“Show Them the Playbook That These Companies Are Using”: Youth Voices about Why Computer Science Education Must Center Discussions of Power, Ethics, and Culturally Responsive Computing

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Culturally responsive computing (CRC), that centers sociopolitical issues and transformational uses of technology, has been described as valuable for increasing engagement with computing, especially for historically underrepresented minoritized students. But what do high school students think? Through a sociocultural lens prioritizing student voices recorded in 56 interviews over a period of 2 years (1–3 years after students' first experience with computer science (CS) education through Exploring Computer Science or Advanced Placement CS Principles in high school), this study centers the perspectives of 39 primarily low-income, Latine and Black youth from urban California and rural Mississippi public schools to understand what they perceive as the role of technology in our world and what they subsequently desire of their computing education. While none have studied CRC before, the majority responded with CRC ideas about the kind of pedagogy they believe would make for a more meaningful computing learning experience: They see computing as a form of power that impacts both good and bad in the world and want computing educators to prepare them to take on these issues of equity, ethics, social responsibility, and underrepresentation in the field. The students' perspectives offer important pedagogical insight into how to support deeper engagement with computing in current CS for All initiatives, while also preparing youth for the rapidly evolving and increasingly complex computing landscape that impacts all of our lives.

CCS Concepts: • **Applied computing**; • **Education**;

Additional Key Words and Phrases: Student voice, equity, ethics and social responsibility with technology

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1 Introduction

The ubiquity of computing in daily life continues to increase, encouraging the growth of movements fostering computational literacies and skills for students in the United States. Over the past two decades, the underrepresentation of women and people of color in **Computer Science (CS)** [60] has also led to an increase in diversity-focused initiatives specifically. For example, in 2006, the **National Science Foundation (NSF)** launched its "**Broadening Participation in Computing (BPC)**" program that supports communities historically underrepresented in computing to learn CS and pursue postsecondary degrees and careers in **technology (tech)** [20]. This was followed by NSF's CS 10K Project that began in 2012 and focused on preparing educators to teach this new subject area in more schools [20]. In 2016, President Obama introduced the "CS for All" initiative encouraging all K–12 students to learn computational thinking skills and CS [77], and a nationwide CS for All movement simultaneously blossomed [10] that included a number of state-specific initiatives (e.g., CS for California, CS New York City, CS for Mississippi, CS 4 Georgia, CS 4 Texas). All of these efforts have resulted in the creation of new K–12 CS curricula and programs visible today, focused on providing more equitable and engaging CS experiences across a range of ability levels—including **Exploring Computer Science (ECS)** in 2008, Code.org courses in 2013, **Advanced Placement CS Principles (AP CSP)** in 2017—and out of school CS diversity-focused programs including Techbridge Girls (1999), Digital Youth Network (2006), CompuGirls (2007), Black Girls Code (2011), Girls Who Code (2012), and so forth.

While more students now have access to CS across K–12 education—with five states making CS a high school graduation requirement (Arkansas, Nebraska, Nevada, South Carolina, and Tennessee) and four states requiring that schools offer CS (Kansas, Missouri, Nebraska, and Tennessee)—only a little over half of high school students are enrolled [8]. Latine high school students are 1.5 times less likely than their white or Asian peers to enroll in foundational CS courses or attend schools that offer it; rural, urban, and low-income schools attended by majority students of color are less likely to offer CS; English language learners, students with disabilities, and low-income students are underrepresented in these courses as well [8].

As a result, many recognize that focusing on increasing the number of students taking CS classes and designing new curricula are not enough to address the underrepresentation of women, people of color, low-income communities, immigrant communities, and people with disabilities in computing [e.g., 7, 19, 29, 49]. Sociocultural perspectives that address the broader implications of computing in society are also needed, especially considering the serious tensions between goals to increase the number of minoritized communities studying CS and the ways that CS creations are negatively impacting those same communities. For example, some CS education efforts are preparing minoritized youth for the unknown tech jobs of the future to support US economic and military competitiveness, but this could ultimately mean death and poverty for the communities to which many minoritized youth belong [39, 84]. Similarly, current technologies have been shown to inflict harm on both our planet and specifically low-income communities of color globally [e.g., 1, 12, 56, 57, 88], creating personal conflicts for the minoritized people that CS education efforts seek to reach. The growing number of articles describing how today's newest social media tools and **Artificial Intelligence (AI)** inventions are specifically harming teenagers, women, people of color, and low-income communities further complicate the challenge of how CS education efforts should move forward in preparing vulnerable populations to study and engage with CS [e.g., 2, 3, 25, 62]. Finally, few have addressed how the tech jobs that minoritized students are being prepared to fill may ultimately become lower-wage programming positions rather than positions of creative leadership, especially as people fear that AI systems will take over jobs that CS students were preparing to apply for [3, 55, 62].

This is why many have turned to **Culturally Responsive Computing (CRC)** as an approach to supporting inclusivity in CS learning, by elevating students' identities/cultures toward critical consciousness, rather than preparing them to be "serfs of the information age" [58]. "Critical consciousness" here refers to Freire's [22] legacy around "conscientização": understanding and responding to the social and political phenomena shaping our world. CRC builds on Ladson-Billing's [40, 41] **Culturally Relevant Pedagogy (CRP)** to encourage meaningful engagement with CS at the intersection of academic achievement and cultural knowledge by valuing learners' identities and lived experiences for excelling with new ideas/practices [e.g., 16, 23, 24, 67, 73]. More specifically, CRC focuses on learning contextualized within the larger sociopolitical and historical power dynamics defining whose ideas and voices have usually been valued and how communities can disrupt that [73]. The goal is not simply to celebrate one's cultural heritage, as is a common focus in over-simplified misinterpretations of CRC [76], but to actually prepare youth to critically challenge inequitable structures in society [73]. In these ways, CRC pushes beyond a "numbers" approach to CS education by focusing on the *quality* of students' CS learning experiences toward supporting critical analysis of personal engagements with tech and what computing participation may eventually lead to [73].

Today, young people have easy access to tech and media, news (both real and falsified), AI tools, and social media platforms. At the same time, they also have easier access to information about world and community problems impacting their lives and families. Within this context, there is growing urgency to understand how we can bridge the challenges that CS education currently faces in ensuring that all students are prepared to engage with computing, but in ways that do not harm but actually uplift their communities. We believe that this problem can be addressed by listening directly to what students—and specifically students belonging to communities most underrepresented in CS—say they want and need from a computing education in light of recent technological developments.

Through a qualitative analysis of interviews with introductory CS high school students from two groups who have been historically denied access to computing [48]—youth in a low-income, urban, majority Latine school district on the West Coast and youth in low-income, rural, majority Black schools of the Deep South—our findings share that (1) students have strong understandings about the complexities of power and underrepresentation in computing and (2) want their computing educators to engage them in critical analyses of these issues of power, ethics, equity, race, and social responsibility. This article elevates student perspectives toward informing CS pedagogies that can more meaningfully engage students in computing education, while sharing student views of issues centered in CRC.

2 Literature Review

2.1 CRP as an Origin of CRC

As historical inequities in educational environments, opportunities, and testing and standardization continue to negatively impact minoritized students, particularly those in low-income areas in the United States, scholars and activists alike recognize the need to directly address the systemic, structural, economic, and social barriers that contribute to negative educational outcomes [4]. The evolution of Ladson-Billings' extensive work on CRP [40–43] illustrates an ongoing attempt to do so through classroom practice. Defined originally as a "theoretical model that not only addresses student achievement but also helps students to accept and affirm their cultural identity while developing critical perspectives that challenge inequities that schools (and other institutions) perpetuate" [42], CRP has taken shape in efforts to meet ever-changing needs of teachers and students alike, toward frameworks of culturally responsive pedagogy [18, 23, 24], and later culturally sustaining pedagogy [44, 63, 64]. Such framings grounded in CRP—though supported by differing philosophical roots [54], offer tools for educators to refuse disparities in the outcomes of education while facilitating liberatory, asset-based pedagogy by expanding three guiding principles of CRP [40]: a commitment to supporting students' (1) academic development, (2) cultural competence, and (3) critical consciousness. These core alignments refuse deficit-based views of minoritized students, toward encouraging students to form positive self-views while centering student voices and counterstories.

The documented success of culturally relevant and responsive teaching built on these principles [15–17, 33, 34] has encouraged emerging theories and practices specific to **Science Technology Engineering and Math (STEM)** education. Tenets of evolving CRP and related framings have been helpful in highlighting and addressing challenges in STEM education that impact minoritized students specifically [5, 6, 36]. Within the field of computing education, concerns regarding issues of recruitment, interest, and retention in the discipline have prompted further expansions of culturally relevant, responsive, and sustaining pedagogy to address the nuances of computing education through the development of CRC. Proponents of CRC in the United States argue that since computing technology is deeply embedded in daily life, it is not only critical that *all* develop digital technological literacies [37, 72], but practitioners and policymakers must also go beyond technology access toward building sustainable learning ecologies that support all students and engage culture and community [73]. To these aims, CRC began with identifying ways in which CRP could be mapped onto computing education, where "researchers and theorists focused on how culturally responsive pedagogical strategies could be used to make technologies and technology education accessible to diverse sociocultural groups using asset building approaches" [73]. Much like CRP and the theories that have branched out from its core tenets, CRC is undergoing theoretical and practical shifts of its own to meet the nuances of computing education challenges [53, 73].

2.2 CRC Revisited, Revised, and in Practice

The articulation and implementation of CRC learning interventions has developed alongside national efforts to broaden participation of minoritized students in computing, where more recent arguments critique many of these efforts for their short-sighted focus on coding without prioritization of community, culture, cultural identity [73], or other key facets of frameworks like CRC that aim to meet gaps in equitable learning experiences in computing [16, 36]. Further, Yadav and Heath [86] note how BPC efforts often support ideologies that assign deficits to marginalized students, their interests and competencies, and cultures, and particularly when uncritically engaging with technologies that reproduce biases in their designs, rather than bridge computing education with multiple facets of minoritized groups' heritages and practices. While pushback against some threads of BPC efforts continues, the aims of CRC in relation and response to these efforts are also being critiqued to more concretely defined goals, tenets, and methods for evaluation [73]. The early work of Eglash et al. [15] defined a set of characteristics for CRC centered around practices such as improving learning experiences, cultivating space for critical social engagement, and centering culture through widened definitions of cultural engagement. In later works, Eglash et al. [16] offer insight into how CRC approaches can take on a more expansive view of culture to support equitable computing education. For example, by embracing longstanding cultural traditions (e.g., native pattern making), vernacular culture, and activities that minoritized children feel a sense of ownership over, including hacking culture and revamping, remixing, and repurposing technology. Still, researchers acknowledge the ever-changing needs of computing education as digital technologies and usage evolves and relate these changes back onto CRC as practice that must keep up to meet such shifts [73]. Toward such ends, the Kapor Center [37] offers reinvigorated goals and theories for CRC that redirect some of the emerging deficit-based practice in computing education toward pedagogy centering intersectionality and sustainability in K–12 computing education. In rearticulation of the goals of CRC, Scott et al. [73] highlight five guiding statements that prioritize student motivation and improved learning experiences, encouraging a deeper understanding of students, and creating synergies between various cultural aspects while meeting pedagogical demands of CS through sociopolitical critique.

The Kapor Center's [37] two-part framework for Culturally Responsive-Sustaining CS elevates pedagogy that:

> "…ensures that students' interests, identities, and cultures are embraced and validated, students develop knowledge of computing content and its utility in the world, strong CS identities are developed, and students engage in larger socio-political critiques about technology's purpose, potential and impact." (p. 5)

This includes six core alignments centering equity, student voice, community, and rigorous, relevant curricula, alongside actionable pedagogical strategies to address each alignment [37, p. 6].

While there are many programs both in and out of school that center CRC, since this study focuses on in-school contexts, here we highlight those in formal learning environments and related successes and challenges in implementation. For example, Davis et al. [11] embedded cultural artifacts into a programming unit built on Interactive Python to better understand how engagement with this curriculum might impact student perceptions of computing, culture, and the relationships between computing and culture. The authors detail the challenge in integrating cultural artifacts (e.g., Culturally Situated Design Tools [15]) into the curriculum while ensuring that students retain knowledge of necessary computing concepts such as variables, loops, and conditionals. Evaluations of learning outcomes and overall perception of the course reveal challenges in maintaining student engagement and in equipping teachers to engage with social issues in technical classrooms. The latter barrier to the success of the curriculum is described within the phenomenon of the "social/technical dichotomy," a separation of science and social science being contested in fields like science and technology studies [11]. This has been identified as a persisting challenge in implementing CRC. For example, while the majority of educators in a study in New York City public schools believed in the value of CRC, a minority described feeling uncomfortable discussing issues related to race/ethnicity in their classrooms [50]. Similarly, high school teachers in CS professional development focused on culturally responsive pedagogies wanted to make CS more engaging and meaningful for students, yet had the tendency to use "colorblind" language that reflected some resistance to CRC values [30].

Relatedly, Nasir and Vakil [59] build on several years of work developing CRC curricula [80, 81] to co-design a 10-week course encouraging students to think through equity issues at their technology magnet school using computing principles. The unit drew connections between students' racialized and gendered school experiences and CS concepts/practices, with aims to improve the social experiences in the classroom while expanding views of how computational learning happens [59]. Students spent the first few weeks of this course discussing how inequality manifests at their school, then collaboratively designed digital artifacts addressing these social issues. For example, two girls of color created a video game for other girls of color that elevated important parts of their identities—in this case, pride in being Latina or African American—to computing that aren't typically afforded in classrooms where discussions of race, technology, and equity are seldom held [59].

Franklin et al. [21] work to improve computing education experiences of students at under-resourced high schools through developing an introductory curriculum that attempts to navigate institutional barriers related to funding and teacher expertise. They blend computational thinking [47] with three cultural threads to guide activities within the modular curriculum, where they define a multicultural, youth culture, and gaming thread that can each be used or modified within the curriculum. Franklin et al. find success in their holiday-themed unit where students were able to build projects around holidays of their choosing that hold cultural significance (e.g., Christmas, Chinese New Year, and Juneteenth). McGee et al. [52] are similarly interested in practical implications of building curricula around computational thinking and culture in their study of student learning in culturally relevant ECS classrooms across Wisconsin and Chicago public schools. One primary goal of their research was to understand how student attitudes develop within culturally relevant ECS courses and the related impact on computational thinking and expectancy-value [14]. Study findings indicate that teaching practices grounded in equity and inquiry and focused on key CS concepts fostered significant learning gains and positively improved most students' expectancy-value ofCS. However, Latine students participating in the ECS courses held lower expectancy-value at the end, revealing a need to further explore how culturally relevant ECS courses can better fit this student group.

Lachney et al. [39] partnered with several local experts to develop CRC curricula with the goal of understanding the process and impact of collaborating with local professionals in fields relevant to the cultures and local communities of the student group. One segment of the study detailed the process of a middle school technology education teacher collaborating with a cosmetologist to create an 80-minute culturally responsive lesson bridging cornrow braiding with geometry as altered from [15] to fit the context and culture of the classroom and community. The curriculum involved students simulating hair-braiding in both virtual and physical environments with digital tools and mannequins, centering cornrow braiding in general African mathematical knowledge systems. Interviews with the professionals involved in the study highlight an emerging call to action for those developing CRC interventions to not only adopt expansive views of culture as the literature has suggested but to also consider dynamic determinations of race as a social construct that changes with time.

2.3 Student Discussions of Power, Ethics, Equity, Race, and Social Responsibility in Computing in Recent Literature

While there is not a large literature base focused specifically on high school CS students' perceptions of topics such as power, ethics, equity, race, and social responsibility in computing—foundational foci of examination and critique in CRC—and specifically not from the perspective of those who are most underrepresented in the field of computing, there is a range of literature involving interventions with young people of color that begin to share their beliefs about various CRC topics.

For example, in a project where high school students used computing technology to address a social problem in their school, Vakil [83] illustrates how engaging in equity-focused, socially relevant CS activities helped bolster the growth of students' racial and political identities as well as deepened their understanding of how values and ethics get taken up or ignored in the discipline of CS. He describes two cases of students: one student whose racial and political identity grows in ways that allow her to build stronger critique about ethics in tech, and another who already came into the project with a strong racial and political identity that she felt conflicted with her love of CS because she recognized that the field of computing did not welcome Black and Brown people like herself, and often created tools that directly harmed her community. In these examples, we see slightly contrasting experiences where young people have a range of interpretations of issues of power, ethics, equity, race, and social responsibility with computing, but all are inspired to address these issues when given an opportunity to create socially relevant, equity-focused computing projects.

Similarly, in their work at Youth Radio's Innovation Lab, Lee and Soep [45] supported young people in creating interactive educational media projects about topics important to them and their communities, such as gentrification in Oakland, CA. Through the process of focusing on media production and **Critical Computational Literacy (CCL)**, this work surfaced how young people came to realize that historical knowledge transmitted through technology and, today, through computing technology is controlled by those who hold power, wealth, and dominate geographical regions; they recognize that without an understanding of how to use new media technology, young people in their own communities cannot share their own stories, voices, and counter-narratives to mainstream and often deficit representations of their communities. In these ways, the young people in this project recognized the power that people hold when using technological tools for archival and knowledge-production purposes. In our previous work [68], we also found that adolescents in introductory CS classes saw computing as a tool for (1) resisting racism in their schools and elevating their perspectives and voices about what mattered to them, (2) supporting mental health and well-being in their communities, and (3) defining one's identity and interests to a broader audience. While students in this study did not share their perspectives on how they viewed power, ethics, equity, race, and social responsibility in computing, the ways they took up computing tools reflected a desire to counteract imbalances of power and unfair treatment in their schools.

In a more recent intervention, Salac et al. [70] sought to build on students' funds of knowledge regarding algorithmic bias toward supporting their learning about agency and safety with computing tools, including AI. Overall, Salac et al. [70] found that teenagers were able to articulate when they thought algorithms were biased and unfair in a sample of three scenarios of algorithmic bias, building on their personal experiences related to larger societal issues in ways that went beyond the constructs of the scenarios in meaningful ways. This suggests that teenagers are aware of issues of ethics and equity with computing technology, but in this study, the students had greater difficulty in coming up with solutions to those biases that focused on more diverse experiences like their own and instead focused on "average users."

High school CS students in another study were also able to draw on their rich funds of knowledge to critique issues of power, ethics, equity, and race in CS when their teacher supported reflection and dialogue about social responsibility in computing [69]. When students were encouraged to build on their personal experiences to articulate what they saw as potentially problematic about CS creations, they shared a number of interesting insights about the lack of attention to the needs of young people without economic independence, homeless people, and immigrants with family far away. In Coenraad's [9] work around "techquity" with middle school students, young people demonstrated that they already had an awareness of how computing technology can harm their communities but did not have the vocabulary or ability to fully articulate biases in algorithms and computing technology until engaging in an intervention focused on these issues in tech. In another study where researchers worked with youth and their parents to identify how young people can have a voice at CS design tables, Solyst et al. [78] also found that children ranging from first to twelfth grade were able to identify and describe algorithmic bias, suggesting an awareness of the ethical issues related to computing technology. This sits in interesting contrast to slightly older studies that have shown young people tend to trust AI tools less critically and may not be as skilled at recognizing and articulating where they see imbalances in power, ethics, equity, race, and social responsibility with computing [13, 75, 79].

While none of these studies had as their primary aim to focus on students' perspectives of power, ethics, equity, race, and social responsibility in computing, the description of students' shifting knowledge, skills, and views over time through learning experiences described in these projects inevitably surfaced students' points of view that lay an important foundation for the youth voices described in this article.

2.4 Turning to Youth Voices

Sociocultural theories of learning—that inform this study's approach to elevating student voices—advocate for youth as legitimate social actors and producers of knowledge [35, 66]. In studies that center child and youth voices, adults are presented with "provocative accounts that challenge many of the taken-for-granted assumptions about what children do or think" [35, p. 264]. This study supports this claim by focusing on the insights youth shared about what constitutes a robust CS learning experience and zooming in on how they describe the larger social, cultural, and historical factors impacting how they learn and what motivates their engagement with learning [85]. Building on the rich research base described above, this article turns to youth voices to understand how they articulate the purpose of their computing education and, specifically, the value of discussing issues of power, ethics, equity, race, and social responsibility that are central to CRC but not always explicitly centered in CS classrooms. Recognizing that computing teachers do not typically talk about CRC with students, this study addresses the following research questions:

(1) How do historically minoritized youth perceive the role of CS in our world and how does this relate to what they think should be centered in their computing education experiences?
(2) How, if at all, are youth thinking about the topics of CRC as described above (e.g., power, ethics, equity, race, social responsibility) without teacher explanation of CRC?

3 Methods

3.1 Study Context, Student Demographics, and Data Sources

Our team partnered with teachers in school districts in urban California, serving a primarily low-income, Latine population, as well as in rural Mississippi serving low-income, Black students. This research-practice partnership sought to elevate the perspectives of students coming from communities underrepresented in computing who were experiencing CS classes for the first time (e.g., students of color, young women, low-income students, and rural students). We chose to partner with schools in these two regions not only because of our pre-existing strong relationships with educators in California and Mississippi that were developed through prior work with ECS but also because we believe that the CS for All movement would benefit from listening to the voices of students from these regions who the movement is directly trying to reach.

This project on the West Coast began during the 2018–2019 school year as researchers visited four introductory CS classrooms on a weekly basis in three schools, getting to know students closely over the course of the year. In Mississippi, researchers came to know youth across six schools during the 2019–2020 and 2020–2021 school years, first through school visits and then, during the COVID-19 pandemic, through video-chat conversations. During the 2018–2019 school year, California students were enrolled in either ECS or AP CSP, and Mississippi students had experienced almost a full year of ECS in the 2019–2020 school year (before the COVID-19 pandemic suspended all CS coursework). The researchers and students developed trusting and respectful relationships over time—especially with regular contact in safe contexts of classrooms or homes—and many students are still in contact with the authors.

ECS is an introductory high school course rooted in the principles of equity, inquiry-based learning, and CS concepts. The course was created in response to the lack of hands-on, engaging, and culturally responsive curricula available in the early 2000s, specifically for students who have had little to no prior exposure to computing [28]. Through activities including Culturally Situated Design Tools (see https://csdt.org/), explorations of social issues related to human–computer interaction, as well as through the ECS professional development program that seeks to prepare educators to teach in ways that build on students' wealth of knowledge that they bring into classrooms, ECS is meant to support CRC (see www.exploringcs.org). While AP CSP is not explicitly created with CRC in

Table 1. Demographics of Students Interviewed

	California	**Mississippi**
Young women	17	11
Young men	6	5
Latine	22	0
Black/African American	0	16
Asian American	3	0
White	1	0
Total	23	16

mind, teacher partners in this study had experienced ECS professional development workshops and applied inquiry-based, culturally responsive, equity-minded pedagogy to their classroom practice. In these ways, students interviewed in this study had most likely been exposed to teachers seeking to make computing more culturally responsive [69]. This article draws specifically on interviews conducted online during the 2020–2022 school years, approximately 1–3 years following initial experiences with ECS or AP CSP. This was done explicitly to create space for learning experiences to sink in while surfacing what stayed with youth the most. A total number of 56 interviews of 39 students across 9 schools were analyzed to answer the research questions above, with some students being interviewed 2 years in a row (see Table 1). The only criteria used for selecting students was whether or not they had participated in ECS or AP CSP with partner teachers during the 2018–2019 and 2019–2020 school years when the study began. All students matching this criteria were sent e-mail invitations from the research team to participate in interviews. Some students never replied because their e-mail addresses were no longer functional (following graduation). The 39 students represented in this study include all those who replied to e-mail invitations and kept in touch with the research team over time. Since students were interviewed every year following their first CS course experience, those who met the research team in 2018–2019 were interviewed more than those who met the team in 2019–2020 (twice vs. once). None of the interviewees had formal CS education experiences prior to their first ECS class, and almost all AP CSP students in this study had experienced ECS before AP CSP. Three interviewees also took a Game Design class following AP CSP between 2018–2019 and 2021–2022. All but one student in this study qualified for free and reduced lunch and were students of color without prior access to computing education.

As noted earlier, interviewees often knew the interviewers fairly well because the researcher interviewers had been present in the students' CS classrooms 1–3 years prior. In this way, when interviews were conducted on Zoom, they were very relaxed and provided a friendly context in which students could reflect on their personal views and experiences. The 1-hour interviews began with time to catch up on one another's lives and activities, followed by reflections prompted by the interview protocol. The interview protocol was designed by the research team, with teacher input. The interview protocol included questions across three major themes: (1) retrospective views of CS coursework in relation to current learning trajectories; (2) views of tech in the world; and (3) identity/interests and aspirations for the future. For example, students were asked, "What was the most memorable experience you had in your high school CS coursework?" and "Do you think it was worth learning CS?" and "Has CS affected your hobbies, interests, or experiences in any way? If yes, how?" Youth were provided with current computing workforce demographics and were asked: "What do you think of these statistics? Why do you think this is the situation?" Students were also asked about how they see computing technology changing our world, and whether or not these topics of ethics, social responsibility, and underrepresentation belonged in CS classrooms.

Questions were worded carefully so as not to be leading, but rather to surface students' honest opinions.

To allow youth voices to guide research analysis, grounded theory [27] was employed as an exploratory approach prioritizing latent patterns to emerge from the data (rather than seeking to prove/disprove hypotheses) via the constant comparative method [26]. More specifically, teams of two researchers collaboratively read interview transcripts for initial themes on shared documents in a secure online folder, notating initial codes. Each code was recorded (with definition, illustrative quote, and data source) on a shared spreadsheet. Every time that same code reappeared in the same or other data sources, researchers would return to the original code and compare for meaning, nuance, similarity, and difference which, in turn, helped generate theoretical properties of each category [26]. On a weekly basis, the paired teams compared codes, discussed questions that arose through readings, and refined definitions of codes and larger categories. In this way, every interview led to refinement of codes and the development of new categories, allowing themes to arise from the data sources directly.

For example, one code category that emerged through this analysis process (and that is the focus of this article) was "student views of CS." In this category, were codes such as "complexity of tech" with the subcode "wants to change CS demographics." Another example of a code in this category was "impact; CS impact" with the subcode "improve world." Interview excerpts that fell under these codes were reviewed more closely for another round of analysis, resulting in the key findings of this article.

Responses year to year did not change significantly, and so analysis of interviews after 1 compared to 3 years following initial ECS or AP CSP experiences was not conducted differently.

3.2 Position Statement

The authors recognize the responsibility that researchers have to critically address their own research agendas/views, and especially when articulating youth perspectives, as notions of power and voice are entangled in these studies [35]. Rooted in standpoint theory [32] we offer our positionalities in this work. We are women of color, particularly Black and Asian American women, who conduct research on equity, empowerment, and representation in STEM education. The authors are early-career scholars with a collective 30 years of experience teaching and working with students of color across a variety of contexts. Both share deep commitments to equity in education, and particularly in finding ways to build community with and uplift the voices of students, educators, administrators, and families toward dismantling institutionalized racism, sexism, and other forms of oppression in education.

4 Findings

The ideas students shared about how they view the role of computing in today's world and what they think educators should focus on in CS classrooms/programs are organized into three major themes, including: (1) students view computing as political and a form of power; (2) students want teachers to prepare them to be socially responsible creators and users of computing technology; and (3) students believe that addressing issues of social responsibility will attract more diverse learners. In what follows, our goal is to *elevate—not evaluate*—students' voices, so that we may have the opportunity to understand their perspectives regardless of whether we agree with them. This way, researchers, educators, administrators, parents, and policymakers can have an opportunity to see how young people are thinking about key CRC topics that were raised in interview conversations with the goal of continuously improving upon CRC pedagogies and practice.

4.1 Students' Perceptions of CS in Our World: Computing, False Neutrality, and Power

All students in this study recognized that CS is neither neutral nor apolitical. Understanding that CS is imbued with human beliefs, values, and errors, youth described how CS creations—including both the intended and unintended uses of tech—bring up important questions of ethics, social responsibility, and ultimately politics and power. For Núria, this reality must be centered in computing classrooms. She explained, "we're always being on our phones, on social media" where a lot of politicians, activists, and "conservatism seems to thrive." At the same time, bringing up the examples of Facebook and YouTube, Núria noted how algorithms—"[that] have the same biases that we do"—are influencing which ideas, information, and political platforms people are exposed to.

As expressed by Laura, just because computers and CS are built on logic "doesn't mean it can't include some kind of bias." She notes "There's this giant myth that science is all completely neutral and objective, and CS gets lumped in with that." Laura emphasized that this must be discussed in CS classrooms to address these problems because of the ubiquity and power of computing.

Indeed, of the 32 students who shared about their perceptions of computing in the world, all expressed how CS is a form of power and, thus, CS education must teach youth how to help and not harm with that power.

Students described that computer scientists and people who understand CS have power because everyone is highly dependent on computing technology in their everyday lives. Ebony from Mississippi explained, "I think that [CS] is very powerful. Like that's what everything is connected to." Khaila from Mississippi gave the example of Google search engines to describe this power, noting how "everything we search" shows how "Google are the backbone" controlling the information we have access to and the comparatively small number of Google employees we are dependent on. Similarly, Marta from California noted that everything "revolve[s] around technology now. You can't go anywhere without at least a little computer, which is your phone, in your back pocket." Marta explained that this means knowing CS is essential for survival today.

However, the general public does not necessarily learn CS and understand how computing technology works, which was why students also described CS as a *secret* power that computer scientists have an *insider* view and control over. Augusta from Mississippi explained:

> "[Computer scientists are] in the inside and everybody else is on the outside. Because you know how everything works. If you're an employee at a place you would know the dangers and the positives and you would know how to avoid those."

In this way, Augusta recognized knowledge of CS as "insider" capital that people can use to their advantage. Similarly, Xander from Mississippi explained: "They probably have the power to know more about how certain things go... they're probably a lot more caught up on the things that a regular person wouldn't know." Anna from California agreed, noting, "I feel like it's more like secret power, because no one really pays attention much to the person behind the computer... you can create whatever you want." In this statement, Anna is not suggesting that CS is a superpower, but that learning CS gives one a behind-the-scenes knowledge that people who haven't had access to computing education cannot understand. As noted by Eloise of California, those who work in the tech industry "have that kind of power of understanding computers and just manipulating how they work" with the "secret" knowledge that others do not get to use.

Many students also explicitly described how this resulted in computer scientists being able to influence how people think, especially by accessing personal data that non-computer scientists may not realize they are sharing. Núria from California explained:

> "I think [CS] just allows to really manipulate our perspectives on certain things… Depending on how your Instagram feed might look like, or what you're being recommended on TikTok. That's still ideas and perspectives that are being fed to you and that you are consuming. So based on how someone can manipulate that, you can change someone's perspective very drastically… I think that is the main type of power."

This was particularly troubling to Carlos from California, who noted:

> "In today's society [computer scientists] hold a lot of power because I feel like they could have anyone's information… it would just be at the tip of their fingers without anyone knowing. Because it's not like a robbery, where you go into your house and you see that you've been robbed. How are you going to see something digitally, that your information has been stolen?"

Carlos notes that the kind of power computer scientists hold, therefore, is greater than that of a robber because the impacts of taking one's personal data and using it are not always immediately visible. In these ways, CS is a form of power that results in people losing their privacy and control of their own information as Laura explained:

> "[P]eople underestimate the value of privacy… once some company has your information and has that, they have this degree of power over you… Of course my internet search history is saved, of course my phone knows where I am. And I've never even lived in a world where that's not the case is the terrifying part."

Laura was deeply aware of how computer scientists use her data as a "way of getting you to look at more stuff so they get more ad money. Because you are the product in their giant game of how to make the most money possible." Raquel also noticed this as a form of power that was "scary" and "shocking" when describing how tech companies can check our daily activities and manipulate our phone/laptop cameras. As Mei from California explained:

> "[A]s great as computer science knowledge is and as you can use it to lift up so many things and expose so many things, but you can just as easily use it to like, spread horrible, horrible messages… like it can be used to spread a lot of fake news… [computer scientists] can kind of do anything well within the realms of like coding. But just because you can do anything doesn't mean it's good."

The specific example Octavia from California provided was how young women of color internalize Eurocentric beauty standards through tech that spreads "really harmful stereotypes… And that's really heartbreaking. And so, when I think [of computing's] impact, I always think about that, and how easy it is to impact someone's way of belief, or way of thinking."

Importantly, a common theme from the interviews was that CS needs greater diversity specifically because of the power it wields on all communities. For example, Andreas from California described gentrification in their city and the placement of 5G towers in poor communities of color as an illustration of why diversity is needed in computing: more often than not, tech negatively impacts communities of color because decision-makers in computing fields do not come from these communities and understand their experiences. Similarly, Savana from California described how "uncomfortable" she was with the ways white computer scientists analyzing data portray her community and have power in the ways the data of people of color are used. She noted, "It's our data, it should be working for us" and thus diversity was needed in computing fields. Kimberly from Mississippi agreed with this sentiment, noting that if someone is a computer scientist, "people will believe anything that comes out of your mouth…So you could definitely use it for harm." As a result, she hopes to see greater diversity in tech so that a minority, privileged few are not always manipulating and controlling the experiences of others.

4.2 Empowering Students to Be Socially Responsible Creators and Users of Tech

Speaking exactly to this point about how youth should be empowered to create more socially responsible tech to address current CS problems, Marta explained that ethics in computing should be central to all CS coursework. She noted, “Because you never know who’s the next billionaire that’s going to create the next thing that’s going to change the world. So you also want them to be thinking, ‘What can I do that’s going to make the world better?’ ” She shared the example of self-driving cars and noted that tech companies (and CS classrooms) should be asking, “who in the world is going to be buying this and what are they going to be using it for?” While Marta centered technocentric stereotypes in this assumption about “the next billionaire” who will “change the world,” the point she was making was specifically that pedagogy should encourage people to critically assess the impacts of their engagements with computing, whether they are students with preparatory privilege in a wealthy private school CS class or a CS student in a low-income rural school. Marta believed everyone would benefit from these conversations about socially responsible creation with computing technology.

Roberto agreed, suggesting that all students should take a foundational CS course, regardless of whether or not they pursue CS, that focuses on social responsibility: “With all this kind of new cool technology... [we] should be... knowing the bad and the negatives with computer science.” Roberto believed that computer scientists have “a lot of responsibility” and should be taught to work on “caring behind the scenes.”

Savana pushed this a step further noting that conversations about ethics and social responsibility must also explore how capitalist production culture permeates large tech companies. As a result, learning about ethics is even more important. Savana explained:

> “[T]here’s also this whole Silicon Valley start-up culture that feeds into that capitalist kind of mindset of, ‘I’m going to make profit and whatever happens, happens, because I have to be able to compete with these big companies.’ And so that kind of pushes this emphasis in computer science for a lot of the really talented people to focus more on being productive in service of these big companies to help them make more profit, instead of focusing on the betterment of humanity and solving problems that need to be solved.”

Savana believed that if CS classrooms actually examined the consequences of real decisions made by tech companies, youth who want to pursue computing as a career will be better equipped to face these problems head-on. She described how she often reads stories in her newsfeed about employees who say they cannot work at a company anymore because it goes against their ethics. But Savana noted, “by then the damage is already done. You’ve already helped them... You crossed whatever moral line you already had and *then* you quit, so it’s too late.” Savana’s voice emphasizes how CS education should prepare students to make positive decisions, not poor ones that lead to quitting after it’s “too late.”

Students also consistently noted the importance of empowering people to make better-informed decisions with the computing technology that is at their fingertips as socially responsible users of tech. Anastasia explained that CS education should “giv[e] accountability to those using [tech],” and Ramona said “It would be a great thing to have in schools, just like an Internet safety class, how to take care of yourself on the Internet” that could be the “same thing as Sex Ed” but “for the Internet.”

This was particularly important to Raquel who was concerned about how algorithms sold people things while simultaneously narrowing their world view. Raquel felt that CS students need to learn about how algorithms are written so they understand “Your ads are targeted towards you... so you can consume more” and “think certain things.” This results in people becoming “close-minded” and believing that their ideas are always right, thinking “I got all these articles to back me up, and I got all these people on my feed backing me up,” but, as Raquel explained, “Obviously the app isn’t going to tell you you’re wrong. It’s going to tell you you’re right, so you can stay there.”

Savana agreed, sharing a story about her younger brother whose TikTok posting became viral in middle school. He told Savana: “If I didn’t have unrestricted internet access throughout my whole life, I wouldn’t be as smart as I am, but I don’t think I would be as sad as I am.” Savana described the social media algorithms he was subjected to as “aggressive” and worsening his quality of life. Savana believed CS classes “need to show them the playbook that these companies are using so they can make their own decisions about what they’re going to do on social media.” If people understand how the algorithms function, they might be more aware of how their own actions impact themselves and others when using tech.

Kimberly also believed that CS courses should show learners how the comments they post can easily be traced back to their social media accounts and their real names and family. Octavia described how she valued her own CS class taking time to examine terms and conditions for an app, and she was surprised that the app required access to microphones and other data that were not necessary for it to function.

All youth felt that addressing these issues of how to be socially responsible tech users and aware of the ethical implications of one’s actions and data use should be a critical component of CS classes.

4.3 Addressing Issues of Socially Responsible Computing Attracts Diverse Learners

Some students also thought that ethics and social responsibility could engage the interest of more diverse students who may not initially enjoy computing. Recognizing that not all computer scientists enjoy programming for the sake of programming, but rather are motivated to solve coding problems for a greater purpose, several students articulated how they believe the computing field might become a more diverse place if issues of social responsibility and ethics were a key focus of CS programs. Andreas shared:

> “[D]on’t go into a computer science class as a teacher only wanting to teach strictly computer science… Especially to the ones who are not necessarily already interested in computer science… it’s good to get them drawn into [it] by having them think about outside issues, quote-unquote. And it’s also good to get those students who are already interested in computer science to get started to think about those issues, because they are issues they are going to have to deal with.”

Charles from Mississippi felt similarly to Andreas about how engaging CS students with the everyday impacts of computing on our sociopolitical world might actually inspire more diverse voices to try to be at the CS design table. He reflected on the pros and cons of computing technology today:

> “Technology has its limits… And maybe that would change more people’s mind and make them want to make an impact, make them want to change the world if they see what people of diversity is facing, women are facing… If classes taught us half of the things that actually happen, and 100% truth, way more people would be interested in making a change.”

In these ways, Charles believed those historically underrepresented in computing would become excited to work toward elevating the needs of their communities in tech. Similarly, Stefany of California believed that if she had received a CS education that actually addressed issues of ethics and social responsibility, as well as the sociopolitical context of computing today, she would have become more excited about learning CS. She described: “I would have loved to learn that. I think that would have interested me in the class, and maybe I could have appreciated it more at the time, and seeing how I could put myself in those real-life situations." She compared this to what is taught in a psychology class: "because in psychology when you're doing an experiment, you need to know how to apply ethics so none of your patients get hurt." Stefany believed the same applied to CS and would have engaged her interest more.

5 Discussion

A primary goal of revised CRC frameworks is to engage and develop student knowledge bases surrounding CS content, the utility of computing in the world around them, and the impact, purpose, and future of computing [37]. The groups of students interviewed in this study were not asked specifically about CRC goals, yet their opinions on engaging conversations of power, ethics, equity, race, social responsibility, and real-world social phenomena in CS classrooms point back to the relevance and timeliness of building CRC curricula. Importantly, students' voices centered in this research help advance our knowledge base about the value of CRC pedagogies, rooted in the rich experiences and perspectives of the minoritized young people that CRC (and current CS for All) movements are trying to reach. The topics and concerns expressed by students in this study stem directly from their own experiences as Black and Latine students in low-income and rural areas, articulating a specific experience and desire for learning rooted in how they see the world from their viewpoint. Educational efforts centering justice and equity can only be made stronger by hearing directly from minoritized students themselves. More specifically, students in this study voice a pressing need to better equip and empower Black and Latine students from rural and urban schools with not only the technical skills that support their own agency, but with a more well-rounded knowledge of the harms *and* benefits of technology. Youth have clearly articulated here that they want more than "access" to computing education, and instead want to "move beyond hardware, software, and programming to encompass a more realistic, broader, real-world context as a discipline that equips students to build and use powerful tools to solve complex problems in service to society" [31, p. 343, 87]. This may, for example, take the form of integrating lessons on the technical and social impacts of notable people in CS history—such as George Boole, the creator of Boolean algebra who also championed women's movements, animal rights, and equality in education [17]—or the larger complexities of power, prestige, and money-making in large tech companies as described by Savana in this study. As Marta noted, CS education needs to examine "the logic and the big picture of it all"—relating emerging ideas in the tech industry back to the broader world and the people that computing designs impact.

Echoing what a number of educational scholars have emphasized as a need in computing classrooms [e.g., 69, 82, 86] youth described a desire for empowering experiences that coach them to be socially responsible producers and consumers of computing technology, and they believe that questions surrounding power, ethics, equity, race, and ultimately culture should be central to this education. What might it look like for computing curricula to address topics like agency in data literacy or, as Savana puts it, "the playbook that these companies are using so [people] can make their own decisions about what they're going to do on social media," while also providing a hopeful space where students see positive representations of what CS can do? As is shown in this study, youth are contending with complicated perspectives about society and the role of technology in their world. One example is found in Charles' critique of technology companies that appear complicit in youth experiences of cyberbullying on social media. Students are producing powerful ideas about computing technology and the "tech" industry, and a CRC curriculum might provide a more expansive picture of the discipline with space for critical examination of computing practitioners who have evoked both positive and negative change throughout the history of digital technology development. Student narratives in this study reinforce previous findings that students in CS classrooms are forming perceptions of the discipline and that practitioners must do a better job of communicating to students the nuances and complexities of CS [51].

Furthermore, when focused on access and participation alone, responsibility is often placed on students to get “engaged” and change the system by sheer demographics, with little attention to what, how, and why the system needs changing beyond racial/ethnic or gender diversity. As noted by Lachney et al. [39], “diversity and inclusion are not by themselves liberatory concepts when only bolstering neoliberal policies and nationalistic goals that may not serve the interests of those communities who are the intended recipients of BPC efforts” (p. 4). Focusing on increasing representation of specific skin colors, languages spoken, gender identities, and so forth does not address the larger contextual forces both within and beyond computing fields that perpetuate discrimination and underrepresentation of minoritized groups in the first place [39, 48]. Students in this study both support this point, as well as further complexify the limitations of CS education focused on broadening participation alone, by articulating why computing education contexts must address issues of power, ethics, equity, race, and social responsibility on a regular basis.

Findings from this study remind us of the necessity of CRC pedagogies that support and engage the diverse, layered perspectives of students from minoritized groups taking their first steps into CS. More particularly we’re reminded of pedagogies of resistance in computing, such as Lee and Soep’s [45] articulations of the application of CCL to help “young people conceptualize, create, and disseminate digital projects that break silences, expose important truths, and challenge unjust systems, all the while building skills such as coding and design” (p. 480). This study highlights the ways in which Black and Latine youth are already challenging injustice in ‘big tech’ and computing and discussing harms and truths, and the ideas that they hold about what should constitute their own literacies and strengths in CS. Their ideas bring us back to Lee and Soep’s [45] calls for critical consciousness in computing toward more liberatory aims:

> “…we must systematically teach youth to analyze the powerful impact of various institutions and systems that reproduce inequality through the content of media messages and, equally important, the vehicles through which those messages circulate…. Besides preparing them to critique content and tools, we also must teach young people to create and produce their own interactive platforms that support counter-narratives to existing dominant ideologies.”

CRC that cultivates student agency, critical and computational thinking and literacy, and design and computing skills centered in practices of social responsibility [69], counter-hegemony [17], criticality and creation [46] stand as building blocks on which educators and researchers can continuously add to creating a more culturally relevant and humanizing computing education.

As CRC makes intentional moves to center minoritized students’ cultures and funds of knowledge as assets to learning in tech-centered education, it is important that researchers and educators address a pressing barrier to implementing CRC: the challenge of engaging complex sociocultural and political issues in computing classrooms [11]. It is equally important that research on computing education grapples with student perspectives of computing to better meet the pedagogical demands of providing a robust CRC experience while developing lessons and activities that address misconceptions. One challenge in the United States, however, includes increasing efforts by policymakers to remove all discussions of racism and sexism from classrooms despite the pressing need to center these issues to find solutions and end them. More specifically, in states like Idaho, Iowa, Oklahoma, and Tennessee, teachers legally cannot discuss racist or sexist biases [71], placing teachers’ jobs under threat when they attempt to contextualize learning in the very sociopolitical issues that youth in this study have emphasized are critical to a meaningful computing education. Additionally, 39% of US computing teachers do not see the importance of discussing computing’s role in perpetuating biases related to racism or sexism, and 41% of white teachers do *not* feel confident using material that is related to race, ethnicity, or culture in their CS classrooms [38].

This mismatch between what youth have articulated wanting and needing in their computing education experiences, what politicians want in public schools, and what teachers either think is important or feel prepared to teach in CS classrooms reveal a pressing need for professional development programs that support and protect educators in driving forward the kind of high-quality computing education youth have so eloquently described in this research. As noted by Shah and Yadav [74], moving beyond technical competencies in computing education "requires us to rethink the goals of computing education, what we teach in it, and how we teach it." Educators need to be a part of that conversation as well as be supported in engaging an "archaeology of self" that involves "deep excavation and exploration of beliefs, biases, and ideas that shape how we engage in the work" of education [65]. To bring CRC into our classrooms as originally envisioned and as articulated by youth in this study, adults must take a moment to stop, listen, and prioritize what youth have to say about their education, lives, communities, and future. It is through such effort that educators can be better prepared to engage what youth in this study described they want and need, which involves "a profound ethical commitment to caring for the communities in which we work" through "critical love" [65]. In centering youth voices and meeting their pedagogical desires through a CRC foundation built on ethics, care, and criticality, BPC efforts can expand beyond notions of access and participation toward supporting critically conscious, technologically empowered youth of the digital age.

6 Conclusion: Study Limitations and Future Directions

In both California and Mississippi, minoritized students passionately spoke about the importance of centering issues of power, equity, and ethics in computing classrooms. They saw the current-day, negative consequences of a digital world shaped by human biases and believed the key to addressing these problems lay in computing education. However, it is unclear whether students' perspectives in this study were shaped by their ECS or AP CSP curricula and teachers, or if they would have shared the same perspectives regardless of the introductory computing courses they experienced in high school. Do students who take courses focused solely on programming still believe that teachers should be engaging students in discussions of power, ethics, equity, race, and social responsibility? And at the other end of the spectrum, do students who are enrolled in more advanced CS courses (such as AP Computer Science A or college-level computing) believe that it is more important for educators to focus on programming problems instead of the issues raised by students in this study, as reported by teachers in Mark et al.'s research [50]? In the current computing education discourse, there continues to be a debate about how to balance CS "content" with the sociopolitical issues that students discussed in our interviews. While we believe that sociopolitical issues can be woven seamlessly with CS course content in ways that would make computing education more relevant to all students, some disagree and are overwhelmed by the idea of applying CRC to their computing classrooms. These are study limitations that would be valuable areas for future research. Comparing student perspectives from ECS/AP CSP classrooms against those of AP CSA and non-culturally responsive or sustaining courses would be important lines of inquiry to pursue.

Indeed, recognizing that implementing CRC pedagogies focused on equity and ethics described by students in this study can be challenging—especially given the amount of professional development and personal work it would entail for teachers who continue to be undervalued and underpaid for their efforts in the United States, and also considering the diversity of different backgrounds and goals of students themselves—another potential area for future research could involve having in-depth conversations with educators about what they think it would take to support CRC tenets in computing education. How do teachers respond to the perspectives shared in this article, and what would they try to change in their practices to address students' voiced needs? And as we explore the challenges to implementing CRC in such a study, how can this simultaneously advance what we know about CRC?

The voices of students shared here only begin to describe the important and rich perspectives of young people our CS education efforts are trying to reach. More studies that elevate student voice as a touchstone for improving computing curricula and pedagogies are needed to ensure that CS is made more consequential, meaningful, and equitable for future generations.

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