (Case & Hunter, 2012). These spaces may exist in physical structures or include the "presence of participants in an organization" that advances the needs of a certain racial or ethnic group (Howard-Hamilton, 2003, p. 23). In contrast to STEM academic environments, which have been known to create "chilly" climates for students of color (Ong, et al., 2011), these spaces provide refuge from pervasively White spaces or microaggressions that subjugate students to harmful interactions (Howard-Hamilton, 2003). Counterspaces allow students to be their whole selves (i.e., intellectual, race, gender) (Carter 2007), feel a sense of belonging (Strayhorn, 2012), and lead to an intact psychological self necessary for science identity formation (Carlone & Johnson, 2007). Most importantly, "counterspaces serve as sites where deficit notions of people of color can be challenged and where a positive collegiate racial climate can be established and maintained" (Solorzano, Ceja, & Yosso, 2000, p. 70). In the context of STEM environments at PWIs, I extend this definition to encompass spaces that affirm and validate students as emerging Black scientists and engineers. In these spaces, Black students can experience wholeness and congruence with their Black and disciplinary identities.

Methods

Study Design and Context

The current study is a part of a larger, holistic case study that investigates the Comprehensive STEM Program (CSP, pseudonym), a STEM enrichment program, at Jefferson State University (JSU, pseudonym). I employed a case study methodological approach in this study for the following reasons: (1) an emphasis on in-depth analysis, (2) context as central to the phenomenon being studied, and (3) usage of multiple sources of data. In case study research, "deep data" and the ability to produce more detailed information than what can be provided through statistical analyses alone are critical to a holistic case development (Merriam, 1985). Also, the context is a salient component of case study research. As Stake (2000) stated, "the case to be studied is a complex entity located in a milieu or situation embedded in a number of contexts or backgrounds" (p. 449). Understanding the case requires that the researcher explore the complexities, contexts, and backgrounds of the unit of analysis.

JSU is a predominantly White, large, public research university in the Midwest with nearly 40,000 undergraduate students. CSP contains eight program components: summer bridge program, residential housing, course clustering, weekly recitation sessions, peer mentoring, academic advising, freshman seminar, and an undergraduate research experience. CSP's capacity is 50 students. I selected CSP due to its considerably higher retention and graduation rates for students of color. For instance, 70% of the first cohort attained a STEM degree, which was 27% higher than non-CSP participants from underrepresented backgrounds in STEM.

Interview Protocol

Each participant engaged in a 45-to-60 minute semi-structured interview. Participants were given $10 for their participation in the interview. Relevant literature on students of color in the STEM disciplines, undergraduate research programs, and the science identity model informed the interview protocol and questions. Some interview questions are presented here: (1) How do you describe your science identity? (2) What experiences or personal characteristics have contributed to that definition? (3) What changes have you noticed in your science identity over time, and what has contributed to those changes?

Data Analysis

Semi-structured interviews were recorded, transcribed verbatim, and coded. A systematic coding process of first and second cycle coding was utilized (Saldaña, 2009). The first cycle coding included in vivo coding (Miles, Huberman, & Saldaña, 2013). Because I wanted to center the participants' voices, I used their words and "short phrases" to create codes (Miles et al., 2013, p. 74). The second cycle of coding entailed reviewing the "first cycle codes to assess their commonality and assess them a pattern code" (Saldaña, 2009, p. 154). Descriptive content about the codes was developed from comparing the codes to the extant literature on undergraduate research programs, the science identity literature and framework, and counterspaces (Yin, 2003).

Trustworthiness

I used peer debriefing to ensure that my codes and themes were what they should be (Miles, et al., 2013). Although I am the primary investigator for this study, I reviewed my findings with two researchers who study the experiences of students of color in STEM to critique my findings and provide alternative perspectives. I also engaged in member checking through reviewing my findings with participants and Black non-participants in the STEM fields. I reached out to participants by phone or email to share my findings. I met with individuals and attended a National Society of Black Engineers (NSBE) meeting to discuss the findings. Both groups (i.e., individual meetings and NSBE participants) confirmed my findings and provided additional perspectives and potential implications for practice.

Limitations

The qualitative methodology limits the generalizability of this study. While this study closely aligns with literature regarding the experiences and perceptions of people of color in STEM, these findings will need to be confirmed through additional studies. This study took place at one institutional site, and it excluded students who did not participate in CSP. Findings may not reflect the experiences of non-program participants. According to Padilla (2007), students who do not persist may also possess “expert” knowledge on what it takes to be successful. For the proposed study, students who did not persist in the STEM enrichment program and/or STEM major were not included.

Findings

Students described their experiences in undergraduate research environments in more positive ways than STEM classroom environments. In the research environments, participants reported feeling they were capable of making contributions to scientific discovery. Students were also more likely to take on leadership roles including coordinating and delegating facets of the research design and implementation. In contrast, the classroom environment produced a variety of struggles for Black students. Participants pointed out group projects as especially difficult to navigate in science and engineering courses. White students were more likely to assign Black students the menial tasks or schedule group meetings without them. Some participants noted being left out of decisions concerning more technical aspects of the group projects. Such experiences may influence identity development because they limit opportunities for performance, recognition, and displaying competencies. How these factors inhibit and support science identity development for Black collegians is discussed below.

Spaces that Inhibit Science Identity Development

Black students noted two challenges in their STEM classroom environments. First, they described these environments as overwhelmingly hostile and “weird” due to the underrepresentation of racial and ethnic minorities. Second, they suggested that being a visible minority contributed to the egregious behavior of some White students. For example, participants contended that the lack of critical mass of Black students in STEM courses communicated to non-Blacks an inability to succeed academically. Brittney explained:

> They just think that we don’t know anything. Like we don’t know what’s going on in the class. [Or], they automatically do not form a conversation or form a group with [you], [because they think] the Black people don’t know what’s going on or they just here… especially with girls. They don’t want you to… see you like doing better. I had five exams last week. And people [were] like, what’d you get on your exam? They’d be like oh, no, you didn’t. Or they might know an equation that you can put on a [formula] sheet. They won’t tell you. They just wanta see you struggle.

What Brittney described is problematic and counterproductive to her needs as an emerging scientist. Brittney's sentiments that other students do not want to see her succeed point to her peers' reluctance to share course materials. Their inaction on the part of her academic needs limits opportunities for performing more confidently on exams. Brittney's experiences also shed light on the extraordinary measures students of color must undergo in order to be recognized by their peers (Moore et al., 2003). Accusations that she did not earn her test scores are symptomatic of the "prove them wrong" syndrome wherein Black students have to provide substantial evidence of their intellectual prowess (Moore et al., 2003). Much like Brittney's accounts, participants discussed regularly encountering microaggressions or subtle insults directed towards people of color (Sue et al., 2007). Having peers deliberately avoid conversations or exclude them from groups further exacerbated their minoritized status. Consequently, these experiences may cause Black students to inadvertently question their intelligence, self-worth, and value-added to the STEM disciplines (Chang, Eagan, Lin, & Hurtado, 2011). Such oppressive and hegemonic environments necessitate creation and usage of counterspaces that affirm the intellectual capacity of Black students.

Research Environments as Identity-Affirming Counterspaces

Many participants described their undergraduate research environments as spaces that supported their intellectual curiosity and development. For example, Jasmine discussed her research experience in the following way:

> …I was actually doing something, not just reading things from the book but actually getting engaged with something, having the responsibility of making sure that things came out well. Actually being important to a project. You know, they still use the data that I used from the summer to continue on in their research and for future summer interns. There was one girl in the [MEP Learning Center], and she was like, oh, are you Jasmine and I was like, yeah, and she was like, I was talking to [Dr. Bridges] and she was showing me some of your work from last summer 'cuz I may work for her. I was like, oh, she remembers me. I was actually important, you know.

Developing a project that continued to garner recognition beyond her time in the laboratory validated Jasmine's work and strengthened her science identity. Being seen as someone who makes a contribution to science is significant especially for female scientists of color who tend to be the most underrepresented population in STEM (Ong et al., 2011). Such experiences may provide an intrinsic rationale to persist in STEM (Hurtado et al., 2011). Other participants expressed appreciation for their growth and improved understanding of science through research. For example, Gary stated, "I had a science-y mind, and I was doing things that would help improve [my faculty mentor's research] or improve myself. And I learned a lot…I'm a better problem-solver". Because these environments were more welcoming to Black students they confidently engaged in scientific practices and expanded their knowledge.

Unlike the classroom domain, participants were not questioned about their intelligence or what they could contribute to the research environment. In these spaces, students could fully realize their intellectual selves as Black individuals. They did not have to prove themselves to be included and respected for their involvement in the research process. For instance, in other interviews, participants lamented that Black students were often not trusted to conceive and implement strong ideas in the planning of course assignments and projects. Such exclusionary practices may make it difficult to see themselves as scientists, improve in their disciplinary area, and become better problem-solvers as Gary noted about his research experience.

Discussion

Previous studies indicate that STEM environments can be alienating, isolating, and discriminately competitive for Black collegians (Fries-Britt et al., 2013; Hurtado et al., 2009; Ong, 2005). Additionally, their intellectual abilities may be under scrutiny due to their lack of critical mass and representation in the STEM disciplines (McGee & Martin, 2011; Moore et al., 2003). Participants highlighted incidents of subtle and overt forms of racial microaggressions demonstrating that STEM classroom environments may be detrimental to Black students who are still forming their science identities. Exclusionary and dismissive behaviors from Whites may disproportionately hinder Black students from advancing in STEM contexts where camaraderie plays an integral role in completing course projects and information-sharing (Fries-Britt et al., 2013; Strayhorn, 2012).

Similar to the findings of Hurtado and colleagues (2011), engagement in undergraduate research facilitated opportunities where Black students could gain confidence as contributors to STEM. For instance, Jasmine emphasized that she was "important" to a project when she discovered the research team continued to build upon her findings after the appointment ended. Carlone and Johnson's (2007) framework illuminated how research environments can provide access to conditions that are instrumental in helping students develop their science identities. Performance and competencies were realized through scientific discovery and problem-solving, and students were recognized by others and themselves for their contributions. Unlike the classroom environment where Black students had to prove their intelligence, the research environment did not require such demands for participation.

The integration of counterspaces as an additional analytical lens centered the importance of space in the conversation of science identity development (McGee & Martin, 2013). Science identity development or stagnation does not occur in a vacuum. As observed in the current study, Black students faced a multitude of challenges in the classroom settings that did not present themselves in the research environment. In these environments, students were able to affirm their identities as Black scientists and engineers. Previous research shows that competence, interest in STEM, and recognition by others are critical to science identity development (Carlone & Johnson, 2007). Not only did these students experience all of these outcomes, but they realized the importance of being Black and having an ability to engage in scientific practice. Societal norms and culture suggest that Blacks are less capable of being scientists and engineers, and these students were defying those notions (Fries-Britt et al., 2013; McGee & Martin, 2013)

Implications for Practice, Policy, and Future Research

More students of color should be engaged in undergraduate research in order to strengthen their commitment to the STEM disciplines, expose students to the kinds of work conducted in STEM environments, and involve them in spaces that ignite and affirm their intellectual identities. Because STEM classroom environments may operate more like battlegrounds than spaces for learning and development, college faculty and administrators should seek to capitalize on learning experiences that result in more positive academic outcomes.

Regarding institutional and programmatic policies, undergraduate research should be instituted early in a student's college career. In the present study, undergraduate research opportunities occurred prior to the sophomore year in college. First to second year persistence is a critical juncture in college student retention overall (Tinto, 2012), but it is especially significant in the case of the STEM disciplines, where a net loss of 50% or more is typical. Finally, the current study took place at one, large, public, predominantly White research university, which may have implications for the generalizability of the study's findings. Future studies should include other institutional types and sizes. For instances, counterspaces may serve different purposes for Black women at co-educational, Historically Black Colleges and Universities (HBCUs).

Though this article focused on counterspaces that affirm racial and disciplinary identity, future research should examine counterspaces that support identity development among other marginalized groups in STEM and the intersections of various identities such as first-generation and lower-income students. For example, many students expressed concerns about being disenfranchised not only for their race, but also class and/or first-generation college student status that limited access to information, knowledge, and exposure to scientific practices and careers prior to college attendance.

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