An Examination of Black Undergraduate Women's Intersectional Experiences and Academic Motivation in Computing Education

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Objectives. We aim to understand, from a motivational perspective, how Black undergraduate women in computing make sense of their intersectional computing experiences. We examine their motivation to major in computing, their experiences as Black women in computing, and how these vary across institutional contexts.

Participants. A sample of 77 Black undergraduate women in computing programs (computer science, computer engineering, information systems, information technology, and software engineering) from diverse college settings was recruited to participate in the study.

Study Method. Participants responded to an online survey that included several Likert-scale measures for identity, motivation and retention variables, demographic questions, and two open-ended questions: *Why did you choose to study computing?* and *What is it like for you to be a Black female student in computing?*

Findings. Key themes that emerged from our quantitative and qualitative analyses revealed the range of motivational factors driving Black undergraduate women to study computing and the nuances across their intersectional experiences in the computing education context. Additionally, Black undergraduate women located in HBCU computing education contexts demonstrated both similar and unique perspectives and experiences compared to their counterparts in non-HBCU settings.

Conclusions. In addition to the isolation, pressure, power dynamics and epistemic violence experienced by Black women in the intersectional computing education context, the findings of this study display the unique cultural-social-psychological strengths of Black women in their positive valence and resilience, as well as their joy, empowerment, and achievement in computing. Increasing and complicating our knowledge of the motivations and intersectional experiences of Black women in undergraduate computing education, as well as understanding when and how their beliefs and perspectives vary across institutional context, will better inform efforts to retain them and promote their success both in college and into their careers.

CCS Concepts: • **Social and professional topics** → **Computing education**; **Race and ethnicity**; **Women**;

Additional Key Words and Phrases: Black undergraduate women, academic motivation, intersectionality, computing education, retention intention

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1 INTRODUCTION

Amid decades of calls and efforts to diversify the technology workforce, the return on efforts to expand computer science education [40] remains elusive for Black undergraduate women partly because psychological frameworks and understanding are scarce in the computing education research literature. There are gaps in our knowledge about the identity beliefs and the psychological implications of the intersectional experiences that influence pre-professional Black women's motivation and retention in computing fields. In the present article, we use the *expectancy-value theory* (EVT) of achievement motivation to examine the social and behavioral processes at play for Black undergraduate women who pursue computing studies, including their intention to remain in those fields. This work introduces a more nuanced understanding of Black women's experiences in computing education that is grounded in a socio-cultural theory of academic motivation. The study results are interpreted through the critical lens of *intersectionality* in computing education.

Intersectionality (a lens for "understanding and analyzing the complexity in the world, in people, and in human experience"; [5], p. 2) provides a contextual metaphor for understanding Black women's experiences with overlapping oppressions in computing that leads to many questions about how they might also thrive in this positionality. We focus on how Black women interpret, make meaning of self and experiences, and succeed in this context from a motivational theoretical framework. Motivational variables may be more important in educational achievement than cognitive ability/intelligence [20]. However, more information is needed about the nature of Black women's identity and motivation to persist in undergraduate computing. Because of what intersectionality scholarship has revealed about the multiple, overlapping oppressions and intertwined inequities experienced by Black women [19, 28–32, 36–39], it is important to understand their motivational psychology to persist in computing, which can inform more about remedying injustices and broadening participation in this field.

The literature on academic motivation has established that a student's sense of self (identity) informs their goal-directed behaviors (motivated choices) in academic settings [14, 25–27]. For Black undergraduate women, racial and gender identity are two significant aspects of identity that impact their motivation, experiences, and ultimate success in computing education [19, 36–38]. Scholarship in computing education would be strengthened by studies grounded in psychological literature to explain the range of motivations that draw Black women to pursue this course of study (given the challenges) as well as a more complex understanding of how to interpret their intersectional experiences in the computing education context psychologically. Clarifying whether and where distinctions occur is especially insightful concerning institutional contexts where one or more of Black women's social identities are designed to be fundamentally, structurally, and interpersonally affirmed (such as historically Black colleges and universities). Methodologically, the empirical literature on Black undergraduate women in computing education would benefit from further study with research designs/approaches, sample sizes, and sample compositions that provide a broader range of experiences and perspective and within group diversity across the aforementioned psychosocial processes.

1.1 Description of Research Problem

The field of computing education needs in-depth and nuanced evidence of Black undergraduate women's intersectional experiences in computing education that is grounded in motivational

theories that account for the relationship between social structures, social identity, and student motivation. Additionally, as we address the structural processes at play, we must examine the psychological implications for the self, including the agentic effect of Black women's academic motivation in the midst of intersectional computing education. Increasing and complicating the knowledge in this area provides more usable data to inform educational practice, interventions, and change efforts because of the detailed and rich, broad spectrum of information within a focused population (focused on one group of Black women at a critical juncture in the computing pipeline: undergraduate education) strengthens the extant computing education research base.

1.2 Motivation and Social Identity

We conceptualize achievement motivation through **expectancy-value theory (EVT)**, which posits that an individual's personal and collective (or social) identities such as racial and gender identity can motivate action by influencing expectations for success and subjective task values associated with a particular achievement choice [12–15]. Within this framework, social role systems, personal and familial characteristics, previous personal experiences, and schooling contexts are theorized to influence emerging personal and collective (or social) identities, which in turn influence students' motivations (expectancies and values) and behavioral choices, all of which are assumed to be situative or context-bound. This framing is particularly relevant to this study because Black female students identify with multiple social identity groups that have been historically marginalized (particularly in education) and computing is a field that has been historically dominated by White and Asian men. We consider how the intersectional position and experiences of Black undergraduate women in computing and the resulting psychological implications (e.g., *identity interference*, or sensing conflict between identifying as a Black person, as a woman, and identifying with the field of computing), including psychological cost, may compromise the motivation of Black undergraduate women in computing and ultimately reduce the likelihood that they will stay in the field.

In the EVT model, students' self-concept of ability shapes their expectancy for success (or self-efficacy), which influences their choice to persist at a task in the face of difficulty. Values in the EVT model include interest value, attainment value, utility value, and cost [12–14, 41]. Interest is a positive value that refers to how interesting or enjoyable the task is to the individual. Attainment is a positive value that refers to how well the task fulfills various needs and goals that are central to the individual. Utility is another positive value similar to attainment value but is more extrinsically focused (e.g., obtaining a career goal or status). Cost is a negative task value conceptualized in terms of psychological cost, financial cost, opportunity cost, or time and energy. It is essentially what an individual will stand to lose or risk by engaging in an achievement task, such as the pursuit of a computer science degree. As previously mentioned, these values are informed in part by students' collective (or social) identities, along with other socializing messages and personal factors. Additionally, student expectancies and values can vary by institutional context, which is imbued with historical, cultural, and interpersonal norms that guide how individuals interact with structures of authority and power such as policy and practice [1].

Given the importance of social identity to motivation and our focus on Black undergraduate women in computing, we employ the **Multidimensional Model of Racial Identity (MMRI)** [34, 35] to operationalize racial identity (and gender identity) among Black undergraduate women in computing. The MMRI holds four assumptions regarding racial identity for African Americans: identities are situationally influenced, yet stable aspects of the person; individuals hold multiple identities (including racial identity) which are hierarchically ordered; individuals' reported perceptions of their racial identity is the most valid indicator of their identity; identity status is prioritized over identity development, and there are no *a priori* judgments regarding what constitutes

a healthy racial identity. Based upon these assumptions, one of the dimensions that the MMRI establishes is identity *centrality*, or the stable or normative measure of the significance of race in how individuals define themselves. This study focused on the centrality dimension of racial identity among Black women in computing, as it is hypothesized that these normative beliefs of racial identity significance contribute to their sense of self and motivation as students in the field of computing, which is largely White and male.

Sellers et al. [35] discuss the application of the MMRI to other social identity groups including gender identity and suggest that salience and centrality dimensions may be suitable for such study. As previously mentioned, this study focuses on the dimension of centrality; this aspect of the model was adapted for the study of gender identity. For the purpose of this study, gender identity centrality was defined as an individual's sense of their own gender and the centrality or importance of this identity to their overall sense of self. Much like racial identity, gender identity is typically assumed at birth, yet will vary in meaning and importance across individuals. Each individual will have his or her own conceptualization of what it means to be a particular gender (e.g., stereotypes, social roles, etc.) and how much these scripts matter in their own everyday life. For example, among 259 collegiate woman-scientists, Settles [36] found that women-scientists that had lower levels of scientist identity centrality showed increased *identity interference* when their level of woman centrality increased and women-scientists who reported the experience of interference between their woman identity and their scientist identity had lower science performance and reduced psychological well-being. The present study did not focus on the racial or gender self-schema [25] associated with racial or gender identity, but instead sought to understand how the importance or centrality of Black undergraduate women's racial and gender identity beliefs related to their motivational beliefs in the computing education context.

1.3 Intersectionality and Intersecting Identities

Intersectionality is developing as a critical social theory (situated between critical analysis and social action [6]) and has been used for "understanding and analyzing the complexity in the world, in people, and in human experience" [5 p.2]. It can also be defined as a theoretical and methodological approach to understanding the meaning and consequences of holding multiple co-constructing categories of social group membership, centered on an examination of power and privilege (within and across groups) as well as attention to the personal, interpersonal, and structural significance of simultaneous social group membership." [19]. In Crenshaw's [9] early discussions of intersectionality in the context of violence against women of color (an analysis at the intersection of racism and sexism), Crenshaw distinguishes three types of intersectionality: structural intersectionality (which refers to the societal status associated with one's multiple social identity groups), representational intersectionality (which refers to the ways members of multiple social identity groups are depicted), and political intersectionality (which refers to holding the political interests of two or more social identity groups). The premise of this framework is that examining multiple identity-based dimensions of an experience provides an understanding that would not be captured if these same dimensions (i.e., being a Black person and being a woman) were examined separately [8–10].

Collins and Bilge [5] (see also [6]) discuss six core concepts that underlie intersectionality's approach to critical inquiry and inform one another: *relationality* (how categories relate and are connected to one another); *power* (how systems of power co-produce one another within social hierarchies); *social inequality* (that power relations result in social inequality, which is not normal or inevitable); *social context* (particularly the importance of understanding dynamics of the interpretive community involved in the critical inquiry); *managing complexity* (the complexity of the iterative and interactional aspects of intersectional examination and analysis); and *social justice* (concerning the ethics of intersectional scholarship and practice).

The dynamic of power is further discussed by Collins and Bilge [5] as they outline four distinct yet connected domains of power that are relevant to intersectional analysis. Interpersonal power refers to how people relate to one another and which people are advantaged (or disadvantaged) in social settings. Disciplinary power refers to how different people receive different treatment (i.e. rules, restrictions) based on their social position. Cultural power refers to how ideas and messages about who wins and loses are manufactured, communicated, reproduced (often through repetitive scripts). Finally, structural power refers to how power (and control) is organized and institutionalized.

Collins and colleagues [2021] also establish four guiding premises of intersectional projects, which "provide a cognitive architecture for investigating intersectionality as critical social theory and the form that critical social theorizing might take." [7 p. 694]. Among those premises is that "the social location of individuals and groups within intersecting power relations shapes their experiences within and perspectives on the social world" [7 p. 694]. This study addresses the social location, experiences, and perspectives of Black undergraduate women in computing education with a focus on how their intersectional experiences across four domains of power relate to their social identities and motivation in computing education contexts.

The present work explores the relationality of racial, gender, and computing identities among Black women in computing and how their social position in the field is influenced by interpersonal and structural power dynamics which deepen social inequality in the field and may undermine students' motivation. Additionally, we emphasize the importance of the context of psychological scholarship in our interpretations of the study data and the complexity of our cross-sectional sample as well as our analytic approach to understanding the link between identity and motivation for Black undergraduate women. Additionally, we demonstrate the social justice imperative for computing education to respond to the policy and practice implications of this (and previous) work.

Intersectionality is not a theory of multiple identities but can help us to better understand how, in social systems, holding certain identities simultaneously can make one especially vulnerable to interpersonal and structural modes of power, discrimination and exclusion. Collins and Bilge [2016] discuss how intersectionality identifies power domains and how interpersonal relationships within and across those domains contribute to the oppression of marginalization of social groups. Psychologists have taken up intersectionality in context of the discipline, seeking to apply this lens theoretically and methodologically towards our understanding of personal and interpersonal processes as they relate to the structural dynamics (such as power and inequality).

Bowleg [3] examined Black lesbian women's experiences with social identity and social inequality and discussed the methodological dilemmas involved in efforts to apply an intersectional research framing to this population. Bowleg addressed the ways that typical approaches to measurement, analysis, and interpretation in psychological research fall short when employing intersectionality and suggests that a focus on interpretation is most substantial. Cole [4] poses three overarching questions for conceptualizing intersectionality in the methodology used in the psychological research process: (1) *Who is included in this category?* (2) *What role does inequality play?* (3) *Where are the similarities?* These questions take us beyond the task of categorizing and disaggregating demographic groups and towards uncovering more substantial and practical empirical evidence about the lived experiences within and between subgroups in our study samples. More recently, McCormick-Huhn et al. [22] provided a practical guide for psychological researchers who are not familiar with feminist or intersectional inquiry to apply intersectional thinking and improve psychological science [22]. Their suggestions centered on four ways to shift perspective and increase intersectional thinking (which are aligned with previously established tenets of intersectionality): multidimensionality, dynamic construction, structural power, and outcomes of systemic disadvantage and advantage.

1.4 Identity, Motivation, and Intersectionality among Black Undergraduate Women in Computing Education

In the U.S., Black women are socially located as members of minoritized racial and gender groups and subjected to the various oppressions based on both how they identify and are identified by others, particularly by those with membership in a majority group who hold a place of power and privilege in the computing context, and also by others (even other women) who may uphold and enable the power and privilege of others. In computing education, Black women have experienced interpersonal and structural challenges related to their gendered and racialized positionality relative to peers and instructors. These challenges of gendered racism are also situated in and varied based on factors such as social class, family of origin, and the type of undergraduate institution they choose. Prior scholarship has established that intersectionality facilitates an examination of overlapping systems of power and privilege based on social location and is a particularly relevant lens for studying Black women's experiences with oppression and opportunity in the undergraduate computing education setting [28–31].

Rankin and Thomas [2020] operationalize intersectionality as "the complex overlapping social constructs of gender, race, ethnicity, class, etc." (p. 199) and a theoretical framework to explore the overlapping social constructs of race and gender that inform the experiences of Black women navigating the computing ecosystem at various levels and institutional contexts. Their work established the concept of intersectional computing, which is "a more complex understanding of the experiences of marginalized groups in computing who live at various intersections of racism, sexism, classism, xenophobia, heterosexism, ableism, etc." [29, p. 200]. Many of the themes found in the Rankin and Thomas [2020] study reflect a general sense of isolation and exclusion for Black women in mainstream computing education but also depict the historically Black college/university (HBCU) learning context as particularly supportive, inclusive, and encouraging of Black women in computing. These findings indicate opportunities for white dominated institutions such as universities and companies to learn from and adopt best practices from the culture of HBCU institutions. Other scholars have documented the positive influences of HBCU contexts on African American students in STEM majors [17, 21, 27] but they often do not analyze or disaggregate results specifically for computing majors specifically.

Rankin et al. [31] employ intersectionality as a critical social theory and demonstrate that computing education is a site of saturated power relations and epistemic violence (i.e., the rejection and silencing of forms of knowledge produced by marginalized populations [6, 31]) for Black women. This particularly occurs across three planes: K-12 classrooms, predominantly white institutions, and internship sites as informal learning experiences. As the intersection of race and gender in computing is established to have implications for power, privilege, and epistemic violence, it follows that racial and gender identity (the extent to which one's identification with those social categories is important to their sense of self) has psychological implications within those same systems of power, privilege and violence. Our study centers on those implications and the intersectional experiences of Black undergraduate women in computing in both predominantly white and historically Black postsecondary institutions.

Thomas et al. [2018] interviewed 11 Black women CS professionals (working in the academy, government, or industry) about their experiences in the field of computing and analyzed the data to understand intersectional identities, systems of oppression, and forms of agency. They found that despite often being the only one and feeling isolated and sometimes depressed, and enduring low expectations and stereotypes about Black women, the women stayed focused on their long-term goals. In addition, female and male mentors in schools and the workplace provided the women with critical support, socialization, and access to information and cultural capital. Also, spending time with their fathers, who worked in computing, mathematics, or other related fields, inspired

the women's initial interest in computing. The women in the study persisted in computing and were successful, but at a cost. Thomas et al. [39] concluded that:

> "What Black women in computing appear to lose are aspects of their personhood and humanity because computing spaces can reject their Blackness and womanhood. The culture of computing is competitive, male, and largely White; consequently, Black women receive implicit and explicit messages that they do not belong in computing." (p.7)

In another study, Rankin et al. [2021b] interviewed 24 Black women about their experiences in computing in multiple spaces of the CS pipeline, and "conducted an intersectional analysis of power to explore Black women's experiences navigating the computing ecosystem and identify CS education as a saturated site of violence" (p. 9). The group of participants included two faculty members, 16 early career professionals, 5 graduate students, and 1 undergraduate student. They found that the three most saturated sites of violence in CS education that emerged from the data included: K-12 classroom environments, predominantly white colleges and universities, and internships. In each of these sites and phases of the CS pipeline, the Black women in their study described how they were subjugated, excluded, and isolated in the computing ecosystem including having a lack of access to computer science courses in high school, experiencing racism and sexism at all three sites that are unwelcoming and hostile, and being marginalized and overlooked as often the only Black woman in a class, group project, or internship site. Many of the women used coping skills to survive in computing (e.g., developing "thick skin", working alone successfully, self-motivation), and some left CS education as an act of resistance. This study only included one undergraduate student, however, and although the other women gave retrospective accounts about their experiences in undergraduate education these are less reliable than current, real-time data. Given that undergraduate education is a critical juncture in the CS pipeline that often determines whether students enter the CS workforce, our study focuses exclusively on Black women currently engaged in undergraduate studies in computing.

Solomon et al. [2018] conducted a literature review to explore "what it means to belong in computing." They analyzed computing education research on belonging for inclusion of Black women and an intersectional focus in studies. They argued that computing education research has emphasized the importance of belonging for persistence in computing, but this body of work has not used an intersectional lens which may render Black women invisible or hidden in the research. They review literature showing that for Black students, the culture of computing (white, male, geek) is in conflict with their identity as a Black person, which can make them feel like they do not belong in computing. In addition, for women overall in computing, the most influential reason for not persisting in computing is a lack of feeling of belonging. But the research has not examined these experiences for Black women in particular; thus, Solomon et al. [2018] analyzed the literature for the unique experiences of Black women that affect their sense of belonging in computing and revealed that Black women have to choose/downplay their different identities based on how others view them primarily (just black, or just a woman), versus embracing and maintaining both parts of self – Black and woman. In addition, to fit in, Black women may feel that they have to adopt the femininity of White women (quiet and passive). Thus, Black women are forced to negotiate different aspects of their identity in unique and complex ways to fit in or belong in computing. Solomon et al. [2018] argue that when Black women can be and embrace their whole selves in computing, they will feel like they belong in computing.

The present study builds on and extends these prior studies, as we use a larger sample of students currently enrolled, mixed types of data, educational psychological theory, and a focus on the critical part of the **computer science (CS)** education pipeline: undergraduate education.

This extant research in CS education/intersectional computing lacks psychological theories and research [19]. We argue that psychological science is needed and will add new knowledge and understanding of intersectional computing and the psychology of intersectionality because: with grounding in psychological theory, we have a more accurate, precise, and clearer sense of the psychological constructs, mechanisms, and processes at play during this critical time.

We examine how the women respond motivationally to intersectional oppression, and how they navigate it. As educational psychologists, in this article, we are concerned with the psychological implications of Black women's intersectional experiences in computing, particularly academic motivation and intention to remain in undergraduate computing education. In other words, we address the psychological meaning and experience associated with being a Black woman in computing education because these factors influence students' choices and ultimate success in computing fields. Prior work has focused more on the characteristics of the structural environment (e.g., computing education as a site of violence and oppression) [31, 32]. We acknowledge and identify those characteristics while examining the academic motivation of Black women to pursue computing and persist in the field, in the midst of intersectional experiences and across institutional contexts.

1.5 Study Objectives

We aim to understand, from a motivational perspective, how Black undergraduate women in computing make sense of their intersectional computing experiences. We examine their motivation to major in computing, their experiences as Black women in computing, and how these vary across institutional contexts. Given what has been established in the literature about the intersectional experiences of Black women in computing education, we examine how a relatively large sample of Black women enrolled in undergraduate computing programs respond, motivationally, to the computing education context. Our research questions are:

(1) *What is the nature of Black undergraduate women's academic motivation to pursue computing education?*
(2) *How are Black undergraduate women's intersectional computing experiences related to their sense of self (identity), motivation, and intention to remain in computing education?*
(3) *How do Black undergraduate women in computing experience intersectionality, sense of self (identity), motivation, and intention to remain in computing at HBCUs vs non-HBCUse?*

2 METHOD

2.1 Research Design Overview

This article is based on a subset of the results of a larger study which employed a cross-sectional survey design to examine how levels of racial identity centrality, gender identity centrality, identification with computing, related to levels of identity interference among Black undergraduate women in computing and whether identity interference is predictive of achievement motivation (expectancy for success, task value, and psychological cost) and retention intention among this population. The survey also included two open-ended questions to uncover the academic motivations and intersectional experiences of Black undergraduate women in computing as well as within and between group differences across the aforementioned identity and motivation variables, based on institutional setting. This article focuses on an integration of the quantitative and qualitative results from the aforementioned data collection.

2.2 Participants

A sample of 77 Black undergraduate women in computing programs (computer science, computer engineering, information systems, information technology, and software engineering) was

Table 1. Key Characteristics of the Sample

Characteristic	N	%
AGE	**77**	**100**
18–25	66	85.7
26–30	7	9.1
31–35	1	1.3
Over 40	3	3.9
YEAR IN COLLEGE	**77**	**100**
First	22	28.6
Second	18	23.4
Third	13	16.9
Fourth	18	23.4
Fifth	4	5.2
Sixth or More	2	2.6
MAJOR	**77**	**100**
Computer Science	49	63.6
Computer Engineering	5	6.5
Software Engineering	2	2.6
Information Systems	1	1.3
Information Technology	8	10.4
Two or More and Other Computing Majors	12	15.6
COLLEGE TYPE	**77**	**100**
HBCU	35	45.5
Non-HBCU	42	54.5
GPA Mean = 3.29 (Min. = 2.00; Max. = 4.00)		

recruited to participate in the study. Participants included self-identified Black women enrolled in an undergraduate computing program in diverse college settings. While recruitment was directed towards Black women at four-year institutions in the United States, there were three participants at international schools (in Jamaica, Cameroon, and Canada), four participants at online degree-granting schools, and one participant from a two-year college. However, based on the qualitative responses from these participants, it was determined that they had relevant perspectives to offer this study and that it was worthwhile to include these cases in the final dataset. Full sample characteristics are presented in Table 1.

2.3 Participant Recruitment and Selection

To yield the most robust and representative sample of Black undergraduate women in computing possible, we reviewed data from the National Science Foundation [23, 24] and identified academic institutions that awarded the highest number of bachelor's degrees to women and Black students in science and engineering. We also conducted Internet searches and requested referrals from our professional and personal networks to organizations and online social networks where we could access Black undergraduate women in computing who might be interested in participating in the study. Based on these results, we contacted faculty, staff, and students at those institutions, national organizations, and advocacy groups focused on women and Black students in computing and engineering. The Daily et al. [2022] analysis shows HBCUs are more likely than non-HBCUs to confer degrees in computing fields to Black women, supporting our recruitment strategy of intensely recruiting at HBCUs (and a women's HBCU) and specifically at two of the top producing

HBCUs for Black women in computing. Prior to any recruitment procedures or data collection, we obtained the necessary approvals from all **Institutional Review Boards (IRBs).** Upon IRB approvals, an informational web page for the study was launched which allowed potential participants to learn more about the details of the study, as well as the researchers' contact information and affiliations.

2.4 Data Collection

Qualtrics online survey software was used to collect participant responses for the study. Upon clicking the survey link, participants were asked to indicate their informed consent and then complete the survey questions. The survey took approximately 20 minutes to complete and participants were offered a range of compensation options (e.g., a $5 Starbucks or CVS electronic gift card and entry into a lottery for a $50 Amazon gift card) as an incentive for participation. We distributed the gift cards to their university email address as a way to ensure that participants were current students.

2.5 Measures

The following scales measured the identity, motivation, and retention variables in this study. With the exception of the Black identity centrality scale, each scale was adapted by changing the subject of the statements (e.g., changed "math" to "computing" or "Black people" to "women") in order to make the statement relevant to the social identity groups and academic field of interest to this study.

Identity. The centrality subscale of the Multidimensional Inventory of Black Identity (MIBI) [34] measured the importance of Black identity (e.g., "Being Black is an important reflection of who I am." 1 – Strongly Disagree, 7 – Strongly Agree). An adapted version of the centrality subscale from the MIBI also measured the importance of woman identity (e.g., "My destiny is tied to the destiny of other women." 1 – Strongly Disagree, 7 – Strongly Agree). The original measure included eight items and had adequate internal consistency (α = .77) among a full sample of students from both **historically Black colleges and universities (HBCUs)** and **predominantly White institutions (PWIs)**. In the present study, the adapted measure maintained adequate internal consistency for Black identity centrality (α = .78) and woman identity centrality (α = .75) among the sample. An adapted version of the Scientific Identity Scale [16] was used to measure computing identity (e.g., "I feel like I belong in the field of computing." 1 – Strongly Disagree, 7 – Strongly Agree). The original five-item scale has been used among racial-ethnic minority undergraduate students in STEM disciplines and had good internal consistency (α = .86). In the present study, the adapted measure maintained adequate reliability (α = .78).

Identity Interference. The Woman-Science Identity Interference Scale [35] was used to create adapted measures of gender-occupational identity interference and racial-occupational identity interference. These measures included woman-computing identity interference and Black-computing identity interference (e.g.,„ "I feel uncomfortable being a woman when I am with a group of computing professionals." and "Others think I am less authentic as a Black person because I am a computing student."; 1 – Not at all true of me, 7 – Extremely true of me). The original scale had 17 items and good internal consistency (α = .86). The adapted measures for Black-computing identity interference (α = .85) and woman-computing identity interference (α = .84) also had good reliability.

Expectancy for Success, Task Value, and Cost. The expectancy for success and task value scales developed by Eccles and Wigfield [13] were adapted to measure positive task value (e.g., interest - "How much do you like computing?" and utility - "How useful is learning computing for what you want to do after you graduate and go into your career?" 1 – Not very useful, 7 – Very useful);

and expectancy for success (e.g., "How well do you think you will do in your computing courses this year?" 1 – Very poorly, 7 – Very well). The original items for expectancy for success (five items, $\alpha = .92$), interest value (two items, $\alpha = .76$), and utility value (two items, $\alpha = .62$), showed moderate to good internal consistency. In our study, the expectancy for success scale maintained adequate internal consistency among the sample ($\alpha = .78$). The adapted measures for interest value ($\alpha = .63$) and utility value ($\alpha = .34$) scales had low reliability as stand-alone scales so they were combined into one composite positive task value scale. This improved the reliability to an alpha of .68, which was still not ideal but was more acceptable. An adapted version of a subscale in the Value of Education Scale [2] was used to measure psychological cost (e.g., "I'm concerned that I'm not a good enough student to do well in my major." 1 – Strongly Disagree, 7 – Strongly Agree). The original subscale included six items and had good internal consistency ($\alpha = .85$); the adapted measure in our study had acceptable reliability ($\alpha = .74$).

Retention Intention and Demographic Variables. The six-item Retention Intention Scale [26] was adapted to measure students' self-reported prediction of their likelihood to remain in the major (e.g., "I am likely to leave my computing major or computing related track." 1 –Strongly Disagree, 7 – Strongly Agree). The original measure had very good internal consistency ($\alpha = .93$). The adapted measure for the study maintained very good reliability ($\alpha = .89$). Control variables in the web-based survey included prior ability (as measured by self-reported current grade point average) and institution type (HBCU or non-HBCU). Other demographic data included age, current major (e.g., computer science, computer engineering, software engineering, information systems, information technology), and ethnicity.

The first open-ended survey question, *Why did you choose to study computing?* addressed participants' motivation to major in computing in order to identify themes consistent with (and in addition to) the EVT model. The second question, *What is it like for you to be a Black female student in computing?* was an intersectional question about participants' perspectives and experiences "as Black women in computing" in order to explore how the women describe intersectional experiences in computing and the impact of intersectional experiences on motivation and choice.

2.6 Analyses

To analyze the quantitative data, descriptive statistics were calculated for all of the demographic variables and scales in the study to determine mean values and standard deviations among the sample. A series of t-tests was used to examine group differences across the quantitative identity and achievement motivation variables for those who did and did not attend an HBCU. Multiple regression was used to test the direct and indirect relationships among identity interference variables and achievement motivation variables in predicting retention intention.

We used the general coding process outlined by Creswell [11] and selected first cycle and second cycle coding methods detailed by Saldaña [33] to analyze the qualitative results from the two open-ended questions. *A priori* codes were established based on the aforementioned EVT model and the Collins and Bilge [5] intersectionality framework, such as *interest value, psychological cost, interpersonal power,* and so on. Additionally, due to the exploratory nature of the research question, emergent codes were also considered throughout the qualitative analysis. The two authors analyzed the responses to the open-ended survey items through an iterative process to identify codes that represented meaningful chunks of data, categories that represented groups of conceptually similar codes, and themes that connected these parts to provide a larger explanation of the phenomena at hand (the motivation and intersectional experiences of Black undergraduate women studying computing).

Table 2. Means, Standard Deviations, and Cronbach's Alpha for Variables and Scales

Variable	M	SD	α
GPA	3.29	.44	–
HBCU	.45	.50	–
Computing Identity	5.46/7	.94	.78
Black Identity Centrality	4.89/7	1.07	.78
Woman Identity Centrality	4.79/7	1.01	.75
Black-Computing Identity Interference	3.37/7	.95	.85
Woman-Computing Identity Interference	3.51/7	.96	.84
Expectancy for Success	5.25/7	.85	.78
Value (composite)	5.94/7	.72	.68
Psychological Cost	4.15/7	1.21	.74
Retention Intention	6.12/7	1.18	.89

3 RESULTS

3.1 Descriptive Results

Seventy-seven participants took the survey; all 77 provided ratings for the Likert scale items (no missing responses). Seventy-one participants provided responses to the open ended items. The descriptive results are presented in Table 1.

Table 1 shows that over 85% of the sample was between 18 and 25 years old and approximately 60% of the sample was in their first or second year of school. Most of the participants (63.6%) majored in computer science; computer engineering, software engineering, information systems, and information technology majors comprised another 20.8% of the sample. The remaining 15.6% of the sample declared "other" related computing majors including: computer engineering and electrical engineering, computer science and robotics, computer science and business, computer security, engineering science, information technology and health informatics, and combinations of two or more computing majors listed on the survey. Six participants (7.8% of the sample) were enrolled in a dual degree program. The mean self-reported grade point average for the sample was 3.29; the minimum was 2.0 and the maximum was 4.0.

Almost half the sample (45.5%) attended an HBCU which included respondents from one Black women's college. Codes for non-HBCU (54.5%) institutions included, Hispanic Serving Institution, Predominantly White Institution, Online Degree Granting Institution, Two-Year College, and International Institution. With respect to ethnicity and country of national origin, some of the ways participants described themselves included: African -Togo, African American, Born in Nigeria, African American - Eritrean, Afro-Caribbean/Black, American, Barbados, The Bahamas, Cameroon, Black/Jamaica, Caribbean / Trinidad & Tobago, Caribbean / Guyanese, Dominican, Lebanese, Hispanic, Mexico, Senegal, Sierra Leonean, Nigerian American, and United States.

At the mean value level, the sample scored highest on measures of retention intention (M = 6.12) and value of the major (M = 5.94). The mean value for computing identity was also relatively high among the sample (M = 5.64). The sample scored lowest on measures of Black-computing identity interference (M = 3.37) and woman-computing identity interference (M = 3.51). Table 2 presents the results of the descriptive analyses for all variables as well as scale reliability as measured by Cronbach's alpha.

Research Question 1: ***What is the nature of Black undergraduate women's academic motivation to pursue computing education*****?**

Table 3. Themes and Quotes from the Open Ended Survey Question About why Students Chose to Major in Computing

Theme	Exemplar Quote
Task value and identification with computing	"I very organically fell in love with it. I love to code. I can't imagine being any other major. Computer Science is honestly where I feel the most comfortable. I don't think there's anything else that I'm into." (HBCU freshman)
Interest influenced by relatives (especially men) and early exposure	"My father is an engineer and influenced me and I was in a CS magnet program at high school" (PWI senior) "My brother and father studied computer engineering and were successful with it. I developed a love for computers from a young age as well." (HBCU freshman)
Utility value	"Because as a African American female there are going to be many opportunities granted in the computer field because there are not many black women who decide to get a degree in computer related fields." (HBCU senior)

Here we present linkages between the findings that emerged from our thematic analysis of the open-ended survey question about why participants chose computing majors as well as the quantitative survey results. These responses represent the range of motivations among Black women regarding their pursuit of an undergraduate computing degree and include intrinsic and extrinsic dimensions of different types of value for computing as well as early familial influences and exposure to computing education. In addition, the role of identity was salient throughout participant responses demonstrating the centrality of identity in academic motivation as evidenced through statements such as "don't see myself" in technology and computing and feeling "most comfortable" or having a good fit with computing.

The quantitative and qualitative data reveal positive motivational qualities of Black undergraduate women in computing, including high task and utility value (mean = 5.94) for computing major and positive expectancies for success (mean = 5.25). In their responses to the open-ended questions, the students describe their task value as naturally loving different aspects of computing such as coding, and a love for computers. Additionally, they describe the role of relatives, particularly fathers, in developing their interest in computing (the "male fam" code was the 3rd most frequently occurring code and showed up in 10 responses). They also describe the utility value of a computing major being the career opportunities that are available to them and the demand in the field for Black women. For example, participants noted that majoring in computing allowed them career opportunities and benefits such as "a job without necessarily going to graduate school," "a successful career doing something I love," and "very good employment prospects." Table 3 shows the qualitative themes and exemplar quotes/ responses of task value, utility value, and the influence of relatives that demonstrate the nature of Black undergraduate women's motivation to pursue computing education.

The students' scores on the quantitative measures of motivation for computing as well as their open-ended descriptions of why they chose a computing major reflect high task (interest) value, high utility value, as well as positive expectancies for success. Also in line with expectancy-value theory and the influence of key socializers and prior educational experiences, the responses show the significant positive role of family models and involvement and early experiences in women's motivation in computing. Also in line with EVT (Eccles 2009), students' identity or fit with computing is part of their motivation for computing. In sum, this group of Black undergraduate women overall have positive motivation and identification for computing.

Research Question 2: ***How are Black undergraduate women's intersectional computing experiences related to their sense of self (identity), motivation, and intention to remain in computing education?***

Here we present linkages that emerged from our thematic analysis of the open-ended survey question that asked participants "what is it like for you to be be Black female student in computing?" and the quantitative survey results. We also apply EVT and the four domains of power discussed by Collins and Bilge (2016) in our analysis. The quantitative and qualitative data indicate that Black women have varied levels of self-efficacy and outcome expectations in computing education, across all institution types. As previously mentioned, our participants had generally positive expectancies for success (mean=5.25); however, some illustrate how their experience of double marginalization results in feeling that they must work harder than others and need to prove that they can succeed in computing (disciplinary power implications) as they strive towards their goal of completing their computing degree.

The quantitative and qualitative data demonstrate the significance of identity interference and psychological cost to Black women's intersectional experiences in computing as well as their intention to remain in the major. In our regression models, woman-computing identity interference was a significant positive predictor of psychological cost (β = .494, p = .000) and negative predictor of retention intention (β = -.439, p = .000); Black-computing identity interference was a significant positive predictor of psychological cost (β = .504, p = .000) and negative predictor of retention intention (β = -.405, p = .000). These results suggest that feeling conflicted about being a Black woman and fitting into computing education exacts a psychological toll on Black women that may lead them to leave computing. In their open-ended responses, many Black women describe how their intersectional positionality in computing education causes them to feel out of place and insecure and to question their fit within the major due to messages about who is expected to succeed in computing education (cultural power implications) and the pressure to outperform their peers (interpersonal power implications). Table 4 shows the qualitative themes and exemplar quotes/ responses regarding what it is like to be a Black female student in computing with respect to their intersectional experiences, sense of self, motivation, and retention.

The results reveal that, for Black undergraduate women in computing education, the challenge of navigating both racism and sexism, external norms and expectations, and socio-cultural implications associated with both their under-representation and hyper-visibility in computing (cultural power implications) can have both a debilitating and motivating effect on students. In addition to regularly battling loneliness and microaggressions (interpersonal power), they are aware that they receive less support than their peers and have little confidence that much will change any time soon (structural power). Nonetheless, there are some who find a way to leverage opportunities that come due to their intersectional position for personal advancement and as a way to pay it forward for the next generation of Black women in computing.

Research Question 3: ***How do Black undergraduate women in computing experience intersectionality, sense of self (identity), motivation, and intention to remain in computing at HBCUs vs non-HBCUs?***

Our quantitative and qualitative results indicate that Black undergraduate women in computing at HBCUs have different experiences of identity interference (i.e., with respect to racial, gender, and computing identity) and intention to remain in the major than those not at HBCUs; Black women at HBCUs generally have more positive outcomes on these measures. The quantitative data also identified areas where there were no significant differences across women at different institution types. There was no significant difference in the computing identity, Black identity, woman identity, expectancy for success, value, or psychological cost scores for HBCU and Non-HBCU women, suggesting that Black undergraduate women in computing across diverse types of

Table 4. Themes and quotes from open ended survey question about what it is like to be a Black female student in computing

Theme	Exemplar Quote
Isolated and struggling (more than others) to persist and prove your worth	It is lonely. Often I am the only one so I know few are experiencing the same struggles and microaggressions that I am. I think it makes me want to and have to work harder to prove myself as on the same level or better. (PWI sophomore) "As a black female, I feel like I am working X10 harder than others. I seek out outside resources to get help so I don't struggle in CS classes. Ex (open source, data science workshops) I see SO many African American women failing and giving up within the first couple of weeks in their first programming classes." (HBCU junior)
Self efficacy and outcome expectancy–motivated to defy the odds	I always love a challenge. Being a black female student in computing makes me want to defy that odds and prove that I'm just as great as any white student… I've always liked doing what the boys think they can only do and doing it even better. (HBCU senior)
The psychological cost of being a Black woman in computing	Every day, I experience microaggressions, little jabs at my identity as a black woman. People either don't know how to treat me or treat me like an alien. I've had my intelligence questioned multiple times, not all the time verbally. People often don't believe me when I say that I'm a CompSci student because I don't fit their stereotype of one. (PWI freshman)
Leveraging intersectional positionality (counternarrative of empowerment)	It isn't as challenging as some people may lead you to believe. Not in this stage of my career at least. I don't even really think about the fact that I'm in a male-dominated profession. Being black has its perks. So far I've only seen the benefits of being black as companies like Microsoft and Google are actively reaching out to black people trying to increase diversity within their company. (HBCU freshman) I go to both a predominantly male college (ratio is about 6 or 7:1) and a predominately white institution. So it's rough. But it's also rewarding because I'm making strides for both black people, women, and black women, so that makes me happy. Also, people are starting to realize. Anytime I participate in like a hackathon or security competition, I'm always the first to be interviewed. It's like I'm a gold mine; anything that screams "inequality" is good news now. (PWI senior)

institutions share many positive motivational qualities. However, HBCU participants (M = 3.064 SD = .715) had significantly lower *Black-computing identity interference* scores than Non-HBCU women (M = 3.630, SD=1.046); t(72)= -2.809, p = .006. Additionally HBCU women (M = 3.158, SD = .792) had significantly lower *woman-computing identity interference* scores than Non-HBCU (M = 3.800, SD = .990) students; t(75)= -3.096, p = .003. HBCU women (M = 6.405, SD = .980) also had significantly higher *retention intention* scores than Non-HBCU women (M = 5.857, SD = 1.283); t(74)= 2.121, p = .037. Table 5 presents themes and exemplar quotes/responses from an

Table 5. Themes and Quotes from Open Ended Survey Question about what it is Like to be a Black Female Student in Computing (at an HBCU vs NonHBCU)

Theme	Exemplar Quote
Increased identity interference for NonHBCU students	I also feel alone, and sometimes like I'm doing the wrong major. The majority of my female friends are Black, and alot of them either major in Business, Psychology or Social Work. When I talk about Computer Science around them, I almost feel as if I am trying to be "White" or something that I'm not, but it's only because Whites dominate the field. (PWI Junior)
The benefits and limitations of racial and gender representation for HBCU students	I attend [a co-ed HBCU] where, in my opinion, the students represent Black excellence. Therefore, I feel like the world is in the palm of my hand being a Black female computer scientist. (HBCU Sophomore) It's harder to be a female in computing than to be black. My own professors expect me to not perform as well as my male peers. They expect the girls to prefer to do UI and web development (aka make things look pretty) instead of preferring back end development. Some of my male peers will exclude girls from the 'hard' programming. They also want the feminine girls in CS to do the presentations, and to be the face of whatever product is being built. (HBCU Senior) At school it is fine. Once I am in any other environment, it is really tough. I usually feel like an outsider, and people make me feel inadequate. My presence has been completely ignored at times. At conferences, I try to scope out other Black women to find some sense of belonging because I never feel like I belong at large gatherings of computing students and professionals. (Women's HBCU senior)
Unique role of and experiences at Black women's colleges	Because I attend [a women's HBCU], I am actually very empowered as a Black Female in computing. Having professors who are Afro-American and have PhD's in computer science is great because I have great examples right in front of me. (Women's HBCU junior)

institutional lens regarding what it is like to be a Black female student in computing with respect to their intersectional experiences, sense of self, motivation, and retention.

On the quantitative measures of identity and motivation, Black women in computing at HBCUs and non-HBCUs showed a similar profile; however, the Black women who are not studying in computing programs at HBCUs experience higher rates of identity interference and lower intention to remain the major ("alone" was the most frequently occurring code for the non-HBCU sub-sample). Our qualitative results also provide a within-group analysis of HBCU students which indicates that Black undergraduate women's intersectional computing experiences vary even across HBCU contexts. Black women at a women's HBCU consistently report positive experiences at their institution whereas Black women at co-ed HBCUs have a more nuanced perspective where some are even able to isolate the distinctly gendered aspects of their intersectional experience from their racial ones. For example, one HBCU senior noted "It's harder to be a female in computing than to be black. My own professors expect me to not perform as well as my male peers." Though the

negative intersectional experiences are mitigated at the Black women's college, the awareness and experience of interlocking systems of oppression are still present for these same students in their broader pursuit of the computing profession (i.e., at internship and conferences).

4 DISCUSSION

Our analysis yielded insight into the range of motivations among Black women regarding their pursuit of an undergraduate computing degree including intrinsic and utility values, positive expectancies, and familial influences. The role of identity (personal, academic, and social) was salient throughout participant responses, demonstrating the centrality of identity in achievement motivation. The data also showed a range of intersectional experiences Black women have in undergraduate computing, such as exclusion, discrimination, identity dissonance or interference, the burden of disproving stereotypes, and the satisfaction of succeeding and persisting in the midst of these challenges. The women also described different intersectional experiences and perspectives ranging from isolated and pressured to empowered and successful. The gendered racism in the computing education landscape and the nature of Black women's intersectional experiences in the field is a microcosm of the broader structural and interpersonal challenges Black women navigate via their social location in American society (i.e., the "situated" or position and context-based experience of intersectionality).

This study extends prior work on Black women in computing in several ways. One, with a fairly large sample of Black undergraduate women currently enrolled in computing programs, we were able to broaden the scope of typical studies, which focus on either women who have persisted or those who have not [e.g., 32]. We examined how motivation and identity variables relate to whether Black women students plan to remain in or leave computing during their undergraduate studies. Also, we observed the important role of other family members, in addition to fathers, in Black women's pursuit of computing. In addition, using motivation theory from educational psychology allows us to describe the nature of Black women's motivation in computing in specific terms that are well-established in motivation scholarship and research, which helps to clarify important student psychological processes that affect achievement in computing. The "self-motivation" of Black women who persist in computing discussed in prior studies [e.g., 32, 38] is revealed in this study to be intrinsic task value and interest or love for computing; as well as utility value for excellent career prospects, and positive self-efficacy or expectancy for success in computing. The present findings also reveal the ways in which identity conflicts or challenges that Black women experience in the computing education environment can undermine their motivation to persist. These findings provide detailed evidence that can be used to create effective practice and policy.

There are several theoretical implications for these findings. Eccles and Wigfield [2020] call for research employing an expanded version of EVT model, **Situated Expectancy Value Theory (SEVT)** to address how the interaction of culture, ethnicity, and gender (as well as experiences of racism, discrimination, and oppression) inform individuals' expectancies and values and ultimately their motivated choices. Our study provides examples of the connections between the situated experiences Black undergraduate women have in the computing education context (including its cultural and disciplinary power dynamics) and their sense of self and motivations to study computing. Additionally, though the methodological limitations of measuring intersectionality have been discussed [3], as well as the difficulty in disentangling race and gender among Black women, some of our participants were able to clearly indicate when and how an experience was more salient to their racial and or gender identity. Finally, some of the women in our sample found opportunity in their intersectional positionality, which speaks to the nuanced dimensionality of power and privilege that Cole [2019, p. 171] observed:

> "...some members of disadvantaged groups also hold privileged identities (e.g., middle-class Blacks, White women). This reveals that although much of the literature on intersectionality has been theorized from the standpoint of those who experience multiple dimensions of disadvantage, this framework can also inform how privileged groups are understood."

In terms of institutional context, there were positive and negative experiences described by Black women in computing at HBCUs and PWIs, but Black undergraduate women situated in HBCU computing education contexts often endorsed a sense of empowerment and fulfillment in their studies, particularly because they were among peers and faculty who looked like them. Those in non-HBCU contexts expressed more experiences of identity interference, social isolation and hostile learning environments than women attending HBCUs. Our study found that greater identity interference leads to greater psychological cost, which undermines Black women's motivation and retention in computing. Additionally, prior work on Black women in computing included smaller samples of retrospective self-report data on HBCU undergraduate education that depicts the generally positive, nurturing experiences at HBCUs; our data from a larger sample of Black undergraduate women in computing reveal a range of experiences and motivation at HBCUs and support prior findings, but also show that HBCUs have work to do too, particularly around gender power dynamics in the classroom. Perceptions of the status of Black women in society and in the context of computing on their college campus served as a lens through which they interpreted their academic self-concept, their motivation to achieve, demonstrate or prove their competence, and their challenging interactions with students from other social groups. These perceptions were situated in and varied across institutional settings, demonstrating HBCU students experience more positive psychological experiences than Black women at other institutions. The role of institutional context warrants further examination.

There are practice and policy implications for higher education resulting from this work, which include: administration and faculty improving retention efforts; disrupting racism and sexism directly by giving faculty anti-racism and anti-sexism training and implementing the learnings from intersectionality literature in CS education; recruiting and retaining more diverse (Black women) faculty in CS; and recruiting and retaining more Black women students in CS. We recommend that colleges and universities make a focused effort to increase the number and retention of Black students and Black women students in computing majors. One way this can be achieved is through partnerships with K-12 education, particularly high schools, to create computer science classes, and feeder, pre-college, and "grow your own" programs; which could strengthen computing education pathways, and increase equity and belonging in K-12 spaces too.

Faculty, staff, and administrators working with Black undergraduate women in computing must consider the sources of self-efficacy (e.g., verbal persuasion, vicarious experiences) and the motivations guiding student choice. They should be proactively responsive to (anticipate) students' needs for encouraging and constructive feedback on their progress towards mastery and performance in computing. Additionally, they must be aware of and address the power dynamics in classrooms and programs, including what messages are being communicated about who will and will not be successful, how the rules are applied, and balancing an overemphasis on performance and competition with cooperation and peer support.

Additionally, faculty, staff, and administrators must make efforts to repair the epistemic violence in computing education with an ethic of care and justice and find opportunities to establish a culture of inclusion such as those modeled by HBCUs. Institutions, particularly where student and faculty diversity are lacking, must also invest in external opportunities for Black women to be affirmed, seen, and supported including: sponsoring their participation in organi-

zations and convenings such as the blackcomputeHER Conference, the Grace Hopper Celebration of Women in Computing, and the Richard Tapia Celebration of Diversity in Computing. These spaces allow Black women in computing to expand their support network by meeting other Black women in computing across institutions and connecting with successful role models who look like them and share their experiences. They also often serve as a respite from the persistent isolation and pressure they may experience in their day-to-day lives in a computing department. Opportunities for connection and identity affirmation can also be found in inter-institutional partnerships between HBCUs and PWIs, where students can benefit from the strengths of each institution.

To foster belonging, Gray [2018] recommends that schools create interpersonal, instructional, and institutional opportunity structures for Black student belonging [18]. These can include: promoting positive peer and teacher-student relationships, at the interpersonal level; using culturally relevant pedagogy that affirms Black women's racial and gender identity and cultural heritage at the instructional level; and eliminating and prohibiting institutional standards that devalue, subjugate, isolate, and exclude Black women at the institutional level.

Lastly, administrators must foster systems of accountability to support the authentic and sustainable implementation of the above practices. Faculty, staff, and students, should be encouraged to disrupt racism and sexism, not only with anti-racism and anti-sexism training, but also through having clear processes for reporting and repairing such harm. The labor of mentoring students must be recognized and in ways that incentivizes more faculty and staff to serve in this capacity in support of students who are most in need.

This study contributes to the emerging research on the psychology of intersectionality, "the mental processes and behavioral choices associated with managing the complexity of holding multiple co-constructing categories of social group membership and the power dynamics therein" [19]. Understanding the psychology of intersectionality helps us derive the psychological processes associated with intersectional computing, including the relationship to motivation and retention. In addition to the isolation, pressure and epistemic violence experienced by Black women in the intersectional computing education context, the findings of this study display the unique cultural-social-psychological strengths of Black women in their positive valence and resilience, as well as their joy, empowerment, and achievement in computing. There was an awareness among participants that their decision to study computing has an agentic effect in that their individual choice to study computing can influence the larger social context. In many ways, it seems that the academic motivation of Black women in computing serves as a protective factor in their intention to persist despite their intersectional experiences. Be it through their technological achievements, or their role in broadening the image of what a computing professional looks like, these effects are theorized to shape the social systems that inform the identities and motivated behaviors of other Black women that follow them.

This study also contributes to the broadening participation literature in computing education by adding more complexity and depth to understanding the phenomena particularly from psychological science frameworks and perspectives. Future research on Black undergraduate women in computing might consider studying women at the start of college in different institution types and observing changes in their motivation and sense of self over time, given that the motivational profiles of the women in our study were very similar across institutional contexts. Increasing and complicating our knowledge of the motivations and experiences of Black women in undergraduate computing education, as well as understanding when and how their beliefs and perspectives vary across institutional context, will better inform efforts to retain them and promote their success both in college and into their careers.

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