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Navigating Underrepresented STEM Spaces: Experiences of Black Women in U.S. Computing Science Higher Education Programs Who Actualize Success

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Women in the United States have long been underrepresented in computing science disciplines across college campuses and in industry alike (Hanson, 2004; Jackson & Charleston, 2012). This disparity is exacerbated when African American women are scrutinized. Additionally, prior research (e.g., Hanson, 2004; Jackson & Charleston, 2012; Jackson, Gilbert, Charleston, & Gosha, 2009) suggests a need to better understand this underrepresented group within computing—a field in dire need of additional skilled workers. Using critical race feminism and Black feminist thought as theoretical underpinnings, this study examined the experiences of Black female computing aspirants at various levels of academic status. In doing so, this research captures the unique challenges that participants experience in their respective academic computing science environments, as well as how participants navigate this historically White, male-dominated field.

Keywords: STEM, computer science, African American females, higher education, broadening participation

Many government entities within the United States (e.g., National Science Foundation, Department of Labor) have expressed an urgent need to increase the number of job seekers within science, technology, engineering, and mathematics (STEM) fields (American Council on Education, 2006; National Science Board, 2012). In particular, strong emphases have been placed on increasing participation within the computing sciences among underrepresented populations. Even though STEM-related jobs are a growing sector of the U.S. economy, the nation faces a severe shortage of computing scientists (Beyer, Rynes, Perrault, Hay, & Haller, 2003; National Science Foundation Division of Science Resources Statistics, 2011). For the last decade, the U.S. Department of Labor projected that approximately 1.6 million additional workers with degrees in computing sciences were needed to fulfill workforce demands (Beyer et al., 2003; Hecker, 2001).

African American women in particular are an underrepresented group within the computing sciences, particularly at the highest degree attainment levels (e.g., PhD; Hanson, 2004; National Science Board, 2012). Moreover, the majority of opportunities to pursue doctoral degrees in computing take place in homogeneous environments, which are generally not welcoming to African American women (e.g., predominantly White institutions; Hanson, 2004). For example, a report from the National Science Board indicates that Whites represented over 70% of the country's 3.5 million scientists and engineers. Furthermore, there is sufficient evidence to conclude that African Americans collectively achieve the lowest number of doctoral degrees in science and engineering (4%; National Science Board, 2012). Consequently, African American women are typically isolated in terms of race and gender as it relates to their matriculation toward doctorate degrees in computing sciences (Museus, Palmer, Davis, &

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Maramba, 2011). These factors make African American females in computing a prime target for efforts to expand participation in the computing workforce (Hanson, 2004; National Science Board, 2012)—and an ideal group to study. As such, this qualitative inquiry into the lives of African American women in computing in higher education may provide insight that will positively contribute to this body of research by illuminating how these underrepresented students negotiate their unique status in computing science departments.

Relevant Literature

More than 30 years of research involving the gender divide in STEM fields have effectively demonstrated significant differences related to participation rates, attitudes, and perceptions among males and females (Jones, Howe, & Rua, 2000). However, the varying and conflicting nature of relative research results prompts a need for further clarification regarding these differences, particularly as it relates to African American women in computing sciences. Women now outnumber men with regard to college enrollment, and minority students are enrolling in record numbers at the postsecondary level (Beyer et al., 2003; National Science Board, 2010). These changes should be assessed and addressed appropriately, particularly with respect to whether they have been accompanied by any changes in perceptions, attitudes, or experiences within and about computing sciences among African American females. Better understanding of these dynamics is necessary in attempting to construct interventions that aim to foster increased participation (Jackson, Gilbert, Charleston, & Gosha, 2009).

The world of computing, along with other STEM cultures, is one that has long been perceived as an exclusive discipline open only to males, most notably Caucasians. It was not until the latter portion of the 20th century that these disciplines experienced a growth in enrollment for minorities and women. Since 1989, women and minority participation rates in STEM have seen modest yet steady increases (National Science Foundation, 2011). Gains experienced over the last 15 years are especially intriguing. Between 1995 and 2007, the proportion of science and engineering bachelor's degrees awarded to underrepresented groups increased (National Science Board, 2010) among Asians/Pacific Islanders (from 8% to 9%), Black students (from 7% to 8%), Hispanic students (from 6% to 8%), and American Indian/Alaska Native students (from 0.5% to 0.7%).

These gradual, yet noticeable, advances for minorities in STEM may be due in part to intentional efforts on the part of the government and researchers to increase and diversify the numbers of STEM degree recipients. Likewise, natural population shifts and increased college attendance of women and minorities may also play a role. In fact, since 2002, women have earned an astounding 58% of all bachelor's degrees, as well as about half of all science and engineering bachelor's degrees since 2000 (National Science Board, 2010). Although these figures are worth touting, one must be mindful of, and keep vigilant, the unsettling variations in degree attainment in STEM fields among women—particularly minority women.

In 2007, women earned half or more of bachelor's degrees awarded in psychology (77%), biology (60%), social science (54%), agriculture (50%), and chemistry (50%); however, women's share of bachelor's degrees in computing, mathematics, and engineering remain disproportionately low (National Science Board, 2010). The majority of bachelor's degrees awarded in engineering, computing, and physics (81%, 81%, and 79%, respectively) were awarded to male STEM aspirants (National Science Board, 2010). Given these data, a simple but salient question emerges: What are the experiences of minority women in STEM and their perceptions of careers in the field, and how does that relate to their relatively low participation rates?

Several research studies (e.g., Charleston, 2012; Charleston & Jackson, 2011; Etzkowitz, Kemelgor, & Uzzi, 2000; Herzig, 2002; Tinto, 1993) have noted a variety of factors that contribute to doctoral persistence. Salient factors range from having family or close friends who were involved in the same field of study, participation in undergraduate research experiences, effective professional development and mentoring, to adopting a self-identity as a practitioner in the specific area of study (Charleston, 2012). Accordingly, researchers also found that students who do not adopt a field-specific identity circumscribed by faculty expectations (e.g., mastery of implicit knowledge and dominant discourses in the field) may be deemed incompetent in that particular field (Etzkowitz et al., 2000; Herzig, 2004). Thus, being a

woman and being Black within the field of computing poses serious questions regarding the integration of said population into the academic and social world of the White, male-dominated field of computing sciences.

Tinto (1993) asserted three stages of persistence toward the doctoral degree. The first stage involves students' adjustment to academic and social communities within their home departments. It is within this initial stage that students make judgments about the relevance of their program of study as it relates to their career goals (for the purposes of this study, computing sciences). However, it is within the second stage that students develop the knowledge base and skills necessary for doctoral research, wherein their competence is assessed through comprehensive exams and other requirements that demonstrate a mastery of the field's literature and practices. Though the third stage involves the completion of the dissertation, it is within the first two stages that student persistence reflects the tenor of social interactions between faculty and students alike (Tinto, 1993). Ultimately, these interactions significantly affect the development of competence within the students themselves, as well as the judgments faculty and peers make toward the knowledge and skills the individual has developed. Those judgments are also, in turn, shaped by social circumstances outside of classroom interactions (Herzig, 2004; Tinto, 1993).

A sociocultural perspective of education dictates that the process of learning occurs, and is inseparable from, students' participation in the communities of practice available to them within their individual graduate programs (Boaler, 2002; Herzig, 2004; Rogoff, 1994). This intertwining of scholarship and community that is required for learning comes in a variety of forms, such as collaborating with peers to solve problems, attending seminars, observing lectures, teaching and grading assignments, conducting research, as well as studying. These activities represent learning opportunities; participation in a community of practice is not simply a distinct educational activity, but a lens for analyzing the broader environment in which students engage (Herzig, 2004). Therefore, it is helpful to focus on learning as participation, as opposed to simply a process of acquiring or transmitting knowledge (Herzig, 2004; Rogoff, 1994). As such, evaluating the structure of doctoral education requires examining the specific activities and practices in which students participate, the nature of their participation, as well as the knowledge students gain as a result of their participation (Herzig, 2004). Such an examination deserves a critical eye, particularly as it relates to facilitating positive experiences for students that endeavor to participate in homogeneous educational environments. Therefore, this study addresses the following question: What are the unique challenges that African American women experience in their respective academic computing science environments, and how are these homogeneous spaces navigated among this demographic group?

Theoretical Framework

In an effort to provide the sociohistorical lenses necessary to understand the experiences of study participants (i.e., African American female computing science aspirants), this study employed Black feminist thought (BFT) and critical race feminism (CRF) as its theoretical foundations. Applying these frameworks enabled the researchers to enrich the analyses in terms of how Black women negotiate their intersectionality (Few, 2007). Likewise, these critical lenses allow for Black women's voices about their own experiences to take precedence over conventional descriptions and iterations of Western (White) thought and practice, which has tended to define the standard of "normal," to which all others are compared (Few, 2007; West, 1982).

With its roots in critical social theory, BFT "consists of ideas produced by Black women that clarify a standpoint of and for Black women" (Collins, 1986, p. 516). In other words, BFT seeks to empower African American women within the context of social injustices sustained by the intersecting oppressions of being both Black and women (Collins, 2000). From an epistemological standpoint, BFT affirms the uniqueness of Black female knowledge that stems from similar experiences and common challenges related to subjugation by race and gender (Collins, 2000). Recognition of this uniqueness challenges normative assumptions. From a historical perspective, racial segregation in housing, education, and employment fostered the formation of a group-based, collective standpoint rooted in Black women's shared experiences (Collins, 2000). As Patricia Collins (2000) writes, "this collective wisdom on how to survive as U.S. Black women constituted a

distinctive Black women's standpoint on gender-specific patterns of racial segregation and its accompanying economic penalties" (p. 24). BFT, applied epistemologically and as a tool of empowerment, serves to substantiate the experiences of the Black female collective.

CRF theory emerged from critical race theory, and was inspired by the exclusion of racial and/or ethnic legal women scholars by their male peers and White feminist legal scholars (Few, 2007). Contrary to some critical race theorists, CRF rejects essentialist arguments and generalizations concerning all minorities. As articulated by Adrien K. Wing, "our antiessentialist premise is that identity is not additive. In other words, Black women are not white women plus color, or Black men, plus gender" (Few, 2007, p. 456). This framework emphasizes the intersection of race and sex, wherein Black women are understood to have an exclusive viewpoint stemming from their intersecting racial and gender identity (Wing, 1997). CRF theory asserts that various institutions with which Black women must interact daily reinforce social inequities (Few, 2007). Furthermore, CRF emphasizes the intersecting nature of identity—of Black women being both Black and woman (in no particular order)—thereby prompting an analysis that treats race and sex as interrelated when evaluating the experiences of women of color (Crenshaw, 2003).

Although the concepts of CRF and BFT have been well-developed by a cadre of scholars (Collins, 1986; Crenshaw, 2003; Wing, 1997), empirical assessments employing these frameworks have been more limited. Critics of feminism and critical theory have generally presented two claims: (a) "it is difficult to measure feminist concepts," and (b) "such theories cannot help researchers to predict individual or group behavior" (Few, 2007, p. 464). Although these theories cannot be used to predict behavioral outcomes for targeted groups, CRF and BFT are critical tools that provide a context for examining how women come to understand themselves through the development of Black female subjectivities—those identities that are most significant to an individual in various social contexts (Few, 2007). Likewise, both theories assert that identity politics and the politics of location are predicated on differences that can at times either marginalize or empower groups or individuals (Few, 2007). Ultimately, CRF and BFT provide the necessary critical lens that takes into account the sociohistorical context of a specific group or community when examining behavior—in this case, the African American woman in computing sciences in higher education.

Method

The researchers conducted a qualitative inquiry into the lives of African American women in the computing sciences, as we attempted to understand and describe the participant's lived experiences (Creswell, 2002). A phenomenological design was well-suited to the study because the aim of our inquiry was understanding a common experience of a group of people, allowing the researcher to use data from participants to develop foundational knowledge about the phenomenon (Moustakas, 1994; Shank, 2002). In this context, the goal of the inquiry was to explore African American women's perspectives on their participation in the historically White, male-dominated field of computing science. Conducted by an African American woman, the focus group lasted approximately 60 to 90 min in duration. Informed consent was given orally, and participants were made aware of their right to suspend the session at any time. The focus group session was videotaped, and upon completion of the session, the tape was transcribed and filed for possible future use as a promotional or professional aid (depending upon the consent of the participants). The session was comprised of a series of closed and open-ended questions designed to gather information relative to the participants' experiences, with specific attention to the role gender and race plays within the computing sciences (see Appendix).

Characteristics of Focus Group Participants

Purposeful sampling techniques were employed to ensure that all participants met the following criteria (Lincoln & Guba, 1986): (a) identify as "African American" or "Black" women, (b) are enrolled full time or were recently (in the last 3 years), and (c) are between the ages of 18 and 35 years. All 15 of the focus group participants were African American females and were recruited from the 2007 African American Researchers in Computing Sciences (AARCS) Conference. All of the focus group participants had either majored or were majoring in an area within or related to computing as an undergraduate or graduate stu-

dent. Moreover, at the time of the study, two participants had already obtained a PhD in computing sciences, 12 were current graduate students (PhD aspirants), and one participant was completing her baccalaureate degree. All undergraduate student participants were attending a historically Black college and university, and all graduate students and current PhD-holder participants were receiving or had received their graduate degrees from a predominantly White institution (PWI).

Validity

In an effort to address reliability and validity of the qualitative inquiry within this study, the researcher employed a naturalistic approach. As prescribed by Lincoln and Guba (1986), this approach to qualitative research addresses validity in terms of credibility and fittingness. Reliability in qualitative research involves the ability to replicate the study, given a similar set of circumstances. Through naturalistic inquiry, the researchers coded data in a manner in which emerging themes and theories are replicable.

Credibility was brought to this study using triangulation techniques: prolonged engagement, persistent observations, field notes, and the analysis of multiple data sources. First, corroboration was ascertained by spending ample time with study participants to check for distortions, which facilitated prolonged engagement with study participants. As noted earlier, focus groups lasted an average of 60 to 90 min. Second, the participants' experiences were explored in sufficient detail, which exemplified persistent observation. This is evidenced from the interview protocol, which included a significant number of open-ended questions to understand and capture the essence of participants' experiences. Third, multiple data sources were checked through comparing various forms of data such as digital audio recordings and physical transcriptions. For instance, the inclusion of information-rich responses from participants also enhanced our ability to capture and illustrate the collective and individual voices of African American women in STEM. Moreover, credibility was brought to the study via consultation with other investigators. Rudestem and Newton (1992) asserts that peer debriefing, revising working hypotheses throughout the data collection process, clarifying preliminary findings with study participants, and audio- and videotaping the interviews in an effort to compare with other means of data collected are customarily the procedures necessary to insure the credibility of a study.

Positionality

As cultural outsiders, this study was approached not only with sensitivity but also with a desire to uplift the voices and experiential realities of African American women in STEM fields. As such, the team of researchers reflected on their own positionality, and the impact of their own complex identities with regard to interactions with participants and the interpretation of the results. Throughout the research analysis process, the authors debriefed about their interpretations to be reflective, address potential assumption and biases, and to ensure consistency with phenomenology. Although some members were not involved in every step of the research (e.g., some were involved in coding but not interviews), the presence of multiple researchers allowed us to function as auditors of the overall process (Creswell, 1997). Multiple members of the research team transcribed and coded the focus group recording, which allowed for peer debriefing and the inclusion of thick-rich descriptions in the findings. Moreover, the use of inductive data strategies allowed the data to serve as the foundation of understanding, wherein the findings are acutely descriptive and conveyed through direct quotes and thematic analyses.

Findings from this investigation are limited in two major ways. First, the data collected for this study is context bound (Lincoln & Guba, 1986). Given that the participants in this inquiry were all recruited from the 2007 AARCS Conference, we recognize that insights shared by these participants may not fully capture the collective experiences of Black women in the field of computing. A second limitation of this study pertains to the qualitative method employed. Specifically, the use of focus groups may have limited opportunities for divergent perspectives from participants—a trend commonly known as "focus group effect" (Patton, 2002). Although steps were taken by the researchers to encourage an open and honest dialogue among focus group participants, there is still the possibility that the insights shared (or withheld) may have been negatively influenced by what some perceived to be the dominant perspective. To the extent that these conditions are true, the findings offered may have limitations.

Discussion

The findings within this study fostered several thematic representations relating to the participants' experiences in the field of computing science. The following themes arose from the data: (a) the challenges of being a Black woman in the computing sciences, (b) commonality of isolation and subordination, and (c) sacrifices related to computing science pursuance. It is also important to note that some of the data collected did not fit easily in a singular category. As such, there are places in this inquiry in which various themes emerged in more than one category.

The Challenges of Being a Black Woman in the Computing Sciences

In accordance with the tenets of BFT and CRF, participants in this study grappled with their self-identity as women of color in racially and sexually exclusive academic spaces. Although participants described their experiences with regard to being a woman of color in the field of computing sciences in a variety of ways, the group's consensus can be summarized in the simple exclamation of one participant: "It's tough." Depending on the situational context, they noted that they identified as either "Black" or "a woman," or, in some cases, both. As one participant stated, "At different times, different identifications come to the forefront."

Although some participants described the difficulty they felt in determining whether they were being treated a certain way because they were Black or a woman, other participants self-identified as being Black, first and foremost. As one participant shared, "My belief is that the perception is that I am seen as a Black person first." Others expressed an inability to entirely separate their identities as Black and a woman. Consider this example: "At the end of the day, I am who I am. I am a Black woman, and there's no middle ground." The majority of participants were attuned to societal stereotypes about being a Black woman in the field. As one focus group participant expressed, "There are often assumptions that I am supposed to act a certain way because I am a Black woman." She continued to describe how she felt that others expected her to get upset or defiant when events would occur that were not particularly in her favor. Collectively, all 15 participants expressed how the computer science culture in their respective departments was not very welcoming to women, and even less so to African American women.

Participants also recognized that misperceptions and stereotypes about their academic and intellectual abilities were driven by their identity as Black women. One participant described an instance in which a White male classmate who was assigned as her partner blatantly questioned her academic competence. She explain how this partner made decisions without her input, such as submitting components of the group assignment and attempting to fully dictate how it would be carried out. "Maybe there was the perception that I was female, I was Black, and I was incompetent. His perception was I was going to pull him down," she added. Another participant went on to share a similar story: "I get to XXX and the first question someone asked was if I was someone's secretary . . . because I'm Black? A woman? I can't tease those things apart." The aforementioned example illustrates the complexities and intersections of race and gender for Black women in computer science.

Commonality of Isolation and Subordination

Participants in this study also described how they experienced feelings of isolation and subordination to varying degrees during their computing science pursuits. Participants reported instances in which there was limited, if any, social interaction with peers in their graduate program. It took "a good 6 weeks before people were finally opening up to me," one participant shared. Given the virtual absence of institutional and faculty support within and outside of their respective program, several participants began to reevaluate whether they had chosen the best discipline for graduate studies. In response to the sexist nature of some conditional stimulus (CS) departments, one participant asserted the following: "This isn't seen as a discipline for women." Some participants elaborated on the nexus between race, gender, and erroneous assumptions of incompetence. "Why are you still in school?" and "Why aren't you married and taking care of somebody?" were common expressions of surprise among their White colleagues during their initial interactions. The anecdotes highlighted here shed light on the inseparability and confluence of race and gender for Black women in CS departments. These find-

ings support this article's theoretical constructs of BFT and CRF.

Given that most CS departments are skewed, primarily White-male dominated spaces, participants expressed feelings of cultural isolation and subordination through exclusion. Although feelings of cultural isolation may be associated with acclimating to environments in which Black women are underrepresented, participants elaborated in detail how race and gender were intersecting factors that negatively affected their academic experience. In the next example, one participant shares her challenges in obtaining lab partners for course assignments: "[As] the only Black [student], no one wants to partner with you and you have to do all the experiments by yourself." Likewise, participants reported that favoritism would often develop, in which other classmates "no longer want to work with you," creating tension among students and putting them in an inequitable position with the professor. The confluence of race and gender for Black women in CS departments is also illustrative in the following example: "Just having other females there just doesn't cut it because there's no one there that has your experience . . . there are no common threads that connect you." Others cited similar examples that emphasize divisions along race and gender, which reflect the significance of BFT and CRF in the academic experiences of participants.

Participants also cited computing science professors as central contributors to their sense of isolation. One participant described the reaction of a faculty member when an Asian friend, who was well-liked by the professor, confronted the professor about his concern that the African American student was being mistreated. The faculty member replied,

> I don't think she has talent. I think White professors gave her grades because of her race and they felt bad about slavery. I don't think there are any real computer scientists who are Black, and maybe she can be the first.

Women in this study were also cognizant that their isolation in academic spaces was parallel to the isolation they experienced in everyday life as a result of being a part of the Black race. Moreover, it should be noted that isolation for Blacks varied according to gender. For example, despite sharing similar racial experiences, participants noted how Black men and women were not always valuable sources for social support or camaraderie. As one participant elaborated, "Just cause there's another Black brother [in class] doesn't mean they want to work with you either." In sum, participants felt that Black men placed a strong emphasis on developing relationships with White males, whereas Black women were less inclined to do so.

Sacrifices Related to Computing Science Pursuance

Finally, this investigation revealed mixed responses as they related to the participants' assertions of what, if any, sacrifices they made as Black women pursuing computing science. On one hand, some participants emphasized the benefits associated with their educational pursuits. "It was a choice that I made, and I don't think that I made any sacrifices," one participant noted. Additionally, some participants believed that earning a degree in computer science would afford them a flexible and "ideal" lifestyle. Consider the next example: "Computer science promotes an ideal lifestyle . . . I can do anything during the day and work on my projects all night if I want to. If anything, more doors were opened so I didn't experience social isolation at all." On the other hand, some participants expressed concern that the demands of the field sometimes caused strains in relationships with significant others. Consider the following example:

> A lot of the things students do as an undergraduate, I didn't feel like I had time to do. So, it was socially isolating. You have less of a social life going through the CS process. I think that's part of the problem with encouraging others to even consider the discipline, as it is hard work. Others discourage you to continue on the path as well, saying, "Why do you wanna do that? You're a snob, and so forth."

As evidenced from the aforementioned example some participants explained how their computer science pursuits came with a cost in terms of maintaining a desirable social life. This story, although unique to this individual student, is, in many ways, reflective of the sacrifices made by Black women during their computer science pursuits. Ultimately, although responses varied regarding the topic of sacrifices associated with computer science pursuits, participants generally agreed that some of the aforementioned challenges were more discipline specific rather than gender or race specific (e.g., working late hours).

Conclusions

Findings from this investigation contribute to the existing literature in at least three major ways. First, unlike prior research in this area, which has sought to identify factors that facilitate recruitment, retention, and advancement in STEM (Hanson, 2004; Jackson & Charleston, 2012; Jackson et al., 2009; Museus et al., 2011), the current inquiry shed light on the inseparability and confluence of race and gender in the lives of Black female aspirants in the field of computing. Specifically, the self-reports given expose the academic, social, and institutional barriers Black women face in a field of study that remains virtually exclusive in terms of racial and gender demographics. Despite their hardships, it is important to note that many participants had already persisted successfully[1] toward undergraduate and graduate degree attainment. These particular participants were (re)affirmed in their abilities through educational and academic gains, despite the many hindrances. From a BFT and CRF lens, participants' responses suggest a collective understanding of the challenges in the field of STEM as women of color.

When African American women gain access to the coveted world of higher education and fail to perform at the same level as their White counterparts, inadequate academic preparation is often cited as the cause (Museus et al., 2011). Yet findings from this study have significant implications for the climate of STEM-related departments in higher education. Several participants recounted multiple instances in which peers refrained from inviting them to work on projects as a result of preconceived notions about their academic abilities. In fact, as supported by BFT and CRF, some Black women were forced to work independently or with their same-race female counterpart in an effort to resist and respond productively to racist and sexist stereotypes. Among other problematic findings is that faculty members were sometimes complicit in the perpetuation of their marginalization. The reported subjugation of women of color in computing spaces reflects the theoretical foundations of BFT, which states that Black women's experiences with subordination give them a unique perspective on social conditions (Collins, 1986, 2000). Moreover, the CRF framework exposes the disadvantages participants encountered, stemming from stigmata attached to being female and Black (Wing, 1997). Given these findings, future efforts that aim to address diversity in STEM fields should consider critically the educational climate for diversity, especially the ways in which race and gender intersect to create spaces for privilege and oppression (Collins, 1986; Crenshaw, 2003; Wing, 1997).

Second, the current investigation confirms the enduring presence of racism and sexism in STEM education, in general, and computing, specifically. Although previous studies have alluded to the presence of racism in K-12 and higher education (Hanson, 2004; Jackson & Charleston, 2012; Museus et al., 2011), the current investigation sheds important light on the racialized and gendered experiences of Black women in computing. Although the self-reports from this study present the image of an academically unwelcoming and socially isolating culture within computing, the authors do not make any claims of generalizability. Nevertheless, our study helps explain, at least partially, why low participation rates persist among Black women in the computing.

The last contribution of this study is that it reinforces the notion that institutional culture is a significant consideration in the study of underrepresented and underserved populations (Museus et al., 2011). In this study, BFT and CRF were useful in exposing how differently African American women experience computer science cultures. The inhospitable nature of computing at PWIs, as described by our participants, may be especially detrimental to the participation rates of minority women for which STEM degree attainment at the master's and doctoral levels consistently lag behind the attainment rates of their White female counterparts (National Science Foundation, 2011). Although findings from this study are not representative of all women of color, they suggest that more concentrated efforts are required to ensure equitable and inclusive learning environments.

Several implications for practice can be derived from this study. First and foremost, in order to create more inclusive learning spaces for Black women in computing, faculty in the computing field should more critically examine their own prejudices and biases toward both racial-ethnic minorities and women (Museus et al., 2011). As evidenced from the findings, students and faculty were both complicit in the subjugation of Black

[1] For the purposes of this article, success is defined in terms of participants' persistence in White-male dominated graduate science programs.

women in computing, which led participants in this study to question the fit between their academic and professional goals. Also requisite for improving the learning environment in STEM-related fields is the implementation of student support groups, or "safe spaces" in which women of color can reflect on negative experiences, practice self-care, and develop healthy responses.

Findings from the present study also reiterate national calls for greater parity in representation among faculty and students of color in computing programs and industry (American Council on Education, 2006; National Science Board, 2012). Broadening diversity and participation among faculty in computing may help mitigate the educational climate, which our participants described as isolating and insensitive to their needs. For instance, improving the recruitment of women of color to the academy may help strengthen the pipeline for youth who aspire to enter the computing field but lack same-race and/or gender role models. Lastly, such efforts may increase opportunities for mentoring and advising Black women in the computing field. Collectively, these efforts may positively contribute to the retention and completion rates among Black female aspirants in computing.

As the United States and key governmental entities (e.g., National Science Foundation, National Institutes of Health) continue to support programs to improve participation rates in computing, institutional leaders must pay close attention to the varying needs of African American females in order to improve representation in the sciences of women, in general, and women of color, in particular. Addressing gender- and race-specific nuances is likely to benefit the computing sciences workforce overall by enhancing the effectiveness of current and future intervention programs. Findings from this study might be extended by investigating African American women who did not meet success (e.g., those who do not persist) in computing sciences. Lastly, future research might assess the particular ways in which existing programs that encourage broader STEM involvement may enhance or impede participation by gender, and these results can be used to improve current and future intervention programs.

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Appendix

Interview Protocol

Focus Group Questions for the Study of Black Females in Computer Science

1. What is it like to be a woman in the computing sciences?
2. What is first and foremost in terms of how you self-identify yourselves (Are others separating being black from being a woman)?
3. Tell me a time when those perceptions actually hindered you in terms of their studies or career pursuits?
4. How do you all cope with this process?

(*Appendix continues*)

5. Some of the literature on the computing sciences suggests that women experience a lot of isolation at the undergraduate, graduate, and tenure track. Is that true?
6. Describe your experiences with isolation, if any.
7. What drew you to the field of computing sciences? Tenure track? Social Isolation?
8. What drew you to this field and given the hardships you're up against, what keeps you here?
9. Does anybody feel like they have to make sacrifices as a woman?
10. In terms of your significant others, have you had any challenges? Successes?

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