CONCEPTUAL STUDY

You Do Belong! Transformative Black Women Faculty Recommendations for Broadening Participation in US P-20 Computing Education

Shetay Ashford-Hanserd, *Texas State Unviversity, Department of Organization, Workforce, and Leadership Studies*

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Abstract

This study aimed to amplify Black women faculty's recommendations for broadening participation of the next generation of Black girls and women as they matriculate from primary school into advanced graduate degrees (P-20) in computing education (CE). As tenure-track faculty, these transformative women have attained the highest degree (i.e., Ph.D.) in postsecondary CE in the United States (US). To govern the knowledge validation process, I utilized Afrocentric feminist epistemology undergirded by critical race theory and Black feminist thought. Upon conducting thematic analysis, I identified four emergent themes to broaden participation of Black girls and women in computing: 1) improve access, quality, and early exposure to CE, 2) create equitable and equal spaces for Black girls and women, 3) confront unconscious biases of teachers and faculty, and 4) provide mentoring opportunities. As an emerging Black woman scholar, with a bachelor's degree in computer science and 15 years of industry experience, I had a "unique angle of vision" to interpret and inform this study's findings. This study builds upon limited knowledge about interventions needed to support Black girls and women in US P-20 computing education.

Keywords: Black girls and women, Black women faculty, counterspaces, P-20 computing education, STEM interventions, transformative leadership

Introduction

Since the 1990s, policymakers and researchers have noted the underrepresentation of women and minorities in computing education (CE) in the United States (US), also referred to as the leaky or shrinking pipeline, since they fail to enter or persist at all degree levels (National Science Foundation, 2015, 2019b; Singh et al., 2007; Roli Varma, 2009). Historically, women and minorities have lacked access to computers and technology, which has deterred their entry into computing disciplines (Varma, 2009). Furthermore, their lack of adequate academic preparation and undefined pathways into computing have resulted in low enrollments and low degree attainments among women and minorities (Margolis et al., 2003, 2011). While men outnumber women in undergraduate US computer science programs by nearly eighty-four percent, women outnumber men in US postsecondary education (Zweben & Bizot, 2014). Thus, women represent a viable group to focus our attention on, particularly Black women.

Black women are notably underrepresented in the US computing workforce because they fail to persist at all levels of US computing education (National Science Foundation, 2015; Ong et al., 2011; Zweben & Bizot, 2014). Often Black girls do not enter postsecondary computing education because they are discouraged from participating in pre-college programs, rigorous mathematics, and science courses (Smith-Evans et al., 2014). They face significant barriers in these programs. Though their college enrollments have increased by 14% since 1994 (Lopez & Gonzalez-Barrera, 2014), they likely will not choose STEM or computing degrees (George-Jackson & Lichtenberger, 2012; National Science Foundation, 2015). Also, Black women professors are underrepresented in postsecondary US computing education programs (National Science Foundation, 2015). Though researchers have identified gender and racial barriers, which contribute to Black women's double oppression or double bind (Ong et al., 2011), researchers should further explore their experiences at all US computing education levels.

Existing research has not given voice to Black women's experiences in the US P2-20 computing education pipeline, including their primary, secondary, and postsecondary educational experiences. As a result, Black women's voices are presently silenced, and little is known about their unique educational experiences and career trajectories, particularly at the graduate level. Since white women outnumber women of color, their experiences represent the master narrative or majoritarian perspective about women's computing experiences. While researchers have given voice to Black women's experiences in US STEM education (Borum & Walker, 2012; Bush, 2013; Jackson, 2013), fewer studies have done so in US computing education (Charleston et al., 2014). The literature is replete of studies focused on barriers to entry and persistence for Black women in STEM and computing rather than successes. Charleston et al. (2014) explored the role of race and gender in Black women's experiences at various degree levels, including bachelor's, master's, and Ph.D., rather than examining their continuous experiences in the US P-20 computing education pipeline. Jackson (2013) pinpointed the critical need to amplify Black women's voices to operationalize their US P-20 STEM education experiences. However, similarly, Black women's voices in US computing education should be amplified for policymakers, administrators, and educators to operationalize their experiences to broaden Black girls and women's participation. In light of the US national interest to diversify the STEM and computing workforce, I conducted this study to "strike while the iron is hot" (Baber, 2015; Palmer & Wood, 2013, p. xiii). In my previous study (Ashford-Hanserd, 2020), I focused on illuminating the counter-life herstories that influenced persistence among Black women computing faculty at US degree-granting postsecondary institutions. This study aims to amplify these Black women faculty's recommendations for broadening Black girls' and women's participation in computing. In this manuscript, I highlight these transformative leaders' responses by addressing the following research question: What recommendations do Black women faculty provide for broadening Black girls' and women's participation in P-20 US computing education?

Conceptual Framework

This study is undergirded by an integrative conceptual framework (Figure 1), which integrates an overarching Afrocentric feminist epistemology, and incorporates critical race theory (Bell, 1993; Closson, 2010; Crenshaw, 2011; Delgado et al., 2017; Ladson-Billings & Tate IV, 1995), and Black feminist thought (Collins, 2009) as interpretive frameworks to interpret Black women's counter-life herstories in the social and political or sociopolitical context of US computing education.

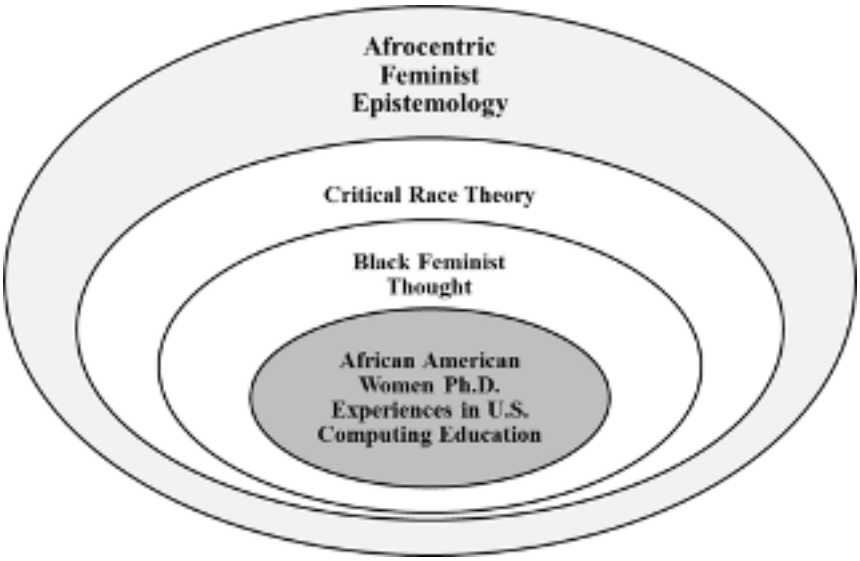

Figure 1. Counter-Life Herstories Integrative Conceptual Framework (Ashford, 2016)

Afrocentric Feminist Epistemology

Epistemology establishes an overarching theoretical framework to evaluate the standards we use in knowledge validation processes (Harding, 1987). It exposes power relationships, which determine whose voices are believed and heard (P. H Collins, 2009). Historically, the US's knowledge validation processes have been dominated by Eurocentric masculinist (EM) epistemologies, transcending time, and space, representing the white male standpoint and overshadowing the Black female standpoint (P. H Collins, 2009). As an early Black woman scholar, I have a 'unique angle' to appropriately examine Black women's experiences in US computing education (Collins, 2009; Howard-Hamilton, 2003). Afrocentric feminist epistemology (AFE) serves as a type of transformative paradigm (Mertens, 2010) or worldview (Creswell, 2014) because it directly engages participants of marginalized groups and follows a social justice agenda (Mertens, 2010). As such, I governed my knowledge validation process with a) concrete experience as a criterion of meaning, b) dialogue to assess knowledge claims, c) an ethic of caring, and d) an ethic of personal accountability. An ethic of caring "suggests personal experiences, emotions, and empathy are central to the knowledge validation process" (Collins, 2008, p. 62). Furthermore, an ethic of personal accountability promotes that individuals are accountable for their knowledge claims to provide insight into one's "character, values and ethics" (Collins, 2008, p. 65).

Critical Race Theory

Critical race theory (CRT) offers a framework to expose the "persistence of racism" in the US (Closson, 2010). In this study, I used the following prominent CRT tenets to situate Black women's experiences in the sociopolitical context of US computing education: a) endemic racism, b) experiential knowledge: counterstories and counter-narratives, c) interest convergence, and d) a social justice agenda. Endemic racism or racial realism describes the normality of racism in the US (Bell, 1993; Closson, 2010; Crenshaw, 2011; Delgado et al., 2017; Ladson-Billings & Tate IV, 1995). Black women may experience discriminatory effects of racism and microaggressions in school-based settings and on college campuses (Solorzano et al., 2000). In response, Black women create counterspaces or sister circles to shield themselves (Solorzano et al., 2000). Bell (1980) posits that interest convergence is enacted when Black people's concerns are only addressed when they converge with white people's concerns. Considering these challenges, CRT promotes a social justice agenda to eradicate discriminatory practices based on race, gender, language, age, or class. CRT scholars have promoted a social justice agenda in education, from theory to praxis, by encouraging student counter-narratives and counterspaces (Solórzano & Yosso, 2002; Somekh & Lewin, 2011). Counter-narratives and counterspaces are vital social justice strategies for the survival of students of color in higher education (Solórzano & Yosso, 2002).

Black Feminist Thought

In the US, Black women experience double oppression, including racism and sexism, and often adopt an "outsider within" disposition, dramatically impacting their educational experiences compared to white women (Collins, 2009; Ong et al., 2011). Collins (2009) introduced Black feminist thought (BFT) to illuminate Black women's standpoint from other Black women's perspectives. In this study, I used the following BFT distinguishing features to illuminate Black women faculty's recommendations for broadening participation of Black girls and women in U. S. computing education: a) Black women represent an oppressed group in the US, b) Black women have unique experiences, despite their commonality, and c) Black women scholars have a social justice agenda (Collins, 2009). As a Black woman and the primary qualitative research instrument, I followed a social justice agenda to illuminate Black girls' and women's unique educational experiences. In conjunction with CRT, BFT is an appropriate interpretive framework or lens to illuminate the unique experiences of Black girls and women in US computing education, from an Afrocentric feminist epistemological perspective.

Broadening Participation of Women and Girls in Computing

Numerous studies have emphasized the barriers to entry and persistence for Black girls and women in computing. Black girls and women share a common bond of double oppression – sexism and racism – in science disciplines (Malcom & Malcom, 2011; Malcom et al., 1976) and the academic workplace (Charleston et al., 2014), even though they represent different disciplines, backgrounds, and ethnicities (Charleston et al., 2014; Malcom et al., 1976). The most salient barriers have included unconscious biases instigated by teachers and faculty (Hill et al., 2010; McGee & Bentley, 2017), a shared sense of isolation (Borum & Walker, 2012; Charleston et al., 2014), imposter syndrome complex (Stout et al., 2011) due to "chilly climate" in predominately white male environments (Borum & Walker, 2012; Bush, 2013; Charleston et al., 2014; Jackson, 2013; Ong et al., 2011; Stout et al., 2011), and under preparation for rigorous coursework (Margolis et al., 2003). To address these challenges, the National Science Foundation (NSF) developed the "broadening participation in computing" initiative to fund various projects that address the underrepresentation of women and minorities in computing education and the workforce at all levels (National Science Foundation, 2019a). To date, the NSF has funded numerous projects aimed to improve educational pathways for women and minori-

ties in computing. While the NSF did not fund this study, my primary aim was to identify solutions for broadening participation of Black girls and women in computing.

Since most studies have focused on the barriers that impede Black girls and women's persistence in US computing education, which follows a deficit approach, researchers have recommended that future studies highlight Black women's successes (Charleston et al., 2014). Therefore, I employ an anti-deficit approach of identifying the most prominent dimensions that have influenced Black girls' and women's persistence in computing, such as resilience, faith, and spirituality, counterspaces, mentoring, and support from family, teachers, and professors.

Resilience, Faith, and Spirituality

Educational resilience is still a relatively new phenomenon. Researchers who have studied resilience among is an innate quality developed over time through life experiences that enables individuals to rebound from adversity or setbacks (Benard, 1993). Individuals who bounced back from adverse experiences are often labeled as "invincible," "hardy," or "invulnerable" (Werner & Smith, 1992). To overcome risk factors that buffer, intercept, or prevent risk (Werner & Smith, 1992), at-risk children access protective factors to divert them from adverse conditions (Garmezy, 1993). Black women who persist in US STEM and computing education programs demonstrate a high level of determination and resilience due to internal perseverance, mathematics, science self-efficacy, spirituality encompassing faith and prayer (Bush, 2013).

Historically, the Black Church has played an enormous role in African Americans or Blacks in the US (Dillard, 2000, 2012; Dillard & Okpalaoka, 2011). Since institutionalized racism and inequitable access to education still exist, the Black Church and other faith-based organizations have intervened to improve Black students' academic achievements in secondary and postsecondary education (Billingsley & Caldwell, 1991). Black and Latino communities have often accessed spirituality and religion to serve as critical sources of fortitude, resilience, and capital (Huber, 2009; Park et al., 2020). To gain power over their multiple oppressions, African American women have traditionally used spirituality to fortify their existence and sustain forward mobility (Dillard, 2000, 2012; Dillard et al., 2000; Dillard & Okpalaoka, 2011). In essence, African American women have embraced faith and spirituality as a "path to self-liberation and self-discovery" (Dillard, 2012, p. 449). As Black women have charted their STEM and computing education paths, they often elicit support from "the Church" to enable their persistence and overall success (Bush, 2013).

Counterspaces

Black women often experience the discriminatory effects of racism and microaggressions in US school-based settings and on college campuses. In response to these barriers, Black women may create counterspaces or safe homogeneous spaces to shield themselves within predominately white institutions, which serve as hegemonic racialized environments (Solorzano et al., 2000). As a tenet of critical race theory, counterspaces serve as a vital social justice strategy for students of color's survival in higher education (Solórzano & Villalpando, 1998). Counterspaces have been utilized to create safe spaces for Black girls and women in informal and formal K-16 STEM and computing education (Ashford et al., 2017; Heo & Myrick, 2009; King & Pringle, 2019). In Ashford et al. (2017), we proposed a STEM SISTA space model to "center the needs and interests" (p. 8) of Black girls and women in K-16 STEM education. Such models are also needed within P-20 computing education to promote the persistence of Black girls and women.

Mentoring

Mentoring is a significant factor in women's persistence in STEM education, in particular, at the graduate level (Borum & Walker, 2012; Herling, 2011). Previous studies have often associated mentoring programs with providing role models, or they have referred to mentoring synonymously with the function of role models (Heo & Myrick, 2009; Herling, 2011). Other studies have considered the impact of race and gender on Black women and men. In Borum and Walker's (2012) study, African American women were impacted by mentors who shared the same race or gender as themselves. Participants with Black female or Black male mentors acknowledged a stronger sense of encouragement to pursue the mathematics field. However, they also have been positively impacted by mentors of any race or gender. While mentors of the same race and gender may be most desirable and useful, researchers equivocally agree that there is a lack of mentors and role models for girls and women of color (Herling, 2011; Varma & Hahn, 2008; Varma, 2009).

Family Support

Family members have played a key role in influencing and motivating Black girls and women to persist and pursue careers in STEM and computing, particularly their mothers (Bush, 2013). Moakler and Kim (2014) found that children with parents involved in STEM fields were one and a half times more likely to pursue STEM-related career fields. Parents and close family members with jobs in STEM or computing fields function as mentors and guides throughout the process, influencing their children's decisions to enroll in STEM or computing. In DeCuir-Gunby et al.'s (2013) study, they found that most Black and Latina women engineering majors had at least one supportive family member who exposed them to engineering and encouraged them to pursue an engineering career. Moreover, Stokes et al. (2015) concluded that parents and family members had a direct influence on participants' positive attitudes and future decisions to enroll in geoscience programs and possibly other STEM majors. Based on these findings, we can infer that family support also directly impacts the persistence of Black girls and women in computing.

Support from Teachers and College Professors

Black women who receive encouragement from high school teachers and college professors are most likely to pursue and persist in the STEM and computing workforces (Schumacher et al., 2008). However, in the absence of encouragement, Black women are less likely to pursue or persist in a STEM or computing job. In Galloway's (2012) dissertation study, Black women addressed how to improve the STEM pipeline, which is also relevant for computing education. One participant explained (pp. 92-93):

> It has to start early in elementary school. I discovered math in that it was interesting and easy for me to do. I was continually inspired. We need teachers to encourage us to actually 'do' math and science…If parents don't get involved, it can be hard to keep the students interested.

In Ireland et al.'s (2018) synthesis of research studies, they identified that identity, STEM interest, and confidence were significant contributing factors for Black girls and women's success in STEM education. Since researchers have focused more on barriers than supports, fewer research studies have focused on Black girls' and women's perceptions about the supports that have influenced their persistence in the US computing education pipeline, which warrants this study's need.

Methodology

Since individuals' lives are influenced by multiple contexts, including social, political, educational, cultural, religious, and familial contexts, life history research methods elucidate lived experiences in a broader context (Cole & Knowles, 2001). Life history research is contrary to narrative inquiry, which focuses solely on deriving meaning from individuals' experiences. In this study, I used the counter-life herstory method (Ashford-Hanserd, 2020; Ashford, 2016) to reveal unhidden truths about Black girls and women's experiences in the US's sociopolitical context computing education. Counter-life herstories are derived from counterstories, life histories, and herstories. Counterstories give marginalized person voice to counter the master narrative or majoritarian perspective about their experiences (Bernal & Villalpando, 2002; Closson, 2010; Delgado et al., 2017; Solórzano & Yosso, 2002). Life histories represent individuals' retrospective accounts about their life stories (Watson & Watson-Franke, 1985), while herstories denote "the rewriting or respeaking of history" from a woman's perspective (Mills, 2003, p. 118). I engaged my participants in a series of in-depth interviews to compile detailed descriptions of their lived experiences in the broad context of US computing education.

Participants

I conducted a nationwide search to recruit a purposive sample of five Black women faculty who met the following criteria (Merriam & Tisdell, 2015): a) US citizen, b) Ph.D. degree holder in a computing discipline (e.g., computer science, computer engineering, information systems, information technology) from a US doctoral-granting institution, c) computing faculty member at a US college or university, and d) willingness to participate in a series of four in-depth interviews. Five participants, ages 32-38 and consisting of assistant professors, associate professors, and a postdoctoral researcher, opted to participate in my study (Table 1).

Table 1. Profiles of Study Participants

Pseudonym*	***Ethnicity***	***Computing degrees***	***Current Role***	***Institution***
Alona	African American	BSCS; MSCS; CS Ph.D.	Assistant Professor, CS, and CE	PWI
Bianca	African American	BSCS; MSCS; CS Ph.D.	Associate Professor, CIS, and CS	HBCU
Dana**	African American	BSSE; CIS Ph.D.	Associate Professor, IS	PWI
Jeanne	Haitian American	BSEE; MSIE; M.Ed. IT CS Ph.D.	Postdoctoral Researcher	PWI
Susan	African American	BS MIS; MS MoT; CIS Ph.D.	Assistant Professor, MIS	PWI

*Notes: *Participants identified pseudonym names during the first interview. **Tenured faculty member.*

CS = Computer Science, CE = Computer Engineering, CIS = Computer Information Systems, EE = Electrical Engineering, IE = Industrial Engineering, IS = Information Systems, IT = Instructional Technology, MIS = Management Information Systems, MoT = Management of Technology; SE = Systems Engineering

Data Collection

Life history data are primarily collected through individual interviews (Atkinson, 2007; Cole & Knowles, 2001; Janesick, 2010). I employed an ethic of caring by directly engaging with my participants in in-depth, one-on-one interviews to construct their counter-life-herstories with rich descriptions of their unique educational experiences (Creswell, 2014; Merriam & Tisdell, 2015). Specifically, I collected confidential data elements such as a) timeline interviews, b) semi-structured counter-life story interviews, and c) participant reflective journal writings that were handwritten journal entries or entered online in Google Docs. Additionally, I used a reflective journal to capture my observational notes during interviews and to record an audit trail to reflect on my experiences during the research process. In the first interview, participants completed a timeline of key life events. During interviews two and three, participants were asked to describe critical scenes or experiences (e.g., low points, challenges, turning points, and high points) that impacted their US computing education persistence. During the final interview, I asked participants to provide their recommendations to improve US computing education at all Black girls and women levels, which I address in this paper.

Data Analysis

During the transcription process, I employed an ethic of accountability by ensuring that the narrative account reflected my participants' voices and words. I only minimally edited their quotations by removing repetitions, question prompts, comments, and fillers such as "like", "um," and "you know" to produce a coherent and seamless narrative account (Atkinson, 2007). In response to the research question, I familiarized myself with my participants' stated recommendations to improve US computing education for Black girls and women by listening to interview audio files and reading transcribed interviews loaded in ATLAS. ti 6.5, and by reading notes in my researcher's journal. To ascertain emergent themes, I performed an open coding process, which consisted of developing codes while reading the data elements (Saldaña, 2013).

Results

During the final interview, participants were asked to share what improvements should be implemented to engage Black girls and women. Upon conducting thematic analysis (Braun & Clarke, 2006) of my participants' responses, I identified four emergent themes: 1) Improve access, quality, and early exposure to CE, 2) Create counterspaces for Black girls and women, 3) Confront unconscious biases of teachers and faculty, and 4) Provide mentoring opportunities (see Table 2).

Table 2. Emergent Themes: Recommendations for Broadening Participation of Black Women and Girls in US P-20

Computing Education (CE)

Responses	*Alona*	*Bianca*	*Dana*	*Jeanne*	*Susan*
1) Improve access, quality, and early exposure to CE	"Change accessibility." "Educate teachers."		"Plant the seed."		"Enhance math rigor; more math opportunities."
2) Create counterspaces for Black girls and women	"Female students need equitable and equal spaces."		Identify a "targeted community."	"Connect CE to targeted audiences values."	
3) Confront unconscious biases	"Change the way people think." "Watch pronouns."				
4) Provide mentoring opportunities			"Have a buddy."		

She said:

> Well, I think at this point, strides have really being made. Without all of the broadening participation grants, and all of the themes of diversity at different institutions and all of these middle school and even elementary school programs… With the computer science education week. It's a lot happening right now.

Bianca also mentioned current initiatives, such as computer science education week (CSEdWeek), that have been implemented. CSEdWeek is hosted annually by Code.org, a national nonprofit organization that provides free computer science resources to promote interest in computer science among K-12 students. CSEdWeek commemorates the birthdate of Admiral Grace Murray Hopper (December 9, 1906), a woman pioneer in computing. Bianca agreed that this effort, along with other efforts, should continue to be sustained by funding and support. Other participant responses aligned with the four emergent themes as follows.

1) Improve Access, Quality, and Early Exposure to Computing Education (CE)

This theme was one of the salient themes among my five participants. While "strides have really been made," three transformative leaders suggested the following additional recommendations to improve access, quality, and early exposure to CE among Black girls and women: "change accessibility," "educate teachers," "plant the seed," "enhance math rigor" and provide "more math opportunities."

"Change Accessibility." Alona provided an example to illustrate the unaffordability of computer science camps for low-income students and the need to offer affordable options. She said, "A lot of times these computer camps are $2,000, and it prices out a lot of people who cannot afford to go. So, they have the aptitude, but just not the money." Moreover, she suggested computing should be as standard as mathematics in school because "computer science is the new math." Alona explained, "…everyone learns math, you can't get out of high school without learning math, why not computing? Because that's the next wave." Furthermore, she said, "Everybody uses math in high school and college to solve problems. It's going to be computing in a second." Overall, Alona suggested that computing should be required, similar to mathematics.

"Educate Teachers." Alona suggested that teachers facilitate more computer usage in the classroom. Moreover, teachers should be further educated on how to use computers to alleviate their fears of using computers in the classroom. Alona perceived some seasoned teachers with "15, 20, 30, and 40 years of experience" are still incorporating "point and shoot" methods because they have the mentality of "I've always done it this way." so they do not explore all of the possibilities available with the technology they are using in the classroom." Furthermore, based on her experience training teachers (i.e., Programming for CS Teachers Summer Camp), Alona witnessed them asking questions such as, "What if they ask me a question I don't know?" Her reply was, "Google it, that's what I did. Even if you're in class, and it [doesn't work], then tell them, "You know what, that's a really good question. Let's find out." Therefore, she encouraged these teachers to introduce computing as "an exploratory kind of thing" rather than having the attitude of "I'm not going to teach if I don't know all the answers." In conclusion, Alona recommended that schools may hire a part-time computer teacher or compensate teachers who are adept in computing.

"Plant the Seed." Dana suggested that teachers and professors should "plant the seed" to help students recognize career pathways in undergraduate computing education. Dana drew from her personal successes and experiences to provide a meaningful recommendation.

"Enhance Math Rigor and Provide More Math Opportunities." Susan provided recommendations to enhance math rigor based on her experience in mathematics. She said:

> I would say enhance math rigor. More math opportunities, [and] more innovation in math courses to make math more interesting. Teach ways that speak to more than one child. Now just standing at the board writing down math problems... As an educator myself, that's not the best way to teach all students. Even in my computer classes, I don't just teach one way. I've been teaching a multitude of ways, and I offer a multitude of assessments because not Everybody takes one particular test. Everybody doesn't like that type of testing or perform well on those types of exams. So, I have to give many different types.

Susan's detailed recommendation may help improve mathematics education at all levels. Although she did not explicitly mention it, she described the need to introduce various learning styles in the mathematics curriculum. Susan agreed that computer logic should be offered to prepare kids for computer science. Furthermore, she thought we should "create a love or passion in that [mathematics] early; I think that that would be good." She suggested "kindergarten" as an excellent timeframe to introduce children to mathematics and logical reasoning. Susan thought "some type of special emphasis on the math," similar to our emphasis on children's daily activities with "sight words" and "reading," should be incorporated, such as doing "math every day." Overall, Susan believed introducing a "fundamental knowledge of math reasoning" in early on will improve mathematics education overall and promote comfortability with Computer classes, regardless of the Computing discipline.

2. Create Counterspaces for Black Girls and Women

This theme was also a salient among the five participants. Three of the five participants emphatically agreed on the need for "equitable and equal spaces," "a targeted community," "plant the seed," "enhance math rigor," and provide "more math opportunities."

"Female Students Need Equitable and Equal Spaces." Alona thought women should be encouraged to enroll in computer science classes similar to home economics classes. She provided an example in the literature that suggests male students need more attention than female students in mathematics and science. However, she asserted that

female students also needed equitable and equal spaces as male students.

"Identify a "Targeted Community." Dana suggested that a "targeted community" was needed to communicate about educational opportunities and best practices to African Americans. Specifically, she recommended that the "Church" serves as this targeted community because historically, the "Black Church" has been a community hub for African Americans:

> Maybe it is through the Church, right, if many African Americans are in the Church? I think more often than not, we can presume, even if they're not currently actively practicing or believe, they're [Churches] our bases. And so, they at least understand, they understand the language.

Moreover, Dana thought the Church could serve as a "subterfuge" or a "sneak attack" to encourage more Blacks to participate in STEM and computing. Similar to "talking urban design, but we're really talking about technology. Alternatively, social media, and we're really talking about computing." She also believed they could offer a multi-level approach to engage parents and students. More than anything, Dana thought the Church could serve as an information source to inform parents about mathematics requirements, summer camps, and other STEM and computing-related information. She also began to think outside of the box about other "sneak attacks." She proposed a "programming app for quickly accessing your aptitude, your l aptitude. But really, it's a way of saying, "You like, art? You're an engineer!" Or "Oh, you don't like that? But why? Here is where you can go to find out why." She did not want to assume these types of solutions were already available. Dana also thought as this idea matured, we should know more about existing targeted communities.

"Connect Computing Education to the Targeted Audience's Values." Jeanne's primary suggestion was related to the connection of computing education to broader experiences, such as students' future goals. She also provided supporting examples in an animated fashion as she shared her recommendation. Jeanne comically introduced the notion of our society being focused on "Kids-like fun" or "You've got to gamify everything," by connecting a computer game to activity. She agreed, "research does show, kids and adults are gaming like nothing before. However, she thought some efforts were "misdirected." She explained her personal experience to describe this phenomenon further:

> Games were fun, but I didn't see how any of that had to do with what I was doing in my life. So, I think we're misdirected. Yes, games can hold kids' attention for hours upon hours. But they don't necessarily see themselves in it. And you can throw as many Black characters as you want. You can make the experience as urbanized as you want. They still don't necessarily connect that to goals, dreams, etc. Right? So, I think, again, connecting the computer education experience to the broader experiences of self-discovery and all the things we do with kids in general, right? Learn about you. Learn about all your options in life. The more you are exposed to options, and then bringing that into computing.

Jeanne also described the current environment of existing informal computing programs (i.e., afterschool, summer camps) that offer some career exploration and real-life application, but she has also seen programs that offer "computing for computing sake." Jeanne finally realized the crux of her recommendation:

> Now I realize what I was trying to say. The problem with computing education is we don't know what they value, and we don't know how to connect it to their value. If you find a way to connect computing education for the targeted audience's value, then build it around there, it will be a sure win, in my opinion.

She further exclaimed: "Kids know who care," and "If you're putting in that effort to figure out who they are, what they value, what's important to them, and then build computing education to that, you won't be able to pull them apart. Jeanne's experience in human-computer interaction was evident in her response.

3. Confront Unconscious Biases

Alona was the only participant that supported this theme. She provided two recommendations to confront unconscious biases in education and the workforce: "change the way people think," and "watch the pronouns."

"Change the Way People Think." Alona recommended "changing the way people think about science and computer science." She gave an example related to most people's immediate perception of the word "geek squad:"

> Say the word "geek squad." You'll immediately have a picture of a white man with glasses, dark hair, fixing a computer. For a Black woman who does not fit that image, that's not something they will typically gravitate towards. And I don't even know if it's anything education can do about it.

Alona did not think computing education could change this perception because it is influenced more by our society. Her central point was that we should change the image of computing to engage more Black girls and women.

"Watch the Pronouns." Alona also cautioned us to consider the pronouns we use in our everyday language. She described an encounter with a student who removed her from his dissertation committee. She apparently challenged his usage of pronouns as he described nurses and doctors in his profession. She said: "Every time he talked about the doctors, he said, "he." Every time he talked about the nurses, he said, "she." Alona summarized his behavior as an "unconscious association" or bias where males are assigned lead science roles, and females are assigned to "helping sorts of occupations." She believed we needed to change the image of computing and the pronouns we use because "We certainly don't fit the mold." Alona drew from her personal experiences to describe this recommendation.

4. Provide Mentoring Opportunities

Dana was the primary participant that suggested mentoring opportunities should be provided for Black girls and women based on her successes with having a "buddy" in her academic classes throughout high school and college.

> I remember standing in the hallway, as a doctoral student, with my buddy. She was crying about the terrible feedback she got. It was almost like a virtual stop. I'm like, "Okay, get a grip on yourself because it's not about you. You're not going anywhere because I can't let you go anywhere. I need you here. So, get your cry, do what you have to do. I'll see you in class." And now she's a leader in the high school, and she's employed the method that she got such terrible feedback on in her dissertation. She mastered it. Now, maybe because she was trying to prove something, but she did it! She did it!

Dana suggested a buddy system for students at the graduate level to encourage peer-level support. She advises all doctoral students to have a buddy. In her educational journey, she often partnered with other students or groups to complete assignments and school work. Specifically, Dana recommended a buddy "because there's going to be some

point in time when you're going to be weak, and it can't be just about you." She then shared to relay an experience when she served as a source of support for her buddy in the doctoral program.

Discussion

During this study, five transformative Black women leaders offered various recommendations for improvements that connected to their personal lived experiences as former students and current faculty members in computing education departments across the United States. These recommendations for improvement were summarized by four emergent themes: 1) Improve access, quality, and early exposure to computing education, 2) Create counterspaces for Black girls and women, 3) Confront unconscious biases; and 4) Provide mentoring opportunities. Next, I connect these themes to the literature and integrative conceptual framework.

Improve Access, Quality, and Early Exposure to Computing Education

To improve access, quality, and early exposure to computing education for Black girls and women, my participants (Alona, Dana, Susan) suggested that policymakers and educators "change accessibility," "educate teachers," "plant the seed," "enhance math rigor," and provide "more math opportunities." To "change accessibility," Alona suggested that efforts are made to increase the affordability of computer science programming. We know that women and minorities have historically lacked access to computers and technology, which has deterred their entry into computing disciplines (Varma, 2009). As such, my participants' recommendations support claims in the current literature since we realize issues with affordability and access that present inequities in K-12 computer science education for Black girls and other girls of color. While girls of color from affluent homes may be able to afford computer camps priced at $2,000, such inequitable access to education reveals that forms of institutionalized racism still exist (Bell, 1993; Billingsley & Caldwell, 1991; Closson, 2010; Solórzano & Yosso, 2002).

Since Black women who receive encouragement from high school teachers and college professors are most likely to pursue and persist in STEM and computing (Schumacher et al., 2008), administrators should increase efforts to "educate teachers" on technology (Alona) to alleviate their fears of using computers in the classroom. Teachers should also be encouraged to "plant the seed" about computing (Dana) to encourage more Black girls to pursue computing careers. As teachers "enhance math rigor" and provide "more math opportunities" (Susan), they have the potential to increase Black girls' early exposure to computing. It is vital since Black girls are often discouraged from participating in rigorous mathematics and science courses, and as a result, do not enter postsecondary computing education (Smith-Evans et al., 2014).

Create Counterspaces for Black Girls and Women

My participants (Alona, Dana, and Jeanne) indicated the need for counterspaces for Black girls and women because they serve as "equitable and equal spaces." To create these spaces, they suggested that a 'targeted community' is identified and that computing education connects to the "targeted audiences' values." Since counterspaces are vital social justice strategies for the survival of students of color in higher education (Solórzano & Yosso, 2002), they are also viable solutions for Black girls and women in P-20 education. In response to barriers in computing education, Black women may create counterspaces or safe homogeneous spaces to shield themselves, particularly within

hegemonic racialized environments such as predominately white institutions (Solorzano et al., 2000). Similar to the STEM SISTA space model (Ashford et al., 2017), I propose the creation of a Computing or STEM+Computing SISTA space to "center the needs and interests" (p. 8) of Black girls and women in P-20 computing education and to promote the persistence of Black girls and women. The Computing SISTA space may be utilized in both formal and informal P-20 computing education contexts.

Since the Black Church has historically played an enormous role in the lives of African Americans or Blacks in the US (Dillard, 2000, 2012; Dillard & Okpalaoka, 2011), it could serve as a "subterfuge" or a "sneak attack" to encourage more Blacks girls and women to participate in STEM and computing. Black women have often elicited support from "the Church" to enable their persistence and overall success while charting their computing education pathways (Bush, 2013). Moreover, the Black Church and other faith-based organizations have often intervened to improve Black students' academic achievements in secondary and postsecondary education (Billingsley & Caldwell, 1991). Therefore, I propose that federal agencies, such and the National Science Foundation, set aside funding or establish new broadening participation initiatives to build the capacity of Black church leaders and other historically underrepresented groups to dramatically increase the number of Black women and girls who enter and persist in STEM and computing.

Confront Unconscious Biases

One of the most salient barriers to Black girls and women persisting in P-20 computing education is unconscious biases. Most often, in P-20 computing education, unconscious biases are instigated by the teachers and faculty members of Black girls and women (Hill et al., 2010; McGee & Bentley, 2017). In this study, Alona was the only participant who identified the need to confront unconscious biases by "changing the way people think," and "watching the pronouns" used in computing education and the computing workforce. In essence, she believed to "change the way people think," we must first change the "image of computing."

Since unconscious biases are so prominent in the literature, and three of five participants (Bianca, Dana, Susan) encountered negative stereotypes and biases from white male professors in my previous study (Ashford-Hanserd, 2020), I was surprised that other participants did not provide recommendations to confront unconscious biases. Furthermore, Alona suggested a shift in the "pronouns" that we use in our everyday language. Based on Alona's recommendations, and the general nature of unconscious biases in US computing education. I propose that a new unconscious bias training is developed for computing teachers and faculty that promotes a transformative paradigm (Mertens, 2010), as a social justice act to cultivate computing interest among Black girls and women intentionally, To shift the racialized environment and culture of P-20 educational institutions, I recommend that participation in unconscious bias training and subsequent actions are connected to the annual performance appraisals of teachers and computing faculty to influence lasting changes due to the criticality of the initiative.

Provide Mentoring Opportunities

The act of mentoring provides significant support for Black women's persistence in STEM education, particularly at the graduate level (Borum & Walker, 2012; Herling, 2011). As the only participant to recommend mentoring as an approach, Dana suggested that Black girls and women should "have a buddy" based on her successful peer mentoring experiences. As supported by the literature, Dana suggested that students at the graduate level should engage in a buddy system to encourage peer-level support. Though Black women seem most impacted by mentors who share the same race or gender as themselves, they are still positively impacted by mentors who do not share the same race

or gender (Borum & Walker, 2012). In the literature, mentoring programs have been associated with providing role models, and they have been referred synonymously with the function of role models (Heo & Myrick, 2009; Herling, 2011). Therefore, I recommend that further study is conducted on the influence of mentoring on the persistence of Black girls and women in P-20 computing education.

Connections to the Conceptual Framework

This study builds upon the current body of knowledge about the supports for Black girls and women to persist in US P-20 computing education. To govern my knowledge validation process, I used Afrocentric feminist epistemology (Collins, 2009), which nullified the Eurocentric masculinist approach to accepting my participants' counter-life herstories as concrete truths. Due to the nature of the interview protocols, I engaged directly in dialogue with participants to co-construct their counter-life herstories. I also invoked an ethic of caring during the interviews by openly sharing my reflections and affirmations of their successes and an ethic of accountability as I maintained their confidentiality through their identification of pseudonyms and my intention of following a social justice agenda. My participants' counter-life herstories support the notion of critical race theory's (CRT) experiential knowledge through counterstories, which nullify majoritarian stories (Bernal & Villalpando, 2002; Closson, 2010). In contrast, some CRT scholars disapprove of white scholars generating knowledge about Blacks because they are disconnected from their experiences and unique histories (Collins, 2009; Collins, 2008; Delgado, 1989; Delgado et al., 2017). I conducted this study from an Afrocentric feminist epistemological perspective as an early Black woman scholar.

Furthermore, my findings were corroborated by the literature to reveal hidden truths about broadening Black girls and women's participation in US computing education from the perspectives of Black women scholars. A limitation of this study is that my participants' collective stories are not generalizable and thus do not reflect all Black women faculty's recommendations for improving P-20 US computing education. However, my results provide policy recommendations to improve pathways for Black girls and women in P-20 computing education.

References

Ashford-Hanserd, S. (2020). Counter-life herstories: Black women faculty pathways in US P-20 computing education. Journal of Women and Minorities in Science and Engineering.

Ashford, S. N., Wilson, J. A., King, N. S., & Nyachae, T. M. (2017). STEM SISTA spaces: Creating counterspaces for black girls and women. In T. Ransaw & R. Majors (Eds.), Emerging Issues and Trends in Education. Michigan State University Press. https://doi.org/10.14321/j.ctt1qd8zjk.6.

Ashford, S. N. (2016). Our Counter-Life Herstories: The Experiences of African American Women Faculty in US Computing Education [University of South Florida]. http://scholarcommons.usf.edu/etdhttp://scholarcommons.usf.edu/etd/6171

Atkinson, R. (2007). The life story interview as a bridge in narrative inquiry. In D. J. Clandinin (Ed.), Handbook of narrative inquiry: Mapping a methodology. (pp. 224–245). Sage Publications, Inc. https://doi.org/10.4135/9781452226552.n9

Baber, L. D. (2015). Considering the interest-convergence dilemma in STEM education. The Review of Higher Education, 38(2), 251–270. https://muse.jhu.edu/article/563939

Bell, D. A. (1980). Brown v. Board of Education and the Interest-Convergence Dilemma. Harvard Law Review, 93(3), 518–533. https://doi.org/10.2307/1340546

Bell, D. A. (1993). Faces at the bottom of the well: The permanence of racism. Basic Bks.

Benard, B. (1993). Fostering resiliency in kids. Educational Leadership, 51(3), 44–48.

Bernal, D. D., & Villalpando, O. (2002). An apartheid of knowledge in academia: The struggle over the" legitimate" knowledge of faculty of color. Equity & Excellence in Education, 35(2), 169–180.

Billingsley, A., & Caldwell, C. H. (1991). The Church, the family, and the school in the African American community. The Journal of Negro Education, 60(3), 427–440.

Borum, V., & Walker, E. (2012). What makes the difference? Black women's undergraduate and graduate experiences in mathematics. The Journal of Negro Education, 81(4), 366–378.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Bush, J. L. (2013). The persistence of black women in engineering: A phenomenological study (Unpublished doctoral dissertation) [Wilkes-Barre, PA: Wilkes University]. https://search.proquest.com/docview/1530298586?pq-origsite=gscholar

Charleston, L. J., Adserias, R. P., Lang, N. M., & Jackson, J. F. L. (2014). Intersectionality and STEM: The role of race and gender in the academic pursuits of African American women in STEM. Journal of Progressive Policy & Practice, 2(3), 273–293.

Charleston, L. J., George, P. L., Jackson, J. F. L., Berhanu, J., & Amechi, M. H. (2014). Navigating underrepresented STEM spaces: Experiences of Black women in US computing science higher education programs who actualize success. Journal of Diversity in Higher Education, 7(3), 166.

Closson, R. B. (2010). Critical race theory and adult education. Adult Education Quarterly, 60(3), 261–283. https://doi.org/10.1177/0741713609358445

Cole, A. L., & Knowles, J. G. (2001). Lives in context: The art of life history research. In Lives in context: The art of life history research. AltaMira Press.

Collins, P. H. (2009). Black feminist thought: knowledge, consciousness, and the politics of empowerment. Routledge.

Collins, P. H. (2008). Toward an Afrocentric feminist epistemology. In Social theory: roots and branches (Reprinted from Black feminist thought, 1990).

Crenshaw, K. W. (2011). Twenty years of critical race theory: Looking back To move forward. In Connecticut Law Review (Vol. 43, Issue 5, pp. 1253–1352).

Creswell, J. W. (2014). Research design: Qualitative, quantitative, and mixed methods approaches. 4th Edition. In SAGE Publication (4th Editio). https://doi.org/10.1007/s13398-014-0173-7.2

DeCuir-Gunby, J. T., Grant, C., & Gregory, B. B. (2013). Exploring career trajectories for women of color in engineering: The experiences of African American and Latina engineering professors. Journal of Women and Minorities in Science and Engineering, 19(3). https://doi.org/10.1615/JWomenMinorScienEng.2013005769

Delgado, R. (1989). Storytelling for Oppositionists and Others: A Plea for Narrative. Michigan Law Review, 87(8), 2411–2441. https://doi.org/10.2307/1289308

Delgado, R., Stefancic, J., & Harris, A. P. (2017). Critical race theory: an introduction. (Third edit). New York University Press.

Dillard, C. B. (2000). The substance of things hoped for, the evidence of things not seen: Examining an endarkened feminist epistemology in educational research and leadership. International Journal of Qualitative Studies in Education, 13(6), 661–681.

Dillard, C. B. (2012). On spiritual strivings: Transforming an African American woman's academic life. SUNY press.

Dillard, C. B., Abdur-Rashid, D., & Tyson, C. A. (2000). My soul is a witness: Affirming pedagogies of the spirit. International Journal of Qualitative Studies in Education, 13(5), 447–462.

Dillard, C. B., & Okpalaoka, C. (2011). The sacred and spiritual nature of endarkened transnational feminist praxis in qualitative research. The Sage Handbook of Qualitative Research, 147–162.

Galloway, S. N. (2012). African American women making race work in science, technology, engineering, and math (STEM) [University of North Carolina at Chapel Hill]. https://doi.org/doi.org/10.17615/yp2a-ae84

Garmezy, N. (1993). Children in poverty: Resilience despite risk. Psychiatry, 56(1), 127–136. https://doi.org/0.1080/00332747.1993.11024627

George-Jackson, C. E., & Lichtenberger, E. J. (2012). College confidence: How sure high school students are of their future majors. (IERC 2012-2). In Illinois Education Research Council. Southern Illinois University, Edwardsville. https://eric.ed.gov/?id=ED544651

Harding, S. (1987). The method question. Hypatia, 2(3), 19–35.

Heo, M., & Myrick, L. M. (2009). The girls' computing club: Making positive changes in gender inequity in computer science with an informal, female learning community. International Journal of Information and Communication Technology Education (IJICTE), 5(4), 44–56. https://doi.org/10.4018/jicte.2009041005

Herling, L. (2011). Hispanic women overcoming deterrents to computer science: A phenomenological study. University of South Dakota.

Hill, C., Corbett, C., & St Rose, A. (2010). Why so few? Women in science, technology, engineering, and mathematics. ERIC. https://eric.ed.gov/?id=ED509653

Howard-Hamilton, M. F. (2003). Theoretical frameworks for African American women. New Directions for Student Services, 2003(104), 19–27. https://doi.org/10.1002/ss.104

Huber, L. P. (2009). Challenging racist nativist framing: Acknowledging the community cultural wealth of undocumented Chicana college students to reframe the immigration debate. In Harvard Educational Review (Vol. 79, Issue 4). https://doi.org/10.17763/haer.79.4.r7j1xn011965w186

Ireland, D. T., Freeman, K. E., Winston-Proctor, C. E., DeLaine, K. D., McDonald Lowe, S., & Woodson, K. M. (2018). (Un) hidden figures: A synthesis of research examining the intersectional experiences of Black women and girls in STEM education. Review of Research in Education, 42(1), 226–254. https://doi.org/10.3102/0091732X18759072

Jackson, D. L. (2013). A balancing act: Impacting and initiating the success of African American female community college transfer students in STEM into the HBCU environment. The Journal of Negro Education, 82(3), 255–271. https://doi.org/10.7709/jnegroeducation.82.3.0255

Janesick, V. J. (2010). Oral history for the qualitative researcher: Choreographing the story. Guilford Press.

King, N. S., & Pringle, R. M. (2019). Black girls speak STEM: Counterstories of informal and formal learning experiences. Journal of Research in Science Teaching, 56(5), 539–569. https://doi.org/10.1002/tea.21513

Ladson-Billings, G., & Tate IV, W. F. (1995). Toward a critical race theory of education. Teachers College Record, 97(1),47.

Lopez, M. H., & Gonzalez-Barrera, A. (2014). Women's college enrollment gains leave men behind. Pew Research Center, 6. http://www.pewresearch.org/fact-tank/2014/03/06/womens-college-enrollment-gains-leave-men-behind

Malcom, L., & Malcom, S. (2011). The double bind: The next generation. Harvard Educational Review, 81(2), 162–172. https://doi.org/10.17763/haer.81.2.a84201x508406327

Malcom, S. M., Hall, P. Q., & Brown, J. W. (1976). The double bind: The price of being a minority woman in science.

Margolis, J., Goode, J., & Bernier, D. (2011). The need for computer science. Educational Leadership, 68(5), 68–72. http://libproxy.txstate.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ972035&site=eds-live&scope=site

Margolis, J., Holme, J. J., Estrella, R., Goode, J., Nao, K., & Stumme, S. (2003). The computer science pipeline in urban high schools: Access to what? For whom? IEEE Technology and Society Magazine, 22(3), 12–19.

McGee, E. O., & Bentley, L. (2017). The troubled success of Black women in STEM. Cognition and Instruction, 35(4), 265–289. https://doi.org/10.1080/07370008.2017.1355211

Merriam, S. B., & Tisdell, E. J. (2015). Qualitative research: A guide to design and implementation. John Wiley & Sons.

Mertens, D. M. (2010). Transformative mixed methods research. Qualitative Inquiry, 16(6), 469–474.

Mills, A. J. (2003). History/herstory: an introduction to the problems of studying the gendering of organizational culture over time. In Gender, Identity, and the Culture of Organizations (pp. 129–150). Routledge.

Moakler Jr, M. W., & Kim, M. M. (2014). College major choice in STEM: Revisiting confidence and demographic factors. The Career Development Quarterly, 62(2), 128–142.

National Science Foundation. (2015). Women, minorities, and persons with disabilities in science and engineering: 2015 (Special Report NSF 15-311).

National Science Foundation. (2019a). Broadening participation in computing (BPC). https://www.nsf.gov/cise/bpc/

National Science Foundation. (2019b). National center for science and engineering statistics. Doctorate Recipients from US Universities, 18–304. www.nsf.gov/statistics/wmpd/

Ong, M., Wright, C., Espinosa, L., & Orfield, G. (2011). Inside the double bind: A synthesis of empirical research on undergraduate and graduate women of color in science, technology, engineering, and mathematics. Harvard Educational Review, 81(2), 172–209.

Palmer, R. T., & Wood, J. L. (2013). Community colleges and STEM: Examining underrepresented racial and ethnic minorities. Routledge.

Park, J. J., Dizon, J. P. M., & Malcolm, M. (2020). Spiritual Capital in Communities of Color: Religion and Spirituality as Sources of Community Cultural Wealth. Urban Review, 52(1). https://doi.org/10.1007/s11256-019-00515-4

Saldaña, J. (2013). The coding manual for qualitative researchers. In International Journal (2nd ed.). SAGE Publications Inc. https://doi.org/10.1017/CBO9781107415324.004

Schumacher, M. M., Johnson, M. N., Floyd, S. R., Reid, C. E., Noland, M. P., & Leukefeld, C. G. (2008). Young women in science: Impact of a three-year program on knowledge of and attitudes toward science. Journal of Women and Minorities in Science and Engineering, 14(3).

Singh, K., Allen, K. R., Scheckler, R., & Darlington, L. (2007). Women in computer-related majors: A critical synthesis of research and theory from 1994 to 2005. Review of Educational Research, 77(4), 500–533. https://doi.org/10.3102/0034654307309919

Smith-Evans, L., George, J., Graves, F. G., Kaufmann, L. S., & Frohlich, L. (2014). Unlocking Opportunity for African American girls: A call to action for educational equity.

Solorzano, D., Ceja, M., & Yosso, T. (2000). Critical race theory, racial microaggressions, and campus racial climate: The experiences of African American college students. Journal of Negro Education, 60–73.

Solórzano, D. G., & Villalpando, O. (1998). Critical race theory, marginality, and the experience of students of color in higher education. Sociology of Education: Emerging Perspectives, 21, 211–222.

Solórzano, D. G., & Yosso, T. J. (2002). Critical race methodology: Counter-storytelling as an analytical framework for education research. Qualitative Inquiry, 8(1), 23–44.

Somekh, B., & Lewin, C. (2011). Theory and methods in social research. Sage.

Stokes, P. J., Levine, R., & Flessa, K. W. (2015). Choosing the geoscience major: Important factors, race/ethnicity, and gender. Journal of Geoscience Education, 63(3), 250–263.

Stout, J. G., Dasgupta, N., Hunsinger, M., & McManus, M. A. (2011). STEMing the tide: using ingroup experts to inoculate women's self-concept in science, technology, engineering, and mathematics (STEM). Journal of Personality and Social Psychology, 100(2), 255.

Varma, R., & Hahn, H. (2008). Gender and the pipeline metaphor in computing. European Journal of Engineering Education, 33(1), 3–11. https://doi.org/10.1080/03043790701745936

Varma, Roli. (2009). Bridging the digital divide: Computing in tribal colleges and universities. Journal of Women and Minorities in Science and Engineering, 15(1).

Watson, L. C., & Watson-Franke, M.-B. (1985). Interpreting life histories: An anthropological inquiry. Rutgers Univ Pr.

Werner, E. E., & Smith, R. S. (1992). Overcoming the odds: High risk children from birth to adulthood. Cornell University Press.

Zweben, S., & Bizot, B. (2014). 2013 Taulbee survey. Computing, 26(5), 10–55.