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"Getting My Feet Wet and Starting Small": Building Capacity for Culturally Responsive Computer Science

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***Abstract*—This paper describes early results from a teacher survey related to the implementation of Culturally Responsive-Sustaining Education (CR-SE) practices in New York City's Computer Science for All (CS4All) initiative. The research questions address teachers' attitudes and beliefs about CR-SE, teachers' implementation of CR-SE practices in CS instruction, and challenges teachers faced when implementing CR-SE practices in CS classrooms. The paper also describes the district's efforts to develop a professional learning curriculum aimed at increasing teacher knowledge and use of CR-SE pedagogies, and deepening teachers' CR-SE practice to address systemic challenges in CS education.**

***Keywords*—Culturally Responsive-Sustaining Education (CR-SE), CS for All, CR-SE implementation, teacher survey**

I. Introduction

Computer Science (CS) is one of the most segregated academic subjects in US schools in terms of race and gender [1], a situation that is also reflected in the computing industry [2], [3]. To mitigate these inequalities, CS for All initiatives focus not only on what Fergus refers to as "numerical representation" [4], but also on equity and social justice in computer science learning environments [5]. This includes efforts to develop culturally responsive-sustaining education (CR-SE) practices that "affirm racial, linguistic and cultural identities; prepare students for rigor and independent learning; develop students' abilities to connect across lines of difference; elevate historically marginalized voices; and empower students as agents of social change" [6]. To support this work, scholars have begun to develop theoretical frameworks that outline what CR-SE approaches and practices look like CS instruction.

II. Theoretical Framework

A. Culturally Responsive Pedagogy in CS

Madkins, Howard and Freed [7] note that the development of such frameworks is grounded in the foundational frameworks of culturally responsive [8], [9] and sustaining [10] pedagogies and culturally responsive teaching [11], and their application to CS education [12], [13]. Building on this work, the Culturally Responsive-Sustaining CS Education Framework created by the Kapor Center [14] offers a helpful approach to designing and implementing equitable and culturally responsive practices in CS classrooms. This framework has six core components: (1) acknowledging racism in CS and enacting anti-racist practices; (2) creating inclusive and equitable classroom cultures; (3) implementing rigorous pedagogies and curriculum that encourage sociopolitical critiques; (4) prioritizing student voice, agency and self-determination; (5) incorporating family and community cultural assets into classrooms; and (6) having a diverse set of professional role models expose students to a range of CS and tech careers.

B. Implementation Challenges and Supports

Translating these goals into classroom practice has been challenging as documented by previous surveys [15], [16] and studies of professional development (PD) centered on CR-SE generally [17] and in CS specifically [2], [18]. While the existing literature is limited, among the more substantial challenges documented in prior research were 1) some teachers do not acknowledge deep structural issues such as systemic racism; and 2) some teachers believe they should be colorblind and maintain the classroom as a politically neutral place (especially White teachers) in order to avoid sparking controversy, parental uproar, or offending someone. Importantly, there was also reluctance based on not seeing the relevance of CR-SE to high-quality CS curriculum and instruction. Further, some teachers who were eager to participate in sustained PD and to

implement CR-SE worried they lacked capacity to do so due to limited institutional support, and feeling a lack of agency and power to make a difference as an individual [2], [18].

III. Study Context

The research in this paper draws on an evaluation of the districtwide CS4All initiative in New York City. The initiative, begun in 2015, strives to provide all K–12 students with high-quality CS instruction that fosters students' computational thinking, problem-solving, creativity, and critical thinking skills. As part of this work, the district provides a range of supports and professional learning opportunities to teachers and school leaders. Teachers participate in PD on CS curriculum and pedagogy, ranging from integrated units to more advanced stand-alone courses, while school and teacher leaders participate in PD on CS planning, instruction, and culture building.

More recently, the district began offering a suite of learning opportunities connected to CR-SE. Beginning in 2021, all teachers participating in the CS curriculum PD were also required to take a 90-minute foundational course aimed at establishing shared language and best practices around equity and anti-racism (e.g., the meaning of white supremacy) and related practices. Teachers with at least two years of CS instructional experience or strong cultural competency can deepen their CR-SE knowledge through multi-year courses that include bi-weekly sessions. The courses build on the seminal work of authors such as [19], [20], [21], and [22] and support teachers in developing and implementing lessons that put CR-SE into practice using approaches such as Universal Design for Learning [23], ethnocomputing [24], and translanguaging [25]. Teachers also create projects to address systemic inequities and get feedback and support from district staff as well as the community of teachers participating in the PD.

Given the relative novelty of the focus on CR-SE in CS instruction in this district, there has been little in the way of systematic study of how such efforts are being implemented in classrooms, and the challenges to doing so. This study begins to address this gap.

IV. Positionality Statement

This paper was authored by five mixed-methods researchers (three East Asian, one South Asian, and one White woman) and a district-level practitioner (a Black woman). The practitioner, Crawford, is a former CS classroom teacher and currently designs and leads CS equity PD, in addition to overseeing the district's larger CS equity strategy; the researchers are part of the initiative's external evaluation team. The broader evaluation team that participated in study design and data analysis also included a Black woman, an Afro-Latinx man, and a White woman. Collectively, the authors have years of prior experience as educators in CS, mathematics, science, statistics, and special education, as well as experience in the CS industry. Our personal experiences in the classroom and CS workplaces—as well as the urgent need for racial, ethnic, gender, ability, and socio-economic diversity in computing—motivate us to employ an equity orientation in our work. This orientation encourages us to reflect on how our backgrounds and biases influence the research we conduct; to attempt to identify and address root causes of disparities, not simply highlight them; and to engage with and give back to the individuals and communities impacted by our work [26]. We also recognize the inherent reductive nature of data analysis—where possible, we strive to uplift the voices of those whose lived experiences are reflected in our research.

V. Methods

A. Research Questions

The research questions guiding the work reported here are:

RQ1 To what extent are teachers implementing CR-SE practices in their CS instruction? Does implementation of CR-SE vary by teacher or school characteristics?

RQ2 What are teachers' attitudes and beliefs toward CR-SE practices in CS instruction?

RQ3 What are the challenges that teachers encounter in implementing CR-SE practices?

RQ4 What are teachers' perceptions of how CR-SE influences teacher and student interactions in CS education?

B. Data Measures

We administered an online survey in Spring 2022 to all K-12 teachers who had participated in district-sponsored CS PD between 2016 and 2022. A total of 614 teachers responded to the survey, yielding a 32% response rate. Almost half of these teachers had participated in CR-SE PD: 39% reported attending the district's equity PD, and 7% reported attending another CR-SE PD. The demographics of the respondents were reflective of teachers districtwide: 12% were Asian, 22% were Black, 0.3% were Indigenous, 48% were White, and 19% were unknown; 14% were Latinx; and 77% were women. Most of the respondents taught at the elementary level (64%), 17% taught at the middle school level, and 17% taught high school.

The survey asked teachers about their implementation of CS instruction; preparation and confidence teaching CS; attitudes and beliefs about CR-SE; use of CR-SE practices and confidence in doing so; and challenges to implementation. The responses for the items regarding CR-SE beliefs were measured on a five-point Likert scale ranging from "strongly disagree" to "strongly agree", while the responses addressing CR-SE implementation, challenges, and confidence were measured on a four-point Likert extent scale ranging from "not at all" to "a large extent." The survey also included open-ended items that allowed respondents to elaborate on aspects of their CR-SE implementation.

C. Data Analysis

We conducted descriptive analyses of the closed- and open-ended survey questions. For closed-ended items, we ran descriptive statistics and logistic regression analyses to predict the likelihood of a teacher having a high level of CR-SE implementation using teacher characteristics (gender, race and ethnicity, whether they attended CR-SE PD training, and

TABLE I
PERCENT OF TEACHERS WHO IMPLEMENTED CR-SE PRACTICES TO A MODERATE OR LARGE EXTENT

%	CR-SE Practice
77	Using my students' knowledge and interests to make connections to new content in CS.
63	Ensuring that a variety of diverse cultures, languages, orientations, and identities are reflected, represented and valued in my CS classroom.
59	Using inquiry-based or project-based CS learning.
58	Modifying CS lessons to connect with students of different racial/ethnic backgrounds or any other social identity.
53	Teaching CS lessons that affirm my students' cultural and/or social identities.
52	Teaching lessons that allow my students to investigate issues of social justice in technology.

TABLE II
PERCENT OF TEACHERS WHO AGREED OR STRONGLY AGREED TO CR-SE BELIEF AND CONFIDENCE STATEMENTS

%	CR-SE Belief Statement
94	CS assignments and lessons should empower and prepare students to solve problems in their lives, communities, and the world.
92	Teachers should connect to students' existing knowledge, cultural backgrounds, interests, and family traditions when planning CS assignments and lessons.
86	Teachers should review CS assignments, assessments, and instructional resources for historical accuracy, cultural relevance, multiple perspectives and stereotypes.
76	An important part of being a CS teacher is examining one's own attitudes and beliefs about class, race/ethnicity, gender, disabilities, language, and sexual orientation.
70	Issues related to racism, sexism, and other inequities should be openly discussed in CS classrooms.
%	CR-SE Confidence Statement
69	I am confident in using culturally responsive pedagogy to support student learning in CS.
61	I am confident facilitating conversation around the impacts and ethics of computing in a CS class.

grade band taught) as well as school-level characteristics (student demographics and the percent of students receiving CS education in their grade band) as independent variables.

For open-ended items, we conducted a content analysis using an iterative inductive and deductive coding process. We reviewed themes that emerged to provide additional context and detail to the close-ended results.

VI. FINDINGS

A. To what extent are teachers implementing CR-SE practices in their CS instruction? Does implementation of CR-SE vary by teacher or school characteristics?

In our sample, more than 50% of teachers reported that they were implementing a range of CR-SE practices to a large or moderate extent (see Table I). These findings suggest that in CS for All classrooms, most teachers are trying to implement CR-SE practices, especially practices that connect CS to students' interests and backgrounds. Teachers were more likely to report implementing CR-SE practices that may be considered a "lower-lift" (e.g., learning about students' backgrounds, tapping into student interests) than those requiring deeper, more engaged practices (e.g., addressing racism in CS education, using CS as a tool for social justice). Describing her journey implementing CR-SE practices, one teacher said: *"I think getting my feet wet and starting small has helped because now I know what to improve on for next year."* When investigating whether implementation of CR-SE practices varied by teacher and school characteristics, we did not find differences in most of the items. However, we did find statistically significant differences in teachers' reports of ensuring that students' diverse cultures, languages, orientations, and identities are reflected and valued in the classroom. In particular, we found that teachers were more likely to report honoring and affirming students' cultural identities if they had attended any CR-SE PD training, taught middle school or high school, were from schools with higher percentages of Black and Latinx students, or had higher percentages of students taking CS at their school ($p < .05$).

B. What are teachers' attitudes and beliefs toward CR-SE in CS education?

An overwhelming majority of teachers found CR-SE practices to be important in CS instruction (see Table II).

In an open-ended response, one teacher described their beliefs about why CR-SE is critical for CS as follows: *"CR-SE helps make lessons more meaningful for students. While much of CS is logic based, they can use the skills they learn to create projects that are meaningful to the students' individual cultures and life experience."* However, among a minority of CS teachers, we found that there is still some reluctance to address issues related to racism, sexism, and other inequities. Specifically, while 70% of teachers in our survey agreed or strongly agreed with the statement "Issues related to racism, sexism, and other inequities should be openly discussed in CS classrooms," 24% of teachers in our survey were "neutral" and 6% disagreed or strongly disagreed.

Teachers' neutrality on this issue may stem from the belief that, ultimately, including more advanced CS concepts is more important for high-quality CS instruction than including CR-SE content, as expressed by one teacher: *"I believe the bulk of CS time... should be focused on literal computer science (coding). ...If the grade teams have strong culturally responsive curricula embedded into other disciplines, we can address the CS gap most effectively by teaching rigorous CS."* This reflects an erroneous belief that addressing advanced CS content is not a core priority of CR-SE. Other teachers may also view CR-SE practices as unnecessary for CS instruction. For example, one teacher remarked: *"Coding is the same for everyone. The [software] doesn't know the difference."*

In our survey, teachers reported moderate levels of confidence in implementing culturally relevant CS instruction, as illustrated in Table II. When asked about confidence using curricular materials that address specific topics, we found that a majority of teachers were quite or extremely confident in highlighting issues related to race/ethnicity (52%), gender (50%), disabilities (55%), and language (55%). A notable exception was the issue of sexual orientation, where only 39% reported they were quite or extremely confident.

C. What are the challenges that teachers encounter in implementing CR-SE practices?

Despite the relatively positive reports of implementation, some teachers described challenges related to time, resource, and capacity limitations. The following were reported to be moderate or large barriers to implementation: lack of time to implement CR-SE (47%); lack of culturally relevant CS

instructional materials (36%); and lack of expertise in CR-SE (32%). As one teacher explained: *"I want to do more, but time to plan CS so that it's integrated with our curriculum, and then actually implementing it, is the biggest barrier."*

Teachers also expressed challenges related to prioritizing CS instruction, given the emphasis on mathematics and ELA instruction, and the need to prepare students for standardized tests. A few teachers expressed that their administrators were not prioritizing CS instruction, and that was a challenge for implementation. As one told us: *"Administration looks at the course as an 'entertainment' part of the students' day. They did not want me to ... spend too much time doing CS projects."*

D. What are teachers' perceptions of how CR-SE influences teacher and student interaction in CS education?

Responses to one of our open-ended questions ($n = 141$ responses) suggest that CR-SE practices are changing the way students and teachers interact with CS. A total of 41% of these responses indicated that implementing CR-SE practices improved the learning experience for students in the classroom, for example by increasing student engagement, enrollment, and enthusiasm for CS. As one teacher put it: *"The most notable aspect of implementing CR-SE practices into CS instruction has been that minority students have gained an understanding that CS is a means for them to gain a voice on the issues that matter to them and that even though they are underrepresented in CS, many successful computer scientists do look like them and share their views on gender, sexual orientation, and so on."*

In addition, 21% of responses indicated that CR-SE professional learning helped to transform teachers' practices: *"CR-SE practices have positively impacted me as a teacher because it has given me the opportunity to reflect on myself, my beliefs and my own unintentional biases and have allowed me to connect with my students."* Teachers reported that CS can be a tool to reduce bias and discrimination, felt empowered to provide a more inclusive classroom, and monitored student participation. They also commented on how using CR-SE practices helped them feel more connected to their students and supported them in ensuring that their CS lessons reflect their students' cultural, ethnic, and racial diversity.

At the same time, we also found that there can sometimes be a tension between providing high-quality CS instruction and implementing CR-SE practices, as illustrated by one teacher's quote: *"I still believe that CS instruction should include more CS. Training teachers in CR-SE is critical; however, it's also critical that we provide quality CS instruction to communities impacted by racism and inequity."* Some teachers may see the two as mutually exclusive; others may struggle with how to do both well in the CS classroom.

VII. Discussion

The research reported in this paper aims to support better understanding of how CR-SE practices are being implemented in CS classrooms, and the challenges to implementation in the context of a CS for All initiative. We found several challenges related to translating the goals of CR-SE into classroom practice. We have learned that most teachers attempted to implement CR-SE in their CS instruction, and largely hold positive attitudes about using CR-SE practices to engage their CS students. However, some teachers appear to believe there is a trade-off between providing high-quality CS instruction and implementing CR-SE practices, and some even question whether CR-SE has a place in the CS classroom. Further, our findings suggest that some teachers do not see the importance of using a CR-SE approach, seeing CS as 'color blind' or neutral. Ultimately, there is still more to be learned about what quality CR-SE in CS classrooms looks like and what support is needed for teachers to use these practices.

These findings point to several implications for practice, and the district administrator leading CS equity efforts has used the data to tailor and improve the content of the program. For example, the finding that some teachers perceive CR-SE as incongruous with rigorous CS content points to a lack of understanding that rigorous CS is a core tenet of CR-SE. In response, the district developed CR-SE sessions that explicitly address rigor and skill building in CS. The district also revised PD content to address teacher reported challenges, such as promoting strategies to manage scheduling difficulties. Much like the teacher that described engaging with CR-SE practices as "getting my feet wet and starting small," the work to support teacher development in CR-SE pedagogies in CS classrooms requires deep thinking and socioemotional learning over the course of multiple years.

For limitations, we obtained a 32% response rate to the survey. Although respondents reflected the demographics of the overall sample, non-respondents may be less likely to have implemented CS and used CR-SE practices, or may have faced different challenges. As with all self-reported measures, teachers' answers may have been influenced by social desirability. Other data, including interviews with teachers and school leaders, largely corroborated these findings, so we do not believe social desirability biased the findings to a significant degree.

Further work is needed to address the implementation challenges teachers reported. Additionally, with many schools and districts adopting CR-SE as a key strategy to broaden the participation of historically underrepresented students, it is critical that we have a clear measurement framework for CR-SE in CS, high-quality instruments, and a deeper understanding of the relationship between CR-SE and student outcomes in CS. The authors of this paper will address these gaps in future work.

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