A Longitudinal Study of the Post-Secondary Experiences of Women of Color in Computing

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***Abstract*— This paper investigates the long-term impact of CompSciConnect (CSC), a three-year computing program for middle school girls and Black, Indigenous, and People of Color (BIPOC) learners. We use the educational debt theory to explore how CSC addresses structural and systemic barriers throughout the K-12 and post-secondary education pipeline. Findings reveal that CSC positively impacted all alumni. However, the isolating culture of post-secondary CS learning environments conflicted with these positive experiences. This study suggests that cultural, economic, and social issues within post-secondary CS education can counteract positive informal learning experiences and reinforce the debilitating effects of educational debt.**

Keywords*— *informal learning, equity, computing education, STEM, broadening participation

I. Introduction

Despite promising increases in the number of US high schools offering foundational computer science (CS) courses [1], annual reports on the status of K-12 CS education repeatedly show Black, Indigenous, and People of Color (BIPOC) students, especially BIPOC girls, are the least likely to have access to CS courses [2]. In response to these persistent inequities in formal K-12 education, a growing number of afterschool and summer initiatives have been created to introduce middle school girls, BIPOC, and low-income students to computing concepts in hopes of increasing their representation in STEM majors and careers [3][4]. Common themes across these initiatives include introducing girls and BIPOC learners to computing concepts, promoting the narrative that they can succeed in computing, and providing them with meaningful spaces to reflect on the relationship between computing and their interests [4]–[6]. While these informal programs are successful at providing positive learning experiences, when learners move beyond these programs into postsecondary education and careers, the long-term impact of these initiatives is less clear.

This study advances our understanding of the ways in which informal summer programs can support girls, BIPOC, and low-income learners in pursuing computing-related degrees in higher education. We conduct a longitudinal analysis, following youth from historically excluded populations after they complete CompSciConnect (CSC). CSC is a three-year computing program, designed to introduce youth, especially girls and BIPOC learners, to computing concepts, support their self-efficacy of succeeding in computing, and create a space that intentionally forges a community where participants' interests in computing can be nurtured through mentorship and continued engagement [19].

II. Theoretical Framework

In this paper, we adopt an educational debt lens to examine the post-secondary experiences of women and BIPOC learners who participated in CSC, referred to as alumni. CSC was designed to address the educational debt accrued by BIPOC students, especially BIPOC girls, throughout the K-12 CS education pipeline. Ladson-Billings defines educational debt as the accumulation of oppressive historical, economic, moral, and sociopolitical practices that lead to differences in educational opportunities across racial, gender, and socioeconomic lines [7]. Racial, gender, and economic segregation throughout the K-12 CS education pipeline contribute to the educational debt and explain the multiple forms of inequities that persist within the US K-12 education system and their impact on BIPOC students and their post-secondary experiences.

Ladson-Billings explains that the historical component of the educational debt comes from long-held practices within the US

979-8-3503-2832-5/23/$31.00 ©2023 IEEE
DOI 10.1109/RESPECT60069.2023.00018

education system, like the segregation of Black and Hispanic/Latino/a/x students in public schools and the forced assimilation of Native American/Indigenous students, that reinforced educational practices and beliefs meant to privilege white, European values and perspectives while excluding BIPOC students from high-quality public K-12 education. Similar forms of debt come from economic structures that promote inequitable funding and resource distribution to US public schools. The effects of the historical and economic forms of the educational debt then led to the underrepresentation of BIPOC individuals in the public K-12 teaching workforce, post-secondary STEM professional faculty workforce, and the STEM workforce, therefore limiting the potential for BIPOC voices to speak up and advocate for change in these professional environments (the sociopolitical debt) [8]. To address the educational debt, Ladson-Billings suggests that educational researchers investigate the root causes of differences in academic achievement and stop relying on short-term, surface-level solutions. This requires that policymakers, administrators, teachers, and other educational stakeholders take on both personal and social forms of responsibility (the moral debt). Similar calls for change echo across the computing community as leaders at the Kapor Center [9] advocate for policies and practices that specifically address systemic factors that limit Black student participation in K-12 CS education.

We specifically explore how CSC did or did not help mitigate the four aspects of the educational debt that young BIPOC women accrue as they progress through secondary, post-secondary, and career environments. quality public K-12 education.

III. Research Goals/Questions

The goal of this study is to investigate the longitudinal impact of CSC on its alumni experiences in secondary and post-secondary STEM education. This study specifically aims to understand how CSC addressed or failed to address the educational debt experienced by BIPOC women in computing. We look at the ways in which alumni describe the impact of CSC on their future trajectories in STEM and whether the program provided meaningful preparation for post-secondary STEM opportunities. Our central research question is: What are the long-term impacts of a three-year long computing initiative when evaluated through alumni reported experiences in science, technology, engineering, and mathematics (STEM) as they progress through secondary, post-secondary, and career environments?

IV. Positionality Statement

The research team includes two faculty, two staff, and four students whose work centers around supporting historically marginalized students interested in tech, especially within their university and local community. The racial and ethnicity breakdown of the research team is one Black/African American, four White Americans, two Asian, and one Latina. The gender breakdown is one male and seven women. The educational breakdown is three Bachelor's degrees, three Master's degrees, and two doctoral degrees.

V. Research Design/Methods

We interviewed CSC alumni about their experiences in the program to better understand the long-term impacts the program did or did not have on how they progressed through secondary, post-secondary, and career environments. Through semi-structured interviews, we gathered data about each alumni's experience in CSC, their involvement in computing education following the conclusion of CSC, their career aspirations, their comparison of CSC instruction to high school and post-secondary computing instruction, and their current connection (if any) to the CSC community. Also, we further looked for significant examples in their interview responses where CSC may have addressed the educational debt compared to their perceived experiences in postsecondary education and/or career. Questions such as, Are you still involved with CSC or other university initiative programs?, What made you decide to switch your major?, and What are your future plans?, were helpful in revealing whether or not CSC addressed the educational debt.

Using purposive sampling methods [10], we contacted via email 90 women and BIPOC women who participated in CSC in 2012, 2013, 2014, or 2015 and were enrolled in post-secondary education or have started a career. Of the 90 women, nine agreed to participate in the study. Following recruitment, we scheduled thirty-minute to one-hour semi-structured interviews with each participant. Table 1 shows the demographic breakdown of the nine women in this study.

TABLE I. CompSciConnect Alumni Demographics

Pseudonym	Race	Major	Year of Enrollment	Number of Years Enrolled
Peyton	Black	Computer Engineering	2012	2
Alex	Asian	Environmental Science and Policy	2015	3
Quinn	Latina	Government and Politics	2014	3
Brooklyn	Black	Computer Science	2015	2
Parker	Southeast Asian	Computer Science	2012	3
Jordan	Black	Information Science	2012	2
Riley	Black	Chemical and Biomolecular Engineering	2013	3
Jade	Latina	Civil Engineering	2015	3

Blake	Black	Computer Science and Information Science	2015	3

Table 1. Demographics of csc alumni by pseudonym, race, gender, major, the year they began csc, and the number of years they participated in csc.

VI. Data Collection/Analysis

Each semi-structured interview was held over Zoom, recorded, and transcribed. All transcripts were uploaded into the Nvivo software for analysis and exploration of themes. Our first step in analyzing the data was to identify patterns across all of the interviews conducted [11]. First, three members of the research team independently coded each interview to look for phrases that aligned with the educational debt or that were reoccurring. Examples of these codes would be resource access, financial support, social support, social impact, or racial experience. These original codes help to meaningfully organize and condense the interview data for more nuanced analysis [11]. From a list of over 70 codes, the researchers cross-compared each code for overlapping themes and rationalized the codes, similar to the process outlined by Rankin and Thomas [12]. Once all codes were reviewed, we then collapsed the codes into larger themes/categories that helped to answer the research question. Our complete analysis of the data resulted in five emergent overlapping themes.

VII. Results/Findings

We identified five themes that address the long-term impact of CSC on alumni experiences in computing as they progressed through secondary and postsecondary education. This section highlights each theme and prevalent quotes to emphasize the impact of these themes on each alumni's path in computing.

A. A Positive Introduction to STEM

Alumni repeatedly shared positive CSC experiences that either led them to pursue a career in STEM or provided them with skills that helped them throughout their postsecondary journeys. They all commented on different aspects of the program, like the project-based learning curriculum, the near-peer mentoring teaching model, the emphasis on community building, and/or the multi-year structure of the program, as providing them with learning opportunities they otherwise would not have access to.

> CompSciConnect was pretty great. I remember, I have a lot of pictures actually of like, teammates, and I and creating our projects. And I still remember a lot when it comes to Unity in the VR side of things. And now I am starting my game design minor. -*Brooklyn*

> I think [CSC] was like really helpful in understanding computer science, or it was just like, it felt more applicable than what I was learning in school, and it also was a lot more interactive than I think school was in teaching computer science. So I really enjoyed it. And I met so many people that I still know, to this day… I've known them since I was in sixth grade. -*Quinn*

Brooklyn distinctly named the community/team-building aspects of CSC and the curriculum as parts of the program that she enjoyed. She also added that CSC motivated her to not only pursue a CS major but to also focus on game design. Quinn related the "interactive" component of the program as helping her better understand and increase her interest in computer science. Quinn is majoring in government and politics, and later in the interview she shares that CSC provided her with the "hard skill" she needs to succeed in her major.

> With social sciences at [my university], they're putting an emphasis on hard skills like computer science. So we do have to take like R studio, we have to take that, which is the most coding I've done. But I think from my CompSciConnect background, it came easier to me. I think it was very helpful in that sense. And just any like, kind of data analysis, I think it's easier to get if you have like somewhat of a CompSciConnect background. -*Quinn*

Jade mentioned that the camp helped her to become more extroverted and feel a part of a STEM community, Jade even keeps in contact with Quinn. She shared, "CompSciConnect definitely made me come out of my shell. People were willing to talk to me and we shared the same interests." She also added,

> I've been in CompSciConnect since I was probably in middle school…And I've been with them for about three years. And it was actually a really great program. I got to meet a lot of people who shared similar interests, especially women, I was so overwhelmed by the amount of representation of the female population and women in STEM that I found there, and made me definitely have a go-getter mindset. -*Jade*

Jade appreciates the CSC community and its emphasis on the inclusion and representation of women in STEM.

Jade credits the program's emphasis on community learning and project-based curriculum to her current interests in STEM.

> [CSC] definitely made me be interested more in computer-aided design programs…I feel like [CSC] really helped just push me into that direction, because without any of that background, I couldn't, I wouldn't have gone anywhere near computers or coding or anything. So that really helped me. … I remember one project we had it was building a Lego robot. And that was definitely the most coolest project I've ever done. I had to go into coding and programming it and actually building the robot. It was definitely an eye opener for me. I think that's what allowed me to want to pursue mechanical engineering at first. So that helped with guiding me into that direction. I've just

> been on that track ever since I've just been on the engineer train from there on out. And I haven't even thought about any other major other than that. It's either stem or nothing. -*Jade*

Jordan also commented on the impact that CSC had on her computing education goals. She shared that her experience attending CSC made her want to major in anything computer-related:

> I think [CSC] was the program that made me want to major in anything computer related, because I always thought I wanted to be a nurse. I think my mom registered us in the program before we came to the US. So I was in Ghana until 2012. And the very first summer we got here, school was out so she had registered us for the program and that was it. I was like, I really want to do something computer-related. It's a great program. -*Jordan*

Every alumnus pursuing a CS, computing, or STEM major also attributed their success in coding-centric courses to CSC. Riley thanked CSC for helping her persist in engineering: "CompSciConnect helped me, you know, further stick it out in engineering, because I already had a little bit of coding background." Similarly, Blake mentioned that "CompSciConnect really gave me a good foundation to start and not necessarily hate computer science." Both Blake and Riley's quotes suggest that computing, CS especially, is difficult without having prior exposure.

B. An Appreciation for Computing Education

Five alumni interviews revealed a passion for teaching and an awareness of how teaching practices in computing impact student interest, confidence, and persistence in secondary and postsecondary computing education. Quinn, Brooklyn, Parker, Blake, and Riley all volunteered to be CSC teaching assistants (TA) while in high school. This means they returned to CSC after completing the program and worked as near-peer mentors [13] alongside the CSC instructors to teach the computing material.

> So I think I just wanted to like explain it in a way I would have liked to. I think the teacher was already good as is because the teachers were also very young, but I think it was just easier for student because I enjoyed helping someone better understand these things. -*Quinn*

Quinn recognizes that computing can be difficult and wants to help incoming CSC learners meaningfully connect with and understand the curriculum. In fact, as an undergraduate, Quinn occasionally attends the Winter and/or Spring CSC showcases where learners present their coding projects to family, friends, university undergraduates and faculty, and CSC staff, as part of the school-year commitment. Some alumni, like Brooklyn, still teach computing through their major.

> I was emailed maybe mid-semester by a professor saying, 'Hey, you did pretty well. This other TA had to leave due to, you know, personal problems or something. Do you want to TA for this course number?' Sure. I have time in my schedule. And that's how I got into it. And I've stuck with it ever since. -*Brooklyn*

Brooklyn is recognized both as a scholar by her professor, but also as an educator who can support other undergraduate students.

C. Commitment to Social Justice and Humanity

A notable trend across the interviews was a connection between CSC and a commitment to social justice.

> It's my favorite story. So, we went on a field trip to an HCI lab on campus. And I was like, this is the coolest thing I have literally ever seen in my life, like seeing all the projects that were built. And an emphasis was on people. So it wasn't like, hey, we built this cool thing. It was like this is how this is going to help people and like this is the whole motivation behind the project. -*Blake*

Ever since a visit to an HCI lab at CSC's host university, Blake has been interested in HCI.

Even for Quinn, who did not major in a computing field, CSC reinforced a passion for social justice. She shared, "I'm really interested in women's issues. So I think part of doing CompSciConnect was like, understanding how women can get into places that they're not, like normally represented." Quinn is now interested in working for a non-profit invested in women's rights issues. Even though Quinn's future career goal is not in STEM, she has found CSC's focus on women and BIPOC to be a continued interest that she shares.

Some alumni were interested in social components of computing because of parental influences rather than by CSC. Peyton shared, "My main motivation was my mother who served as my role model by demonstrating what a woman in this field looks like. She was also the one who signed me up to participate in programs like CompSciConnect." Peyton's mother motivated her to pursue STEM and participate in CSC and emphasized that women can be a part of the computing field. When asked about her experience working at Microsoft, she added, "the work that I've been exposed to, the people that I've been exposed to, have kind of helped me say that accessibility is why I'm passionate about accessibility as it relates to closing gaps to the underserved." In Peyton's case, her mother and career experience helped to establish her commitment to accessibility.

D. Limited Collaboration: CS as Isolating

The alumni often compared their experiences in CSC to secondary and postsecondary CS classrooms.

> I think definitely the compsci I took in high school, there wasn't as much collaboration as there was in CompSciConnect. I distinctly remember that because like every single assignment we took was individual. Even in the couple coding classes I had in college, they're pretty much all individual. -*Riley*

Riley felt that her high school and undergraduate CS courses were focused more on the individual rather than collaboration, unlike in CSC. The culture of CS classes varied greatly from her experiences in her engineering courses.

> Our engineering computer classes are a lot more collaborative, because the problems are a lot more complex…they will literally give us a chemical engineering problem, we'd have to solve the problem first, and then it's like, okay, using the software, then do X, Y, and Z. -*Riley*

For Riley, there is a dissonance between her experiences in her engineering coding class and her CS classes. Reflecting on her experiences, she ended the conversation with, "I don't know why we can't collaborate as much as I was taught to code because coding is very collaborative." Through her experiences in CSC she associated coding as a collaborative learning process, which was not found in her CS classrooms.

When speaking on her experience in an introductory calculus and computer science course Parker stated, "I just felt like a penny in a bank account. So it was that part was just discouraging. I guess. There were so many people. I didn't know if my Professor cared about me or what I was interested in." Parker reiterates the isolating nature of CS learning environments and expresses that she didn't feel represented or recognized in her computing classes.

We also found that the culture of CS courses creates intimidating environments that emphasize authoritative oversight. Jade shared, "It was so intense the way they enforced [cheating rules]. You cannot talk to anybody else about any code ever. That contributed to making me feel like I couldn't ask fellow classmates for help." The oversight on cheating made Jade feel like any form of collaboration was unethical. Additionally, the individualistic and authoritative nature of undergraduate CS courses created an atmosphere of fear and intimidation.

> Everything [in CS] was on passing quizzes, like we had quizzes, we had exams that you had all of these projects you had to complete. It felt like a weed out program. I think a lot of the [students in my information science program] go on that track and then transfer. There's always a joke whenever we start a semester, like, we know some of you started out in the CS department and ended up here. - *Jordan*

Consequently, Jordan switched from a CS major to an information science major because of the high-stakes testing environment in her introductory CS courses.

All of the Alumni interviews reflected a negative perception of undergraduate CS courses that was intertwined with whether or not the alumni's CS Department emphasized diversity, equity, and inclusion (DEI) initiatives. Peyton, who chose to attend a Historically Black College or University, stated, "My instructors were big on encouraging collaboration during exam and project times. They urged us to work in groups to study and use classmates to check work." Brooklyn echoed similar sentiments:

> In terms of professors, more professors coming in are concerned about diversity. So we have a couple of new teaching faculty that really seemed to care about that kind of thing and understand and acknowledge it in class instead of just being like, alright, lecture, and then get out.

Brooklyn felt that her CS Department was committed to DEI and made an effort to acknowledge DEI within computing courses.

E. Who is Heard and Seen?

Some of the women, namely the BIPOC women, highlighted the gendered and racial structure of their high school and college CS courses.

> I was the only girl in the class until I was a junior which was so interesting. And then like one of the very few black people in high school [CS] classes until, like, Junior year…If it wasn't for my direct action to recruit students into the class, which I've never felt like I had to do in the CompSciConnect space. In college, I think there's a little more autonomy to create your own spaces. And there's spaces that were already kind of like pre-built for, like diverse people before I got there." -*Blake*

In Blake's case, she was one of the only Black women in her high school CS courses and she felt a responsibility to recruit other Black women into these courses. Meanwhile, in college, she felt like there was more of an effort to create spaces for BIPOC students and actively sought out these spaces.

Parker's experiences in computing were the reverse of Jade's. She noted positive experiences in CSC and high school computing courses but felt isolated and ostracized in her post-secondary CS courses.

> A lot of those people did not look like me and did not go through the same experiences that I went through.

> Gender wise, sexuality wise, race wise, I'm half Filipino. And like, there are a lot of East Asian people in the [CS] field. But not necessarily a lot of Filipino people. -*Parker*

Parker felt different from her classmates in her post-secondary CS courses and felt isolated. As a result, she left CSC's host university to pursue CS at a local community college where she felt more supported.

Blake and Parker's experiences raise concerns about which students are being seen in CS classrooms and how they are seen. They also raise an important point about who supports these students so that the burden of diversifying secondary and postsecondary courses does not fall on them alone.

> Is it worth it to be the person who sticks it out? To make it better? Or is it not enough? Or you want to just like, leave, but if you leave, then it's not helping the cause? It's a hard balance between those two things, because you don't want all the pressure on you. But you also don't want to give up and continue the problem. -*Quinn*

While thinking about conversations she had with a friend who was majoring in CS, Quinn reflected on the role of being the only woman in a CS space. She questioned who is responsible for changing the conditions of CS classrooms at her institution.

VIII. Discussion

The purpose of this research paper is to understand CSC's longitudinal impact on the trajectories of women and BIPOC learners in computing and ameliorating the educational debt they experience[7]. Our findings shed important light on all aspects of the educational debt addressed by CSC - the historical, economic, moral, and sociopolitical debts - and what remains unbreakable without higher levels of intervention and change in higher education. Most importantly, the findings reveal that BIPOC women may benefit from informal computing opportunities by becoming a part of a sustainable community of peers beyond the program and developing an appreciation for computing, but their positive experiences are not enough to confront the racist and sexist stereotypes in high school and college computing courses. This study emphasizes the stark tension between the positive learning environments that computing camps like CSC foster and the negative culture of high school and post-secondary computing environments.

A. Historical Debt

According to Ladson-Billings [7], the historical debt is accumulated through the "legacy of educational inequities in the United States", across race, class, and gender. The assumption that girls and BIPOC learners do not deserve equitable education is woven into US laws, culture, and politics. The accumulation of historical debt in STEM has resulted in girls and BIPOC professionals being marginalized and excluded from these learning communities at alarming rates [2-4]. Each interview shows that CSC played an important role in cultivating alumni interest and confidence in computing, as well as, their self-efficacy to pursue a future in a STEM-related major and/or career. CSC also positively changed or reinforced perceptions of *who* can pursue computing. CSC's program is designed to intentionally surround learners with near-peers, instructors, faculty, and staff who identify as women and BIPOC and is a visual representation of examples of women and BIPOC women succeeding in STEM [19]. Therefore, CSC challenged the historical debt for these women by helping them redefine what it means to do STEM and their place in the STEM community. CSC also created a space for each woman to determine whether or not STEM is relevant to their future career goals. More specifically, CSC exposed the alumni to the educational, creative, and advanced sides of STEM. Scholars have noted that an important aspect of informal learning programs for BIPOC women is to create opportunities for the women to reflect on their personal interests and investment in computing [14]. For Blake, CSC made computing fun and motivated her to power through boring and isolating undergraduate CS courses.

Although CSC changed historical perceptions of who can or cannot do computing, many of our alumni's experiences, in either high school or postsecondary education environments, reiterated that the historical debt persists outside of the CSC community. The isolating nature of their high school and undergraduate CS courses suggests that experiences in CSC can be temporary, especially when there are structures and procedures in place meant to purposefully exclude students from pursuing CS majors. Therefore, the long-term impact of CSC is diminished by a more complex and superior form of the historical debt which is maintained in advanced computing environments.

B. Economic Debt

The economic debt refers to the centuries of underfunding schools that BIPOC learners attend. This systematic underfunding has holistically affected BIPOC learners and their communities, leading to centuries of poverty and struggle [7]. CSC addressed aspects of the economic debt by providing equitable access to R1 university resources, such as access to high-quality curriculum, interactive activities, and collaborative projects, that challenged and mirrored what a student would experience in the industry but is not always found within traditional K-12 public education. In Brooklyn's account of her experience, CSC was the first time she was introduced to Unity and VR. She also noted an appreciation for the group projects.

We found that CSC had a long-term effect on the economic debt, but only in certain cases. For example, some alumni drew upon their CSC experiences to pursue internships at Bank of America and Microsoft or through Teaching Assistantships with professors. However, others faced the burden of the economic debt that limited their access to community and university resources. Even though Jordan knew she wanted to

major in computer science after participating in CSC, she found it challenging to stay connected with the CSC community and struggled with accessing resources at her university (CSC's host university). When asked if she was able to build a community on campus, Jordan responded,

> No. Because it's usually I go to class, and then I go straight to work. So that's what it has been for the past couple of years…I think it's all about you, the students. leveraging the resources that you have, that the professor gives you. I don't think I did. Like, I did not have time to go to office hours. - Jordan

Although Jordan was at CSC's host university and was familiar with the resources offered by her CS professors, the impact of resources alone can only go so far. We found that whether alumni continued to access these resources depended on the extent to which they maintained their relationships with the CSC community, the availability of CS courses in their high schools, or the amount of financial aid they received. Regardless, the commitment and invested interest of the women who continued to pursue computing degrees overruled any financial or resource burdens they may have faced.

C. Moral Debt

Ladson-Billings [7] describes the moral debt as the disparity between what we know is right and what we actually do. The positive experiences associated with CSC face an impenetrable moral debt that currently exists within secondary and post-secondary CS education spaces. In fact, the moral debt is possibly the largest reason why the long-term impact of CSC is limited when students attend college or a university. In CS, there is a failure of individuals to see beyond an "I" position to a "We" (together) position [7]. Although CSC is grounded in collaboration and building community, the women in this study repeatedly emphasize that their CS courses center on the individual and place little to no emphasis on social interactions or the social implications of computing. This is especially evident in CS courses offered by CSC's host university.

Evidence of the moral debt suggests that interest and confidence gained in CSC are not enough to confront an isolating and exclusionary field. Alumni mentioned that they felt isolated being in computing. One could conclude that some felt invisible, as being one of the few women or BIPOC women in their computing classes. Our findings also suggest that alumni, not their professors or universities, contemplated taking on the moral responsibility of making post-secondary CS courses and their overall experience diverse, equitable, and inclusive. But, is it truly women and BIPOC learners' responsibility to repay the moral debt when they have been historically marginalized in STEM? Ladson-Billings quotes Lyndon B. Johnson's 1965 Commencement speech at Howard University, a Historically Black College or University, who says, "You do not take a person who, for years, has been hobbled by chains and liberate him, bring him up to the starting line of a race and then say, 'you are free to compete with all the others,' and still justly believe that you have been completely fair." [7] Instead, as CS education scholars have repeatedly stated, advanced CS coursework must acknowledge the social impacts of computing in order to create meaningful change in the field [15][16]. The findings from this study also suggest that the structure of STEM postsecondary education reinforces the moral debt, making it so that some voices, especially those of BIPOC women, are silenced and that programs like CSC have limited long-term impacts.

D. Sociopolitical Debt

The sociopolitical debt is accumulated through the systematic exclusion of BIPOC individuals from the civic process [7]. The sociopolitical debt has existed since the inception of the US, through its political disenfranchisement, Jim Crow laws, and the purposeful exclusion of BIPOC learners and their families from participating in the legislative process. CSC alumni have shared that unique program elements, such as being in a cohort of learners with similar interests, having a collaborative and interactive curriculum taught by CSC instructors and staff who identified as women and/or BIPOC, and returning to CSC as teaching assistants while in high school, made them feel comfortable to leverage their interests, creativity, and voices to achieve a level of self-efficacy to pursue STEM in postsecondary education.

However, the sociopolitical structure of CS Departments, especially at CSC's host university, seems akin to Mensah and Jackson's definition of science as white property [18], or the notion that traditional Eurocentric positivist teaching of science gives ownership to White and male scientists; in the case of CS education, CS Departments are overwhelmingly run by White and Asian men who make curricular decisions and perpetuate hostile environments where it is difficult for others to speak up [17]. Underrepresentation is evident and noticeable in the CSC alumni interviewed in this study. Their awareness of being the only woman or only BIPOC woman in their CS courses led some of the alumni to purposefully avoid CS spaces they knew were White- and Asian-male dominated. In other cases, some alumni felt it was their responsibility to change student representation in their CS classrooms. This conflict between wanting to leave and wanting to change the system is not only harmful to these young women but also places them in positions where they must be lone voices advocating for inclusive and equitable computing education.

IX. Limitations

This research emphasizes challenges associated with longitudinal research; since CSC began over a decade ago, many of our alumni emails on file were not updated. We acknowledge that this study does not cover all the stories and experiences of CSC alumni. Additionally, we also recognize that students who may not have benefitted from CSC might be reluctant to participate in the study. We continue to reach out to alumni and expand our conversations with a diverse range of students, especially BIPOC students, who had positive,

negative, or neutral experiences in CSC. Despite these barriers, our study suggests that informal computing initiatives should perform longitudinal analyses to identify ways to bridge gaps between experiences in the initiative and in CS courses. Additional research is needed to confirm that similar experiences can be created outside of the host institution.

X. CONCLUSION

Our study shows that CSC was able to dismantle the educational debt for the alumni in this study while they were in middle school. Because of CSC's ability to provide an initial positive introduction to computing concepts, support learners' self-efficacy of succeeding in computing, and create a space that intentionally forges a community where middle school girls and BIPOC learners' interests in computing can be nurtured through mentorship and continued engagement, alumni were able to be sheltered from the harms of the educational debt. However, this study revealed that "in the case of education, each effort we make toward improving education is counterbalanced by the ongoing and mounting debt that we have accumulated" [7]. As CSC alumni progressed in their STEM journey, CSC could only chip away at a massive educational debt that plagues postsecondary education CS courses. Broadening participation in computing is not a one-and-done activity but must have a longitudinal scope to better address the educational debt that consistently impacts women and BIPOC learners each step throughout the educational pipeline.

Ladson-Billings wrote about the educational debt in the early 2000s, and at that time stated what she believed could mitigate the educational debt: "The closest example that we have of such a dramatic policy move is that of affirmative action" [7]. As we move into a space where affirmative action is once again targeted, it will be important for future research to analyze the impact of programs like CSC and how they fit into the quickly changing landscape of higher education. Future research should also consider applying the educational debt theory to post-secondary computing education spaces and industry. To add to the literature on the long-term impact of informal computing programs, researchers should also continue to consult with program alumni who personally experience the contrasting environments of their informal learning and post-secondary experiences to develop concrete evidence that advocates and requires STEM departments to dismantle the moral and sociopolitical debts that they protect.

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