

Intersectionality in the narratives of black women in computing through the education and workforce pipeline

Black women
in computing

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Abstract

Purpose – The purpose of this study is to investigate the narratives of 93 Black women in computing in the USA to identify salient themes that are at the intersection of race and gender in the field of computer science.

Design/methodology/approach – The study uses a multi-method approach with a survey to describe the sample and a series of focus groups for in-depth analysis of themes. The qualitative methodology uses a grounded theory and consensual qualitative research approach with a research team that includes computer scientists and social scientists to collect and analyze data. Given the highly technical field of computer science and the intersectional experiences of the participants, this approach was optimal to capture and code data through the lens of Black women in computing.

Findings – The authors found four main themes that represented specific needs for Black women in the computing community. The first is the importance of linking Black women in computing (i.e. their recruitment, retention and career growth) to the bottom line of organizational and personal accountability. The second is effective cultural and educational supports for Black women in computing across pathways, starting in middle school. The third is to provide leadership development as a part of their educational and workplace experience. The fourth is a collection of empirical research and scholarship about and for Black women as a part of the computing literature.

Originality/value – Black women comprise one of the most underrepresented subgroups in the area of computer science in the USA. There is very little research about Black women in computing. To promote broadened participation in computing, there is a critical need to understand the narratives of successful Black women in the space.

Keywords Computer science education, Black women in computing, Education pathways, Intersectionality of race and gender, Workforce pathways

Paper type Research paper

Introduction

The excitement and value of computer science is palpable, from K-12 to higher education and the workplace. In a recent Glassdoor study (Berry, 2016), eight of the ten most profitable undergraduate majors are tied to science and engineering. Upon graduation, science and engineering majors earn the highest median salaries for entry-level positions, with computer science identified as the top earning entry-level job. Based on an analysis of more than 500,000 resumes and self-reported salaries, the entry-level salary of computer scientists is \$70,000 for a position as a software engineer, systems engineer or web developer (Berry, 2016). With such potential for career success and industry needs for highly qualified



programmers and computer scientists, it is no wonder that students and parents are interested in computer science as a field of study (Google Inc. and Gallup Inc., 2015), school districts are offering more computer science courses and programming clubs, and more state departments of education are considering computer science as a high school graduation requirement (Computer Science Teacher Association, 2013).

This reinvigoration of computer science provides an opportunity to understand the current state of the computer science field and how to promote an academic environment that is inclusive to all students. In promoting an inclusive computing science education culture, our study investigates the intersectionality of race and gender in the computing field, specifically looking at Black women[1] in computing. These women are one of the least represented groups across the education and workplace pathways (National Academies of Sciences Engineering and Medicine, 2018; National Science Board, 2016; National Science Foundation and National Center for Science and Engineering Statistics, 2013). Our study conducted focus groups and interviewed almost 100 Black women in computing professions in both university and corporate sectors to identify salient themes that describe their experiences in the field. Hearing and learning from the voices of Black women in computing are critical to understanding how to promote an inclusive computing science education and workforce culture. This research represents a twofold opportunity for the computing discipline. First, we learn how we might better support the increase of Black women (and girls) in the computing, and as a result, second, we can create a workforce that is more innovative and productive.

The context

From 1994 to 2012, the percentage of Black women entering college rose from 48 to 62 per cent (Lopez and Gonzalez-Barrera, 2014). At the same time, interest in Science, Technology, Engineering and Mathematics (STEM) careers grew (National Science Board, 2014, 2016), with almost half of first-year undergraduate students (45 per cent) intending to major in a STEM field or related major. Among the 45 per cent of freshmen indicating interest in majoring in STEM, 11 per cent were interested in computer science, mathematics or statistics. The STEM fields with the largest shares of interest are engineering (31 per cent) and biological sciences (32 per cent). It should be noted that *interest* in STEM is not the same as *intent* to major in a STEM field. This point is particularly striking when it comes to minority groups and computing.

Though it is expected that fewer individuals will actually pursue a terminal degree in computer science (CS), it is clear that at every point in the post-secondary ecosystem, Black students are severely underrepresented (Margolis, 2008; National Science Board, 2014, 2016; Zweben, 2013). Drilling down to the race/ethnicity breakdown of the mathematics and CS majors, Figure 1 shows the freshmen intent to major in mathematics or CS from 1998 to 2014. For Black students (green bolded line), the peak was in 1998 at around 17 per cent intent to major in mathematics or CS, with the trend decreasing each year, to a low of 9 per cent in 2014. For Asian and Hispanic students, while the overall intent is low, the trend is increasing over the years to about 20 per cent in 2014. These trends show that intent to major in mathematics or CS decreased for Black students across a 17-year span, while it increased for Asian and Hispanic students.

With intent to major in CS waning for Black students, as shown in Figure 1, it is not surprising that the number of students earning a bachelor's degree in mathematics or CS peaked in 2003 but remains low. In 2013, only 6,512 Black students graduated in mathematics or CS with a bachelor's degree. With respect to graduate degrees, we see the gaps widen further. The number of Black students earning a master's degree in

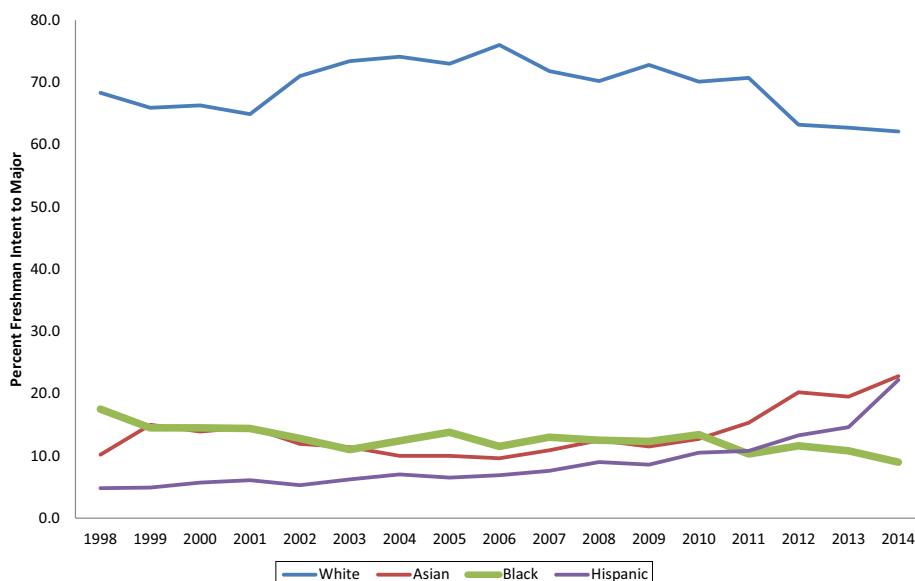


Figure 1.
Freshman intent to
major in mathematics
and computer science

Source: National Science Board (2016). Science and engineering indicators 2016

mathematics or CS is low, where in 2013, only 1,983 Black students graduated and earned a master's degree (National Science Board, 2016). At the doctoral level, Black students earning a mathematics or CS degree have remained relatively stable from 2000 through 2013, with fewer than 100 students graduating with a doctorate degree. In 2013, only 79 Black students graduated with a doctorate in mathematics or CS (National Science Board, 2016).

Looking at the intersectionality of race and gender, the numbers and percentages are significantly lower for Black women throughout the education pipeline (Casey, 2012; National Science Board, 2014, 2016; National Science Foundation and National Center for Science and Engineering Statistics, 2013). Moreover, Black women tenure-track professors remain significantly underrepresented in STEM disciplines (Rankins *et al.*, 2014). With respect to Black women as underrepresented minorities in CS, the most recent data disaggregated by race and gender among the field (which includes computer science, computer engineering and computer information) reveal that in the USA, 3.6 per cent of undergraduate, 1.6 per cent of master's and 1.2 per cent of doctoral degrees were conferred to Black women (Zweben, 2013; Zweben and Bizot, 2015a, 2016, 2017). In the most recent survey of 268 PhD-granting universities and colleges from Computing Research Association (Zweben and Bizot, 2015a), there were 95 Black women in doctorate programs in computer science, computer engineering and information programs. There were four Black women who graduated with a PhD (two in computer science, zero in computer engineering and two in information programs) (Zweben and Bizot, 2015a).

Theoretical framework: the intersectionality of race and gender in computing

To promote more Black women entering the STEM pipeline, researchers have looked at barriers to pursuing CS among women and among students of color (Espinosa, 2011; Hill *et al.*, 2010; Zarett and Malanchuk, 2005). However, there is a scarcity of literature that

focuses on the intersectionality of gender and race (Cantor *et al.*, 2014; Ong *et al.*, 2011; Ross, Capobianco and Godwin, 2017) and even less that focuses specifically on the experiences of Black girls and women in the CS pipeline.

Critical Race Theory (CRT) has been used “in a nice field like education” (Ladson-Billings, 1998) to examine the disproportionality in educational opportunities, school climate, discipline, representation, achievement, instruction and curriculum to name a few (Battey and Leyva, 2016; Ladson-Billings, 1998; Le and Matias, 2018; Ledesma and Caleron, 2015; Mensah and Jackson, 2018; Sleeter, 2017). The central tenant of CRT is in using:

[...] multiple methods and borrowing from diverse traditions in law, sociology, ethnic studies, and other fields to formulate a robust analysis of race and racism as a social, political and economic system of advantages and disadvantages accorded to social groups based on their skin color and status in a clearly defined racial hierarchy (Lynn and Parker, 2006, p. 282).

As an extension or aspect of CRT, the intersectionality framework explores racism experienced within and across divergent intersectional planes such as classism, sexism and ableism (Gillborn, 2015; Ledesma and Caleron, 2015). We explore the intersectionality framework of race and gender under three constructs:

- (1) structural intersectionality;
- (2) political intersectionality; and
- (3) representational intersectionality (Crenshaw, 1997).

The reality and lived experiences of juggling multiple identities is not like wearing different hats depending on the situation, such as only identifying as a computer scientist in a CS class or at work or only identifying as a woman in a female-only setting. The reality is about the intersectionality of race, gender and professional identity (such as CS), where these identities can seem mutually exclusive (Crenshaw, 1997; Parker, 2005; Stanley, 2009). CRT and feminist discourse often do not fully capture the lived experiences of Black women in predominantly white organizations (Stanley, 2009), where issues of race, gender and social class intersect to shape the social realities of women. Unfortunately, while there is much research on the challenges faced by Black women, there is:

[...] an absence of theories that explain, and more importantly, expose how the existence of race, gender, and social class may affect an individual's experience and therefore restrict the capacity to effectively learn and perform (Stanley, 2009, p. 554).

Representational intersectionality refers to how images of race and gender merge to construct the narratives and experiences of women (Crenshaw, 1997; Tate, 1997). For Black women, their educational experiences in computing and the role these experiences play in persisting in CS are often not a focus of study. There are often no – or very few – other Black women in computing programs, so there is no opportunity to form homogeneous networks of shared experiences. Black women do not talk openly about their negative experiences for a variety of reasons, a notion that Sue (2015) calls a “conspiracy of silence.” These experiences range from being ostracized for being different (e.g. peers or professors do not want to work with Black women) to the possibility that raising concerns around inequality can result in being labeled as overly aggressive or as the “angry Black woman” who does not take her academics seriously (Sue, 2015).

Political intersectionality refers to how the mutually exclusive notion of race and gender provide inadequate political framework that fails to contextualize the realities, narratives and experiences of women (Crenshaw, 1997; Tate, 1997). Black women's experiences simply differ from other women's experiences. The “double bind” nature of Black women's

participation in STEM ensures that issues of discrimination are indistinguishable from gender or race (Malcom and Malcom, 2011; Malcom *et al.*, 1975). Within the computing community, awareness about Black women's experiences is closeted. As the computing education experience for Black women is different from other groups, it is important to unpack these differences to better understand the nature of this silence. It should be noted that other women of color groups, such as Hispanic and Native American, may have similar experiences, and further research is needed there, too.

Structural intersectionality refers to how women of color are stuck within overlapping structures of subordination (Crenshaw, 1997; Tate, 1997). The dialogue around broadening participation in computing must change from focusing mostly on women to one that focuses on the intersectionality of race and gender if the computing educational community is to be more inclusive. Engaging more diverse perspectives in computing education can be not only described as a social justice issue but also promoted as a necessity to improve innovations in the industry (National Science Foundation and National Center for Science and Engineering Statistics, 2013). More specifically, to successfully increase the participation of Black women in computing, there must first be an acknowledgement that Black women's experiences in this field are different from other groups. Subsequently, an educational framework can be developed to address these differences. For example, exploring white privilege in the context of computing education would facilitate rich discussion of experiences (and solutions) for Black women students and professionals. This would also lead to the development of intervention strategies that actually work for Black women across their educational and career pursuits.

Therefore, within CRT, we use a framework of intersectionality as the lens for analyzing and interpreting the experiences of Black women in computing. As the contextual data show, computing is a predominantly white and male field in all aspects of K-12, post-secondary and workplace settings.

Purpose of the study

The purpose of this study was to identify and describe the educational and workforce pathways of Black women in computing. Given the very few Black women in the computing field across the USA, we explored the successful pathways of 93 Black women in computing as they reflected on best practices, challenges and lessons learned through the K-12, post-secondary and workplace pathways. With funding from the National Science Foundation, we convened two conferences for Black women in computing. In 2016, we convened 24 Black women in computing; and in 2017, we convened 80 Black women in computing (with some overlap from the 2016 cohort). In total, the study features narratives and validated themes from 93 Black women in computing.

The main research question of the study is:

RQ1. What are the salient themes in the intersectionality of gender and race in computing and, in particular, for successful Black women in computing?

The women in our sample have successfully navigated the K-12, post-secondary and workforce environments, where all are employed (often with leadership positions) or are full-time doctoral students. Hearing and learning from these successful women would help us understand how to help Black girls (and other marginalized students) succeed through the education-to-career pathways.

To answer this research question, interviews and focus groups with the women included the following guiding questions as we explored the pathways of Black women in computing:

- Why do not interventions for women in computing work for Black women in computing?
- What are the implicit and explicit gender and stereotype biases for Black women in computing?
- What are tangible intervention/support strategies for Black women in computing?

These guiding questions were used to elicit narratives from the participants, including identifying strategies and barriers to promote Black women in computing.

Methods

Sample

The sample for the study included 93 Black women in the computing field. In 2016, we convened 24 Black women in computing, all professors of computer science, engineering and information technology at university settings. In 2017, we convened 80 Black women in computing that included university professors (including 11 from the 2016 cohort), graduate students and computer scientists in industry (e.g. private sector).

Among the 93 total participants, all were in a computing field (e.g. computer science, computer engineering, information technology and cyber security) with advanced graduate degrees in computer science, information technology and engineering. Across the total participants, ten were graduate students pursuing a PhD program in computing (e.g. computer science or computer engineering). Fewer than ten participants were employed in the private sector. The majority of the women in the sample were employed in academic (postsecondary institution) settings as professors or research scientists.

It is important to note the significance of this sample. Per data from the National Science Board Science and Engineering Indicators report (2016), there were only 79 Black students who graduated with a doctorate in mathematics, CS or statistics in 2013. According to the CRA Taulbee survey in 2014 (Zweben and Bizot, 2015a, 2015b), there were only four Black women who graduated with a doctorate in CS and information (and none in computer engineering). This pattern of significant underrepresentation has not changed in the past 20 years of National Science Foundation's reporting of indicators. Participants in this study all mentioned the uniqueness of such a gathering, such as with the following comment from a participant in 2017:

I've never had a conference so hyper focused on me. I've been to conferences that serve parts of my soul (my discipline, my gender, my race, my interests) but nothing that includes it all.

Given the severe limited numbers of Black women in computing, to maintain anonymity when using anecdotal narratives or quotes from these women, we will refer to them as participants, women or professionals (without use of pseudonyms) and describe whether they are an early-career (less than five-years in their careers including all doctoral students), mid-career (between 5 and 15 years in their careers) or seasoned professional (16 years or more in their careers) in academe or in industry.

Research method

The research method was a multi-method study, using qualitative and quantitative data from various sources (Creswell, 1994, 1998). For the quantitative component, a participant survey was developed that included demographic background, discipline and expertise (i.e. computing discipline) and open-ended questions regarding Black women in computing

experiences. This information was used to provide a description of the participants, including the breadth of expertise in the computing field.

For the qualitative component, data included interviews and focus groups with participants, observations from an evaluator and notes from facilitators. The purposes of qualitative research are to delve deeper into understanding the context, phenomena, process and developing causal explanations or theory with attention to particulars (Denzin and Lincoln, 1994; Eisner and Peshkin, 1990; Maxwell, 1998; Strauss and Corbin, 1990). Maxwell states that:

[...] although qualitative research is not unconcerned with outcomes, a major strength of qualitative studies is their ability to get at the processes that lead to these outcomes, processes that experimental and survey research are often poor at identifying (Maxwell, 1998, p. 75).

Further, qualitative researchers believe the “virtual reality is shaped by social, political, cultural, economic, ethnic, and gender values” (Guba and Lincoln, 1994, p. 109). Therefore, while the survey data provide description of the sample, we believe that understanding the intersectionality of race and gender in computing is best approached through a qualitative lens.

Our paradigm in qualitative research is constructivist with post-positivist elements. We relied on two qualitative methods, consensual qualitative research (CQR) (Hill *et al.*, 2005; Hill *et al.*, 1997) and grounded theory (Strauss and Corbin, 1990), in our understanding of the intersectionality of race and gender in computing. CQR uses open-ended questions, several judges through the data analysis process, consensus to arrive at meaning in the data, an auditor check to minimize groupthink and analyze data into domains, core ideas and cross-analysis (Hill *et al.*, 2005). According to Hill and her colleagues (1997, 2005), CSR incorporates elements from phenomenological (Giorgi, 1985; Groenewald, 2004), grounded theory (Strauss and Corbin, 1990) and comprehensive process analysis (Elliott, 1989) and relies on a team of researchers to find meaning and consensus in the data. This aspect of finding consensus is critical to our understanding of race and gender in computing. Given the focus on computing and computer science, which is a highly specialized field under the auspices of STEM education, coupled with the “double bind” experiences of Black women, we believe it is critical to not only have a diverse research team per “researcher-as-instrument” perspective (Morrow, 2005; Ponterotto, 2005) but also have a multi-disciplinary team that includes social scientists and computer scientists in analyzing and interpreting the data. The CSR method provides a framework and process for collecting, analyzing and conducting face-validity checks from multiple perspectives and expertise.

Grounded theory is inductively derived from the phenomenon it represents that include discovery and development in conjunction with verification through systematic data collection and analysis on the phenomenon (Strauss and Corbin, 1990). Data collection, analysis and theory have a reciprocal relationship with each other. Unlike traditional positivistic approaches, grounded theory does not begin with theory and then analysis and data to prove it. Rather, “one begins with an area of study and what is relevant to that area is allowed to emerge” (Strauss and Corbin, 1990, p. 23). Grounded theory is the most widely used qualitative framework, where:

[...] the grounded theory perspective reflects a naturalistic approach to ethnography and interpretation, stressing naturalistic observations, open-ended interviewing, the sensitizing use of concepts, and a grounded (inductive) approach to theorizing, which can be both formal and substantive (Denzin and Lincoln, 1994, p. 508).

Given the dearth of literature on the intersectionality of race, gender and a specialized field such as computer science, grounded theory is an ideal method for theory building through the narratives (data) of Black women in computing.

While data were collected and analyzed in a constructivist paradigm to build theory, data collection instruments were systematized with standard protocols to acquire consistent areas of information (Hill *et al.*, 2005; Hill *et al.*, 1997), in a somewhat post-positivist paradigm. From participant surveys to interview, observation and note-taking protocols, the research team had training on the protocols for consistent data collection. The interview and observation protocols did allow for context-specific probing, such as differentiating the experiences of graduate students, academics and computing professionals during the focus groups. The systematized protocols were necessary for consistency in data collection, especially given that our research team included computer scientists (who may not have experience in social science methods) and social scientists.

We believe the application of CQR and grounded theory provides a philosophical and methodological process needed to understand and theorize about the lived experiences of Black women in computing.

Data sources

Across the two conferences, we conducted eight focus groups consisting of 11-15 participants each, with lead facilitators who were Black women in computing conducting the focus groups. A secondary facilitator took notes or helped to probe during the focus groups. Data from each focus group consisted of facilitator field notes, observations, artifacts and a post-focus group participant survey. Table I shows the data source, the respondent (or data collector), the type of data and sample size for each source of data. Taken together, the data sources are rich and varied, with data at the group and individual levels, from different sources (e.g. evaluator, computer scientists as facilitators and participants) and qualitative and quantitative data.

Data analysis

The quantitative survey data gathered were analyzed descriptively, with descriptive statistics and cross-tabulations. The quantitative data reflected the description of the sample, including computing professions and discipline.

Table I.
Summary of data
source, respondent
and data type

Data source	Respondent (N size)	Data type
Pre-conference survey	Participants (N = 35)	One week before the conference, the participants were invited to complete a pre-workshop survey
Focus groups	Participants (N = 93)	During the conference, participants took part in three focus groups during the day; each group had 11-15 participants for a total of 93 participants
Focus group surveys	Participants (N = 88)	After each focus group, participants completed a quick, open-ended survey
Post-conference surveys	Participants (N = 58)	One week after the workshop, participants were invited to complete a post-workshop survey
Facilitator notes	Computer scientist (N = 8)	During each focus group, the lead facilitator conducted the discussion, while a second facilitator took notes of themes, discussion and next steps
Observations	Social scientist (N = 8)	The social scientist followed an observation protocol and observed each focus group for 10-20 minutes
Focus group artifacts and documents	N/A	Group power point slide, flip charts during focus groups, photos, any collateral material created during the focus groups

For the qualitative data, our approach to analysis included grounded theory and CSR methods. Following the CQR procedures (Hill *et al.*, 2005; Hill *et al.*, 1997), all data were converted into digital formats, from transcriptions of interviews, field notes, observations, facilitator notes and artifacts and other documents. The open-ended questions from the surveys were also included in these qualitative data. The primary research team created domains, first with a “start list” (Hill *et al.*, 2005), and moved into core ideas, themes and cross-analysis. The social scientist conducted the audit of the initial results. We obtained feedback on the initial results of the themes from the participants during the auditing process for validation or “trustworthiness” (Hill *et al.*, 2005; Hill *et al.*, 1997; Morrow, 2005). The results were finalized after triangulation of data and data sources and confirmation of consistency of results across qualitative and quantitative data.

Results

The questions that guided this study were situated in the context of Black women in computing – the severe underrepresentation of Black women in computing from post-secondary education and degree attainment to employment. Within this context, the three guiding questions were:

- (1) Why do not interventions for women in computing work for Black women in computing?
- (2) What are the implicit and explicit gender and stereotype biases for Black women in computing?
- (3) What are tangible intervention/support strategies for Black women in computing?

These guiding questions were used to spark conversations about the challenges and barriers, best practices and lived experiences of the participants. While we had a large sample size of women, thematic analysis through a grounded theory and consensual research methodology (CRM) approach led to the following themes:

- the need to link Black women in computing to the bottom line of organizational and personal accountability;
- the need for effective cultural and educational supports for Black women in computing across pathways, including starting in middle school;
- the need to develop leadership through the educational and workplace pathways; and
- the need for more collective research about and with Black women in computing.

These themes represent major ideas that were also vetted by participant feedback and an auditing process during the analysis phase. Within these themes, we also identified sub-themes that highlight common experiences but did not go through the full vetting and face validity analytic process. The sub-themes are meant to illuminate emerging themes for future research.

Theme 1: Linking Black women in computing to the bottom line of organizational and personal accountability

The intersectionality of race and gender in a predominantly white male field such as computer science was at the forefront of interviews and focus group discussions. A prototypical perspective that resonated with other participants was stated from a mid-career professional in industry, “My struggles and experience are par for the course for people like

me in this space. It's not personal; I'm just a Black woman in tech." Within the narratives of the struggles and experiences of Black women in computing, the participants talked about the frustration in the limited progress made in increasing diversity and representation in the CS field.

As Black women in computing, participants talked about various programs, such as Black Girls CODE for kids, MIT MITEs for high school students, the Grace Hopper Conference for researchers and practitioners, as well as funders such as NSF that seek to "broaden participation" in computer science. The guided question about why interventions do not seem to work for Black women in computing is situated in an unfortunate pattern over the past 20 years. There were higher percentages of women and Blacks in computing, especially in industry, decades ago. Yet, those gains have been declining since 1998 (National Science Board, 2016). This unfortunate pattern is confounded by an increased focus on "broadening participation" and increased availability of programs to promote diversity and inclusion in computing. There was consensus that it is not enough to "promote" or "broaden" participation. These were seen as passive policy-orientated stances that did not help Black women in computing. Accountability was identified as a major theme, yet it was nuanced both at the organizational and personal levels.

At the organizational level, emphasis on holding universities, colleges and employers accountable for increasing the diversity of students, faculty and employees was expressed multiple times. However, rather than promoting "underrepresented groups", participants emphasized that the need is to promote Black women specifically. One participant observed that while she attends a historically Black college or university (HBCU), there are no Black women CS professors in the CS department. Her mentor is a Black woman who is a professor in the engineering department, not in the CS department where the participant is housed. One seasoned professional stated, "It is horrible that percentages of women and Blacks in computing are significantly lower than they were 30 years ago." She hypothesized that this may be because of many universities and organizations' focus on improving "underrepresented minorities (URM)" as a group, rather than improving representation of subgroups such as Black women. Women in the study noted that the use of "underrepresented minorities" in CS helped to increase the number of White women in the field but not necessarily Black women. Further, women felt that the phrase minimized people and their experiences by referring to them as "under" or something inferior to the majority. An early-career participant responded, "I'm not an URM, I'm a Black woman." These sentiments led to a unifying perspective and recommendation of the need for organizational accountability to improve the recruitment, retainment and success for specific subgroups and not a generalized subgroup. Rather than grouping into one large category called "underrepresented minority", the participants agreed that accountability would be better based on disaggregated and intersectional groups, such as Black women.

Within this theme of accountability, the women also emphasized the need for personal accountability and responsibility. The participants acknowledged that while organizations should be held accountable for hiring, retaining and promoting Black women, Black women are responsible for "being the best" at what they do. In essence, the participants discussed the importance of having a solid mastery of computer science, engineering or IT (e.g. content knowledge). This mastery starts early with K-12 classes (e.g. accelerated or advanced math classes) and continues with their achievement in undergraduate and graduate school. There was definitely a shared bravado within the group (or as one participant stated, a "fearlessness of your own success") where regardless of whether they were current graduate students, professors or professionals in technology fields, the women had common experiences of being high achievers. These women shared similar educational experiences,

including being identified in the gifted program in K-12 education or identifying in the “smart group” in school. These women were driven from early in their educational career. Some talked about being the only Black girl in her advanced math class in high school, with many more women agreeing or sharing their own stories of “being the only one”. And these common stories of being the only Black girl in advanced math classes were consistent, whether these experiences were shared by seasoned mentors in the field talking about their schooling 40 years ago or current graduate students reflecting on their high school experience four years ago. Rather than commiserating about the social injustice and unfairness of “being the only one” (e.g. single-handedly representing a whole subgroup), the women shared narratives of their singular focus on achievement. The sense of responsibility and personal accountability were dominant themes.

As a sub-theme, it is important to note that on this theme of personal accountability and responsibility, there was the flip-side of needing to take care of oneself (from self-care to mental health) because of the realities of “representing” more than yourself in a predominately white environment (Charleston *et al.*, 2014; Parker, 2005). The participants expressed the pressure and stress, acknowledging the high standards and stress they put on themselves for excellence, but the stress they feel in representing a whole subgroup. This stress was often faced alone, given that these women are often the “only” ones in their department in school or at work. As one seasoned professional said to others, “Take care of yourself. No need to get degreed, get diabetes, and die”.

Theme 2: Increasing cultural and educational supports across pathways, including starting in middle school

Reflecting on the explicit and implicit bias and psychological stress of “being the only one”, from being the only Black girl in an advanced math class in middle school to being the only tenured Black woman in their department, it is worth noting that the participants acknowledged the bias but quickly switched the topic to best practices and supports that could help. The women quickly listed enumerations of barriers to overcome, from psychological such as stereotype threat (Steele, 1988; Steele and Aronson, 1995), imposter syndrome (Clance, 1985; Clance and Imes, 1978) and micro-aggressions (Charleston *et al.*, 2014; Sue *et al.*, 2007), sociological such as lack of social capital that comes with networks and mentors (Ong *et al.*, 2018; Settles, O’Connor, and Yap, 2016), to organizational, such as policies that resulted in the reversal of affirmative action (Reardon *et al.*, 2015). Instead of reiterating the findings of past research on implicit and explicit bias, the theme that emerged was around supports to combat such barriers and bias. Through the discussion and sharing of implicit and explicit biases, the women were adamant about the need for increased cultural and educational supports across the education and employment pathway.

The ultimate goal, for many women, was to be seen, acknowledged and respected for their expertise in computing, to be seen as a computer scientist first and foremost. A seasoned professional in industry stated:

In lieu of enumerating the numerous barriers, I’ll summarize them as being seen and addressed as a Black woman first instead of a computing professional first. I strive to be viewed as a computer scientist who is a Black woman.

Similar to many other fields where, for example, the gender is prominently mentioned (e.g. woman pilot, woman cop and woman CEO), these women view their professional identity as an earned right, especially because in addition to mastering the content and achieving at high levels, they also had to overcome numerous barriers.

The experiences of implicit and explicit bias faced by the participants were shared among current graduate students to seasoned professionals, which spanned the educational and work experiences of the past 40 years. While acknowledging the barriers and bias, a major finding from these women was the need for cultural and educational supports throughout pathway experiences, especially starting earlier in K-12 education. Participants talked about how even high school is often too late to level the playing field with content knowledge and experience of CS. In K-12, participants cited the importance of not only interest but also mastery of mathematics, computational thinking and engineering principles as foundations for CS. In post-secondary and workplace settings, supports included sponsorship, advocacy and mentors, as well as opportunities to be part of affinity and professional community groups. From K-12 supports to continued mentorship through undergraduate studies, participants echoed the theme of needing increased cultural and educational supports as Black women in computing.

In K-12 education, a common barrier in the K-12 pathway involved exposure to, awareness of and valuing CS and computing. While camps abound (such as LEGO to coding camps), the value of CS can get lost. One participant stated:

Computer science is the process of thinking through problems, breaking them down, solving them, and putting it back together for a solution. If you are in biology, you want to develop an app for mothers in prenatal care. That's computer science! If you are the kind of person where you say, "Well, I want to see the latest on Black Twitter." That's computer science! If you say, "Well, I'm into art and how things look and I want to change the way we communicate and express ourselves through art". You can do that with technology. Guess what? That's computer science! If you are into music, there are aspects of making music that require you to use technology and manipulate music. That's computer science! I can't think of any aspect of the real world that, somehow or another, doesn't interface with computer science.

The participants remarked that CS and computing have strong components of not only mathematics but also critical thinking and problem-solving. It is not just about coding, which was mentioned as a pet peeve of some participants (e.g. difference between a computer scientist and a programmer). In the AP Computer Science course taught in high school (if even offered in high schools), algebra and higher-level mathematics are required and can further decrease access, interest and participation. Participants mentioned that trying to promote more diversity in CS in post-secondary education is too late because mathematics is foundational. Barriers to CS start in the K-12 pathway, from the need to master mathematics to the need to interface computer science with other content areas (such as social studies, science, music and arts) to promote interest. On the flip side, for best practices, participants observed that supports needed to start ideally in the middle grades or late elementary levels. While CS is often taught at the high school level, participants believed in the importance of early exposure to and awareness of CS (not computer literacy or coding) in school settings, with emphasis on academic readiness particularly in mathematics. In addition, similar to past research ([Ong et al., 2011](#)), other supports outside of school included informal and summer programs, early connection to role models and mentors and the parental support and influence to get and stay interested in STEM and computing specifically.

As a sub-theme, the role of parents, and in particular the fathers in the lives of these women, was brought up by numerous participants. While we often focus on educational supports, the role of fathers in the daughters' lives was brought up as significant for many of the participants. This pattern was observed multiple times in the data, from explicit statements of the role of their father, or in their narratives of how these women became interested in computing as a child. Whether through encouragement, discipline, emphasis on

grades or “tinkering together” on various household items including computers, the role of fathers was a shared and common theme in sparking and sustaining interest in computing.

In post-secondary education, supports become more specialized in mastering the skills and knowledge of CS. The notion of “proving you’re the best” in class was mentioned multiple times across focus groups. With this pressure to master the content and skills, participants reflected on the needs for supports from mentors and role models, community and social supports and financial support. As one participant remarked, the importance of a community that “looks like her” was critical:

The ability to be surrounded by others who know the good and the bad, and know it as intensely as I do, is a rarity that I know will give me strength to go back to my day-to-day that I wouldn’t be able to get elsewhere.

At this stage, the participants opined on the needed support of leadership development and self-advocacy skills. While post-secondary education focuses on the mastery of content, this pathway is also important to gain leadership skills in preparation for the workplace. In post-secondary education, the most common barrier repeated by current graduate students as well as former graduate students (who are now seasoned professors and highly respected professionals in industry) is the unsupportive environment (e.g. “chilly environment”), where discussions abound about explicit and implicit bias on campus and in the classroom. In fact, this barrier was consistent regardless of whether participants attended large public Research 1 institutions, private elite institutions or HBCUs. Participants shared their personal narratives of when they wanted to quit (the major or even post-secondary education all together), from struggles with continuation of funding or feelings of isolation to a lack of mentors to guide and support their research. An early-career participant stated:

I learned that I am not alone, and there is a support system of Black women just like myself. I felt motivated and encouraged to continue pursuing my degree.

For supports, a group of early-career participants responded that a best practice that worked for them is when a department or advisor purposefully recruited and mentored a small group of Black women (or other underrepresented minority student) so that there was a built-in peer-support system and to ensure that there was no issue of “being the only one.” This purposeful action to create a small cohort of students (a peer network) was perceived as particularly impactful in the participants’ cultural and educational supports in post-secondary and graduate settings.

In the workplace, barriers were similar to the prior pathways, such as the same feelings of pressure to “prove you’re the best” or of showing their worth to the company. However, unlike graduate school where some participants experienced supports through social networks of other students of color, in the workplace, some commented that there is often no such thing. Whether tenured professors or professionals in the technology industry, the participants observed that they are often the only one – the only Black woman in computing – in their division or department. The lack of representation, including a discussion on “assimilation,” led to the exigent need for workplace supports. Example of supports shifted from a focus on content mastery (technical skill development by way of conferences and training) to leadership development (self-development and co-development). Whether the workplace was tenure-track professorships or in the technology industry, leadership development and leadership roles within organizations were seen as a snowball effect. Organizational supports to develop their leadership were seen as extremely efficient because these women would immediately give back, supporting other Black women in computing community (and other marginalized groups in computing), sharing experiences and mentoring staff.

Theme 3: Developing leadership through the educational and workplace pathways

One participant asked, “When we are in other spaces, how much should we ‘assimilate’ so that you don’t come off as a threat?” From here, the discussions in the interviews and focus groups led to themes that were less about the need to “assimilate” which connotes a need to be raceless and genderless, but strategies that focus on embracing the intersectionality of race and gender with self-development, co-development and ultimately leadership. During the analysis process, leadership was identified as the unifying and overarching theme. Leadership was a concept that was discussed hand-in-hand with other roles, such as mentors, role models, advocates and entrepreneurs, along with specific skills, such as self-advocating, collaborating, supporting and mentoring.

Across these roles and skills, leadership was thought of as a developmental issue. Early in the graduate school career, participants discussed the need to self-advocate and develop leadership skills. Senior-level professionals discussed the need to “get a seat at the table” and “be prepared to take action once you get there.” As a seasoned professional stated:

Whether you’re in the corporate arena or academia, it is highly unlikely that no one else has gone through our current challenge. There is a member that can help you get through it.

Therefore, leadership was also about sharing the trials and tribulations, strategies learned and actively supporting the community of Black women in computing. The issue of leadership, therefore, is its own pathway – from acquiring and practicing leadership skills to developing key influencers and thought leaders in the computing field. Examples and strategies, particularly in the academic circle, that were greatly discussed included:

- providing peer reviews and supports to help researchers with their conference presentations and publications;
- advocating for other Black women in computing during funding opportunities and proposal reviews; and
- identifying and promoting Black women in computing for leadership positions at professional organizations and conferences and for open positions at institutions.

Given the heavy representation from participants representing the academic setting, participants recommended the need for greater inclusion of Black women in industry to expand the theme of leadership within the corporate setting (Parker, 2005).

Theme 4: Conducting collective research about and with Black women in computing

The participants in the study were predominately from academe – professors or research scientists at university settings. Therefore, this particular group was also focused on research and publications in a “publish or perish” environment that is highlighted in the academic setting. Within this context, the participants discussed the importance of and the need for more research about Black women in computing, given the lack of data and research. But they also acknowledged the tension between wanting to address the lack of research and not wanting to become subjects (e.g. “lab rats”) of social science research. Participants talked about research “for us, by us” rather than “test subjects” and instead being part of research projects to study Black women in computing. This led to the need for increased collaborations with social scientists to help form (and inform) interdisciplinary research projects. The need for more data and research included topics such as evaluation of programs to determine “what works,” basic research to understand the population of Black women in computing, ways to collaborate to conduct collaborative research projects and

more in-depth analysis at what makes the experience of Black women in computing different from other underrepresented minorities in computing.

As a sub-theme, there were two types of thought, or philosophical standpoint, on where to take the research. Similar to the work on racial identity (Cross *et al.*, 2017; Scottham *et al.*, 2008; Worrell *et al.*, 2017), there were multiple thoughts on the direction of research. One thought leaned towards the Afrocentric/ Ethnocentric view (Worrell *et al.*, 2017) of conducting collective research about and with other Black women in computing, showcasing the uniqueness of this group. Another thought leaned towards the multicultural view (Worrell *et al.*, 2017), with interest in expanding the dialogue and research with other underrepresented minorities. One mid-career professional stated:

I would love to have a serious workshop in which members from “others” (Asian, White, female/ male, Black panelists) will share their experiences and talk about intersectionality between race, gender, diversity, inclusion, etc.

Given the dearth of research and “what works” to promote diversity and inclusion in STEM at large and CS specifically, there is obviously multiple perspectives and thought that can occur at the same time.

Conclusion

This study explores data collected from 93 Black women in computing to identify salient themes in the intersectionality of gender and race in computing. Participants included graduate students, professors and computer scientists in private industry. The research featured a multi-method approach that included focus groups and interviews, facilitator notes, participant surveys, observations and focus group artifacts (Strauss and Corbin, 1990). Analysis included a grounded theory approach coupled with analytic techniques used through Consensual CRM.

Under the theoretical lens of intersectionality, the four major themes identified included:

- (1) the need to link Black women in computing to the bottom line of organizational and personal accountability;
- (2) the need for effective cultural and educational supports for Black women in computing across pathways, including starting in middle school;
- (3) the need to develop leadership through the educational and workplace pathways; and
- (4) the need for more collective research about and with Black women in computing.

These four themes share commonalities of self-development and co-development in reaction to the structural, political and representational realities of these women (Crenshaw, 1997; Tate, 1997).

For self-development, the narratives of these women focused on political and representational intersectionalities. For example, from early in their educational experiences, these women faced political intersectionality (inadequate political framework that fails to contextualize the realities, narratives and experiences of Black women) because they were not just women as an underrepresented minority, they were Black women. They were not just Black as an underrepresented minority, they were Black women. This resulted in “being the only ones” in their advanced class, computer science class or major and place of employment. These women encountered representational intersectionality (images of race and gender merge to construct the narratives and experiences of Black women), where

gatherings of other successful Black women in computing were illuminating and affirming, knowing and seeing they were “not the only ones out there”.

For co-development, the participants experienced structural intersectionality (how women of color are stuck within overlapping structures of subordination) and discussed how organizational and structural reforms are needed to promote and sustain a diverse learning and work environments. To do so, the participants acknowledged that there must first be people in organizations to enact structural reforms. As such, the women discussed how leadership development is a critical, and yet often missing piece, in the educational and work experiences. For these participants, leadership was a collaborative and communal skill and action, such as “getting a seat at the table” and then helping others make their way up.

Similar to past research (Ong *et al.*, 2011), there were inter-related factors across pathways to promote Black women in computing. In each pathway, supports and challenges highlighted the structural, political and representational intersectionality of the women. The first pathway is in the area of K-12 education. In this pathway, political and representational intersectionalities were dominant features. Several participants and survey respondents indicated the need to start early with a focus on girls and starting in the middle grades. For political intersectionality, many participants also reflected on their own resiliency and identified best practices and themes in K-12 settings, including academic readiness (often in accelerated tracks in math courses in middle and high school) within an inclusive classroom so that girls do not have to be the only Black girl in such classes. For representational intersectionality, a consistent narrative included the need for parent support and influence and early connections with mentors and role models throughout. Showing girls and their parents that there are Black women in computing thriving and succeeding was important.

In the area of the college/university experience in undergraduate or graduate levels, political and representational intersectionalities continued, with participants discussing the critical importance of persisting. Persisting included creating a support system, seeking multiple mentors and role models and thoroughly knowing the CS content. This pathway also introduced structural intersectionality, with the need for institutions to be held accountable for diversifying the department with Black women professors and students, not just underrepresented minorities, that included financial support.

In the area of employment and beyond the formal schooling phase, the themes identified and validated by the participants focused on structural intersectionality. Rather than being subordinate in both intersections of identity, participants agreed with the need to develop leadership, illuminate and share experiences and expand and grow the community. Participants from both the private sector and the academy believed in the necessity to hold organizations accountable for promoting and supporting Black women in computing.

In all, it is interesting to note that during the focus groups, the identity of the Black women in computing expanded, a prominent growth in representational intersectionality. Across the 93 Black women in computing, the roles they see for themselves were not necessarily based *per se* on their educational degree, such as a “computer scientist” or “engineer” where their intersectional representation was on being Black, a woman or a computer scientist. The intersectional roles expanded to include technologists, leaders, innovators, entrepreneurs, mentors and advocates (Ross *et al.*, 2017). These roles were larger than their professional training, reflecting a common understanding and mission to promote greater inclusion of Black women in the computing field.

Implications for future research and policy

Throughout this paper, we have peppered our research study discussion with ideas about the importance of understanding Black women’s experiences in computing. The narratives

of this community provide a richly comprehensive perspective of what it means to thrive in the context of isolation and persevere through authenticity of voice. These narratives also empower Black women in computing and create tightly knit cohorts who study and learn together to complete degrees and enter the workforce. We expound on specific areas for future research and policy recommendations that are directly informed by this research.

Foster greater incidents of innovation. Research suggests that leveraging the talents of more women in the workplace is good for business. More women on teams improves their collective intelligence (the shared intelligence within that group) (Woolley and Malone, 2011) and leads to more productive teams (Hewlett *et al.*, 2013). There is also growing evidence that *diverse* teams – those that include women and people who are described as minority (e.g. people of color) – actually drive innovation (Hewlett *et al.*, 2013; Hunt *et al.*, 2015) and profit (Ellison and Mullin, 2014; Lorenzo and Reeves, 2018). Despite these findings, describing a team as *diverse* most often refers to the inclusion of women only, *not* women of color. This is often exacerbated in the computing community such that any research that hails of importance of homogenous teams are not actually supporting non-white women. Our research suggests that paying attention to Black women and their intersectional voices of gender and racial identity leads to highly functioning, productive teams as well as innovations that might not ordinarily be possible.

Create a culture of true inclusion. Distinguishing between *women in the computing*, *women of color of computing* and *Black women in computing* may seem counterintuitive in the context of inclusion. The point of the distinction, however, is in recognizing that women, even white women, are not unidimensional. Consider the following scenario. When designing for diversity, we often ask, with good intentions, the minorities in our spaces what they need to succeed. We ask this of our graduate students and of our Black professionals. However, this isolates people, especially if someone is one of a few minorities (or the only one) in her organization and that leads to feelings of helplessness that Black women often experience. Instead, the approach of asking *everyone* about *what it means to be successful* flips the paradigm and acknowledges that everyone has an experience, which helps to uncover areas of commonality – even with white men. This research has the potential to shift the way we talk about inclusion, more broadly. Being *different*, irrespective of race and gender, is actually an asset, not an excuse for separation. Embracing this as a premise in basic humanity also promotes psychological safety, which is essential to high-functioning teams and the exchange of critical thought, which deepens the very definition of inclusion.

Challenge expectations. When we are truly inclusive, we encourage a mind shift for what it means to be *anything*, especially a computer scientist. Our results suggest that Black women, as a sub-community in computing, see immense value in owning their voices as an expression of their authentic selves. This means that despite the educational, professional and societal pressures that come with growing their technical proficiencies, Black women recognize that their success is motivated, in large part, by owning their contributions to computing, large or small, and applying their knowledge in ways that support themselves and their communities. This acknowledgement is self-affirming and does not wait for validation from others. Such *knowledge of self* is an important expression in the Black community, especially as a form of awareness about its rich history and impact in the society and the world. For Black women in computing, this identity binds them together to create a spirit of excellence that is overwhelmingly empowering, expressive and socially aware. More and more, technical fluency is becoming a basic skill that can affect future career opportunities, generational wealth and social and civil rights. Giving young, Black people a lens through which to see the benefits of computational competence, as it affects their communities, changes impressions of what a computer scientist looks like.

Note

1. For this paper, we will use the term “Black women” to include women of African origin or ancestry, including but not limited to African American, African immigrant, Hispanic non-White, and Caribbean.

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